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IZMIR TURKEY

**"The Era of Collaboration Through Supply Chain Networks"**

# PROCEEDINGS

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# PREFACE

On behalf of İzmir University of Economics and as the chair of the 4th International Logistics and Supply Chain Congress, İzmir 2006, I would like to state that we are honored to host all the participants in İzmir, one of the most important logistics centers and port city of Turkey, during 4th International Logistics and Supply Chain Congress, which was held on November 29-30 and December 1, 2006.

4th International Logistics and Supply Chain Congress, 2006 was organized by the cooperation of İzmir University of Economics-Turkey, University of Miskolc-Hungary, Belgrade University-Serbia and LODER-Logistics Association of Turkey. The congress was titled as "The Era of Collaboration through Supply Chain Networks", which has been unanimously decided upon during the first meetings of the organizing institutions. Today, collaboration is the basic foundation for successful, effective and efficient supply chains. Any activity within the supply chain that lacks collaboration, coordination and trust will inevitably fail in the long run. Therefore, collaboration should be the keyword in further practices, both in business life and scholarly endeavors. The aim of our congress, which was to bring scholars, professionals, decision-makers and practitioners working in the area of logistics and supply chain management together, was successfully accomplished.

The congress brings together more than 300 academicians, researchers and practitioners from different countries. A total of 100 papers were accepted and presented during the Congress, and published in the Proceedings. These papers cover a wide range of topics including Intermodal Transportation, E-Technological Solutions for SCM and LIS, Supply Chain Management Strategies, Inventory Management and Network Design, Regional Logistics, Reverse Logistics, Global Responsibility, Mathematical Aspects of Logistics Management, Sourcing, Service Supply Chains and Transportation Management. We are grateful to our authors and reviewers for all their efforts during this remarkable scientific event.

We would like to thank our partners in organization who have supported us in realizing this event, University of Miskolc, Belgrade University and LODER-Logistics Association of Turkey. We also would like to acknowledge the support of the sponsors of the Congress for their contributions.

I would like to thank the members of the organizing committee, Oznur Yurt, Melike D. Kaplan, I. Ozge Yumurtaci and Bengu Sevil, who have put great enthusiasm, effort and time into realization of the Congress.

Finally, we would like to thank everyone who has contributed for making this Congress a memorable and successful event.

Sincerely,

Prof. Dr. Tunçdan Baltacıoğlu
Izmir University of Economics
Congress Chair

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CONTENTS

# INTERMODAL FREIGHT TRANSPORT AND LOGISTICS IN EUROPEAN UNION: CHALLENGES AND PROSPECTS FOR TURKEY

Hülya Zeybek[1]

Abstract

*This paper aims to demonstrate the importance of the intermodal freight transport and logistics within the policies of the European Union and draw perspectives for Turkey, an acceding country to EU (European Union). The paper considers the general background of intermodal freight transport and the recent policy, research and development projects of EU to support intermodal freight transport.*

Keywords: Intermodal transport, logistics, European Union, Turkey

## 1.Introduction

After recognition of Turkey as a candidate for accession to EU at the Helsinki European Council in December 1999 and declaration of start for membership negotiations in December 2003, a new era in the relations between Turkey and the EU has been initiated. The accession process requires not only the harmonization of legislation with the EU acquis but also requires the creation of new administrative structures and the strengthening of existing structures in order to implement the legislation. Transport is an important issue in that process. Improving and promoting intermodal transport is the core of European Transport policy, as set out in the White Paper 'European Transport Policy for 2010 – Time to Decide' published in 2001 (EC,2001).

## 2. The Concept of Intermodal Transport

In order to meet the door-to-door transport requirements of the customers, intermodal transport has been developed as an alternative to unimodal road transport.

Intermodal freight transport is defined in the "Terminology On Combined Transport" prepared by the UN/ECE, the European Conference of Ministers of Transport (ECMT) and the European Commission (EC)(2001) as;

*"The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes. By extension, the term intermodality has been used to describe a system of transport whereby two or more modes of transport are used to transport the same loading unit or truck in an integrated manner, without loading or unloading, in a [door to door] transport chain.."*

Besides intermodal transport, there are other commonly used similar terms such as "combined" and "multi-modal" transport (ESCAP,2005;UNCTAD;2001). Multimodal transport is a general term refers to the transport of goods from origin to destination using two or more modes of transport. Intermodal transport is focused on a loading unit[2] moving between different transport modes in which the freight not handled (Janic and Bontekoning, 2002).

The term "combined transport" is often used to indicate an intermodal transport involving only rail and road. We are introduced with a new term "co-modality" on the mid term review of the 2001 Transport White Paper entitled "Keep Europe Moving – Sustainable Mobility for our Continent"( EC, 2006a).

## 3.Intermodal Freight Transport in EU

### 3.1 Current State of Intermodal Services

Since decades, the political context in Europe is in favour of intermodal transport because of environmental concerns, reasons of overall efficiency and the benefits of co-ordination of modes to cope with growing transport flows (ISIC,2005). Despite this strong position and the substantial economic support the demand for intermodal transport has failed to generate a commercially attractive supply except where natural and institutional barriers limit the competitiveness of road transport i.e in Austria and Switzerland. and transport between the main seaports and their hinterlands (Eurostat, 2002). However, since the introduction of Swiss road charges for lorries, the share of freight carried by rail in Switzerland has fallen from 70% to 65%. Further, the German motorway toll has failed to shift freight on to the railways (EC, 2006b).

Thus, intermodal transport accounts for little more than 5% of the total surface traffic (tonne-km) of the EU15 (Savy, 2005).

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[2] Loading unit is a container ("a special box to carry freight, strengthened and stackable and allowing horizontal or vertical transfer") or swap-body ("freight carrying unit not strong enough to be stackable, except in some cases when empty, or top-lifted; it is used only in rail-road movements").

## 3.2 Potential for Growth

It is forecasted that the European trade volumes to increase by 45% until 2015(BMT,2004). Besides, the enlargement of the EU, shift of production and distribution centres, the progress in railway liberalisation, the availability of Galileo and new ICT Systems, all contribute to the growth of intermodal transport(ISIC, 2005:93). In this regard, the UIC´s (International Union of Railways) *Combined Transport Group* forecasts the annual growth rate of international intermodal/combined transport units in Europe as 6,8 % in average for the period 2001 – 2015 (Peetermans,2004).

# 4.EU Policy for Promoting Intermodal Transport

In the White Paper "Time to Decide" 2001, the European Commission proposed 60 measures to overhaul the EU's transport policy in order to make it more sustainable and avoid economic losses due to congestion, pollution and accidents. Intermodal transport is one of the measures to achieve this objective (EC,2001). A revised version of the White Paper under preparation attempts to re-balance the policy towards economic objectives focusing on a modal merge instead of a modal shift considering the general recognition that policies for modal shift are not working. The aim of the Communication, presented on 28 June 2006 in follow up to the Transport White Paper Mid-Term review (see Euractiv 23 June 2006), is to optimise the use of all transport modes and facilitate their integration into a single supply chain.

The Commission has outlined several potential areas of action:

- Promoting multi-modal transport chains and ensuring quality of service (especially for rail transport)
- Introducing smart technologies in all modes of transport
- Administrative simplification: establishing one-stop shops for customs formalities and physical checks
- Ensuring interoperability ( common European standards for loading units )

The Commission advocates an intermodal transport system which encourages co-operation and complementarity between the transport modes and which favours competition between transport operators. In order to achieve this goal, major actions taken by the European Commission can be summarized as follows;

## 4.1 Integrated infrastructure investments – TEN-T

Intermodal transport requires efficient transport systems supported by integrated infrastructures and services for the smooth, safe and rapid flow of goods from origin to destination. The Community has recognised the need for a network approach to transport infrastructure planning and has consequently adopted the Guidelines for Trans-European Transport Networks (TEN-T) in 1996 to contribute to the implementation and development of 14 projects endorsed by the European Council at Essen in 1994. However, the extension of the TEN-T network proceeds at a slower rate than anticipated.

In 2003, one third of the network had been built and only three of the 14 had been completed. Therefore, TEN-T projects have been reviewed and 30 priority axis have been identified for realization till 2020 (EC,2005). The Motorways of the Sea has been included in the priority list of the TEN-T programme as a new initiative of the Commission which has received a lot of attention in Europe.

## 4.2 Research and development activities

The European Union supports intermodal transport through research and development projects, thematic networks, concerted actions and integrated projects. The European research and development programmes are regularly evaluated. The research has been mostly carried out in the scope of programmes such as(Janic and Bontekoning,2002):

- The COST-Transport Actions
- Framework Programmes

### 4.2.1 COST (European Cooperation in the Field of Scientific and Technical Research) Programme

The COST – Transport (European Co-operation in the Field of Scientific and Technical Research) actions have represented a framework for European scientific and technical co-operation in the field of transport(Janic and Bontekoning,2002). COST is based on so-called "actions". About 57 actions on transport field(either completed or ongoing) have been undertaken. Some of them related to intermodal freight transport cover particular subjects in design and operation of intermodal freight transport networks and relationships between transport modes including intermodality, interconnectivity and interoperability at urban, regional, national and international scale ( http://www.cost.esf.org/index.php?id=26&domain= 3&country=all&filter=all). Examples include COST 356 "EST - Towards the definition of a measurable environmentally sustainable transport" ( to be completed on January 15, 2010) and Cost 355 - "Changing behaviour towards a more sustainable transport system( to be completed on May 25, 2008) projects(http://www.cost.esf.org 09.05.2006).

Turkey is a member of COST and TUBITAK(The Scientific and Technological Research Council of Turkey) is acting as a national coordinator. However, Turkey has not participated in COST actions in the field of transport ( http://www.cost.esf.org 09.05.2006)..

4.2.2 Framework Programmes (FP)

The Framework Programme (FP) is the European Union's main instrument for funding research and development. FPs have been implemented since 1984 and cover a period of five years with the last year of one FP and the first year of the following FP overlapping. The current FP is FP6, which will be running up to the end of 2006. In the 6th Framework Programme, the Commission favours large so-called 'integrated projects' to increase the involvement of industry, in contrast to earlier programmes which where more research-driven.

It has been proposed for FP7 to run for seven years. It will be fully operational as of 1 January 2007 and will expire in 2013. It is designed to build on the achievements of its predecessor towards the creation of the European Research Area, and carry it further towards the development of the knowledge economy and society in Europe(http://cordis.europa.eu/fp7/faq.htm#1)

The themes identified for FP7 correspond to major fields in the progress of knowledge and technology, where research must be supported and strengthened to address European social, economic, environmental and industrial challenges. In the 7th Framework Programme, the Commission favours transport compared to earlier programmes and Euro 4,1 billion budget was projected for transport (TUBITAK,2006).

Table 1:Major FP projects on intermodal freight transport and logistics

| Project acronym | Research subject |
|---|---|
| APRICOT | A systematic integration of the inland waterway system(s) in optimal “door to door” chains outside the narrow scheme of the river Rhine area by linking the benefits of inland navigation to the merits of rail transport to the destinations in South and Southeast Europe. |
| CENTRAL LOCO | Central European Network for Logistics Competence |
| CAESAR | Coordination Action for the European Strategic Agenda of Research on intermodalism and logistics |
| D2D | Development of tools and IT data bases for Intermodal Freight Transport chains. |
| EMOLITE | Evaluation Model for the Optimal Location of Intermodal Terminals in Europe |
| FREIA | Setting up commercially viable relations with freight villages, their services, procedures and information systems. |
| FV 2000 | Analysis and evaluation of a freight village structure and lay-out in order to determine whether the proximity of different transport and logistics activities is a key factor for the use of intermodal transport. |
| IMPREND | Improvement of pre- and end-haulage at terminals, achieved by defining and testing a number of formulae on how to do that. |
| IMPULSE | Technological improvements in intermodal networks and terminals |
| INTRARTIP | Development of a common framework for a Pre-Contract Intermodal Information System to facilitate the exchange of pre-contract information in the intermodal sector. |
| IRIS | Innovative rail intermodal services |
| IQ | Quality improvement of intermodal networks and terminals |
| IN.HO.TRA | Promotion of specific ‘horizontal transfer technologies’ for intermodal transport, which are expected to provide efficient road-rail transport on short distances. |
| INTERMODA | Integrated Solutions for Intermodal Transport between the EU and the CEEC. |
| PRECISE-IT | Precise Automatic Location System for the Management of ITUs and Vehicles inside Intermodal Terminals |
| PROTRANS | The role of third party logistics service providers and their ımpact on transport |
| RECORDIT | Real cost reduction of door-to-door intermodal transport |
| REDEFINE | relationship between demand for freight-transport and industrial effects |
| SCANDINET | To improve the access to the infrastructure, information and market for intermodal trasport services - in particular for SME's and isolated flows |
| SULOGTRA | Supply Chain Management, Logistics and Transport |
| X-MODALL | The optimised exchange between all modes of all conforming consignments |
| TERMINET | Towards a new generation of networks and terminals for multimodal freight transport |
| TACTICS | The automated conveying and transfer of intermodal cargo shipments |

Source: Janic ve Bontekoning, 2002, http://cordis.europa.eu/fp6/projects.htm 05.06.2006, http://cordis.europa.eu/transport/src/x-modall.htm

Turkey has not participated in transport and logistics projects within 6th Framework Programme which is the first FP progrramme Turkey has ever take part. However, it is desirable for Turkey to be active in the 7th Framework Programme by developing transport projects.

### 4.3 Subsidies for infrastructure and operations - Marco Polo, Pact, Motorways of the Sea (MOS)

The Marco Polo programme, entered into force in 2003, directly subsidises intermodal operations. The Programme's objective is to reduce road congestion and to improve the environmental performance of the freight transport system within the Community and to enhance intermodality, thereby contributing to an efficient and sustainable transport system. To achieve this objective, the Programme supports actions in the freight transport, logistics and other relevant markets (http://ec.europa.eu/transport/marcopolo/index_en.htm ). The current Marco Polo Programme runs until 31 December 2006 and "Marco Polo II" programme will come on stream on 1 January 2007.

Marco Polo, which in fact is a continuation of the PACT programme implemented between 1997-2001, is implemented between 2003-2006 with a € 102 m budget (approximately € 20 m per year). A budget of € 740 m (approximately € 100 m per year) is proposed for Marco Polo II which will cover the 2007-2013 period. (Karamitsos, 2005)

Among projects financed by Marco Polo in 2003 there are 2 projects involving Turkey and these are Rotterdam-Istanbul shuttle train (DARIS) and Cologne-Kosekoy block train application (TRITS). Among the 12 projects financed in 2004 there are no projects involving Turkey (http://europa.eu.int/comm/transport/marcopolo/projects)

### 4.4 New initiatives for intermodal transport

In 2003, the Commission proposed also to bring some order into the sub-optimal world of intermodal equipment, by making a proposal for a directive on intermodal loading units as an important component of the intermodal strategy.

On the other hand, the Commission is considering to establish a dedicated organisation called Intermodal Development Centres for promoting intermodal transport which will complement the investment programme. Intermodal Development Centres will be acting as a catalyst to develop intermodal freight solutions along European corridors showing high intermodal ( ISIC,2005)

## 5. Challenges and Prospects for Turkey

### 5.1 Current State of Intermodal Services in Turkey

Intermodalism has been increasing both in the EU and Turkey due to the demand and supply side developments in transport industry. Turkey has great potential in terms of intermodal transportation owing to its privileged geographical position at the crossroads of three continents: Europe-Asia-Africa. The trend in development patterns in the Mediterranean, the Black Sea, the CIS countries and Central Asia implies new intermodal networks leading to demand increase for intermodal transport. There is a high growth rate in transport demand in trade to/from Turkey and Turkey trade volumes are twice as high as e.g. the trade volumes of Greece with Europe (ISIC,2005: 71-80) For rail intermodal transport Germany and Austria are markets with high potential for Turkey. As a new rail intermodal transport service, Halkalı (Turkey)-Wels (Austria) RoLa Express train will be operational on September 21, 2006 passing through Bulgaria, Montenegro,Sırbia,Croatia,Slovenia (TCDD,2006)

Container and ro-ro traffic plays a key role for the flow of manufactured and high value-added goods in port traffic with Europe(Zeybek, 2006). A significant volume of the sustained increase in maritime container volume is handled through TCDD ports of Izmir, Mersin and Haydarpasa and the private ports in Ambarlı. 54 per cent of the maritime containers were handled at TCDD ports and 45 percent at Ambarlı in 2004 (UYG-AR, 2005). There will be a growing demand for the movement of containers in the near future and it is forecasted that the container traffic (3 million TEU in 2004) will reach 6 million TEU by the year 2020 ( JICA,2000).

Located on the European side of Istanbul, Ambarlı is one of the fastest growing private container port region of Turkey with a throughput of 1,078,406 TEU in 2004 ranked as 71 among the World's top 100 Container Ports (A Cargo Systems Supplement,2005). İzmir port is ranked as 84$^{th}$ container port within the same ranking with its container throughput 804,565 TEU.

In recent years, due to the problems arising in the road transport, ro-ro transport has increased to a significant level. The Turkish-Italian Ro-Ro Line is the fastest growing line in the world and currently is being considered as the first line in the Mediterranean sea as well as being the 6th biggest line in the world (Atılgan, 2005a). The Intermodal Line currently operating between Pendik/Ambarlı/Çeşme-Trieste is a Short Sea Shipping plus Combined Transport operation (Atılgan, 2005b). Also ro-ro traffic is very active in the Black Sea region Ro-Ro vessels are operating between Samsun (Turkey) and Novorossiysk (Russian Federation) as well as between Zonguldak (Turkey) and Evpatoria (Ukraine).

In this regard, Turkish ports on the Mediterranean, Aegean an Black Sea coast are important nodes within Motorways of the Sea Concept of EU. Ro-Ro Ship Administrators and Combine Transportation Association of Turkey (RODER) has established a Shortsea Shipping Promotion Center (SPC) in Turkey to integrate with the European Shortsea Network (ESN) (Atılgan, 2005a).

## 5.2 Challenges for Turkey

The general growth of transport demand between Europe and Turkey and the policy of EU for better integration with the new EU member states and neighbouring countries via intermodal transport services, point out that there is a big potential for a sustainable growth of intermodal transport and logistics services in the forthcoming years.

However, in Turkey, it is clear that there is no sufficient terminals and rail infrastructure in place today for intermodal transport. In order to support the growth of the intermodal transport, and meet the increasing demand, the efforts should concentrate on the investing on the potential intermodal corridors, especially on terminals and railway links. Beyond that, considering the multi-actor nature of intermodal transport, ICT should be developed and smart technologies should be introduced in all modes of transport Another essential which is lacking in Turkey is the participation in EU Research and Development Programmes which offer huge potential in technical assistance and funds available for intermodal transport and logistics. Participating e.g. in FP programmes and training activities, transport decision makers may see the benefits of intermodal transport in general and of specific transport options in particular. Another alternative is developing “Inter-modal Management Programmes” as university study courses in order to provide the required skills to those working in the transport services market companies and struggling to improve their services.

# 6. Conclusion

Transport policy of the EU is very important for Turkey as an acceding country. It seems that the revised version of the White Paper under preparation attempts to support intermodal transport, logistics and supply chains even more than before.

This paper reviews the recent policy, research and development projects of EU to support intermodal freight transport and aims at bringing light upon new possibilities for Turkish transport practices.

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http://europa.eu.int/comm/transport/marcopolo/projects 24/11/2005 List of the best 12 projects out of a total of 62 projects submitted

# COST BASED INNOVATION OF COMBINED ROAD AND COMPANIED RAILWAY TRANSPORTATION

Dorottya Mánik[1], János Fári[2], Lajos Tóth PhD[3], Tamás Hartványi PhD[4]

## Abstract

*In the article we develop the cost structure of combined road and companied railway transportation from each side. We determine the separate parameters of the cost functions and create mathematical model for the resultant function. The purpose of this project is to analyze the possibilities of the RoLa traffic sustainability if the traffic is not generated by the government. According to the economic calculations we will make a proposal for creating new innovative technologies.*

*Keywords: Combined traffic modes, Intermodality, Modal shift*

## 1. Introduction

The first attempts to transport complete road engines and freight vehicles by rail took place in Germany in 1954, France in 1960 and Switzerland in 1964. These attempts were carried out in a quite simply way, namely placing the freight vehicle in one and the trailer in an other carriage. The real Ro-La transportation was launched in 1981. (The name Ro-La comes from the German expression 'Rollende Landstrasse', that is 'rolling road'.) At that time, special 19 metres long rail vehicles were available, fit for transporting a complete road vehicle.

It was in 1992 that the first Ro-La train started in Hungary, followed by construcing several relations. These trains are also often used by Turkish transporters, which makes Turkey interested in the way the combined transportation system is developed.

## 2. Economic character of Ro-La system

The advantages and disadvantages of applying combined transportation techniques need to be examined from the main market participants' aspects, namely road transporters, railway companies, operating companies and other participants of transport (population).

Advantages of Ro-La application:

- Compared with uncompanied combined transportation, the Ro-La system is easy to access widespread as it has no investment requirements by the road transporters. Vast majority of transit transportation in Hungary is streaming from South and Eastern European countries using their own vehicle ranges. Consequently, the above aspect is of key importance, because in these countries means of high investment cost suitable for uncompanied combined transportation are not spread at all.
- Decreasing number of road accidents: A great number of road accidents are caused directly or indirectly by heavy freigth vehicles which are much slower than passanger cars. With Ro-La it is possible to decrease the number of vehicles on the roads, so the possibility of having accidents decreases.
- Saving time: According to logistics tendencies, time is the most considerable factor of quality. Reducing transportation time contributes to a higher competitiveness of the company, which results in attaining new costumers on the transportation market.
- Reliability and transparency are also requirements on various fields of logistics. These requirements are effectively met by Ro-La by establishing timetables and terminals as cheking points.
- Efficient utilizing of driving time: referring to AETR, the amount of time when the freight vehicle is transported on the train, is considerend as resting time from the driver's point of view. Compared to running vehicles, vehicles in the Ro-La system can make a longer distance within the same time.
- Environmental protection: Taking social affects into account, the biggest concern is environmental pollution. It is widely known that rail transportation is much less harmful to the environment than road transportation. Increasing rail freight transportation is a social necessity. Advantages of both road and rail transportation can be utilized by developing combined transportation, that is, goods are forwarded to far distances within short time saving costs and the environment at the same time, and by making door to door transportation on roads possible.

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Disadvantages of Ro-La application:

- High ticket prices: Road tansporters can also experience the disadvantages of the Ro-La system. One of them is the high Ro-La ticket prices compared to current road costs. The differences emerge from the unequal distribution of costs paid by road and rail transporters.
- Transportation can take place on a limited (or fixed) route, due to the characer of railways.
- Transporting passive weight: Concerning environmental protection and efficiency a great disadvantage of Ro-La transportation is transporting 'passive weight'. It means that beside the goods the whole train vehicle is transported in Ro-La system including trailer and semi-trailer, freight vehicle and hauler, that is, the 'passive weight'. This leads to a meaningful gauge of loss of energy, the specific energy-needs per tons increase as opposed to only-rail transportation. However, considering only-road transportation, Ro-La system provides a more reliable solution in terms of environmental protection.

## 3. Ro-La traffic

Ro-La goods in Europe started increasing dinamically in the end of the 80ies, from 104,000 units in 1989 to 358,000 in 1999, that is a thrreefold and a half expanding during ten years. Capacity utilization of the carriages is satisfactory by reaching 1,000 kms a day. Increasing of Ro-La traffic continued and reached the top in 2000 with more than 385,000 lorries transported a year. It was followed by some setback, still with 377,000 lorries in 2003 and 312,000 in 2004 (due to the EU enlargement), and the tendency held in 2005.

The spectacular setback is rooted in the fact that less and less Hungarian, Turkish, Bulgarian lorries and those of former Yugoslavia participate in Lo-RA traffic, which could not even be compensated by the increasing number of Rumanian lorries.

Without the lorries from Rumania and Bulgaria, which is expected after the EU accesions, the number of lorries from the Balkans, crossing Hungary, will not reach a staisfactory amount enough to have an economic Ro-La transportation. This is why lorry transport on the roads will increase, unless some arrangements will be done.

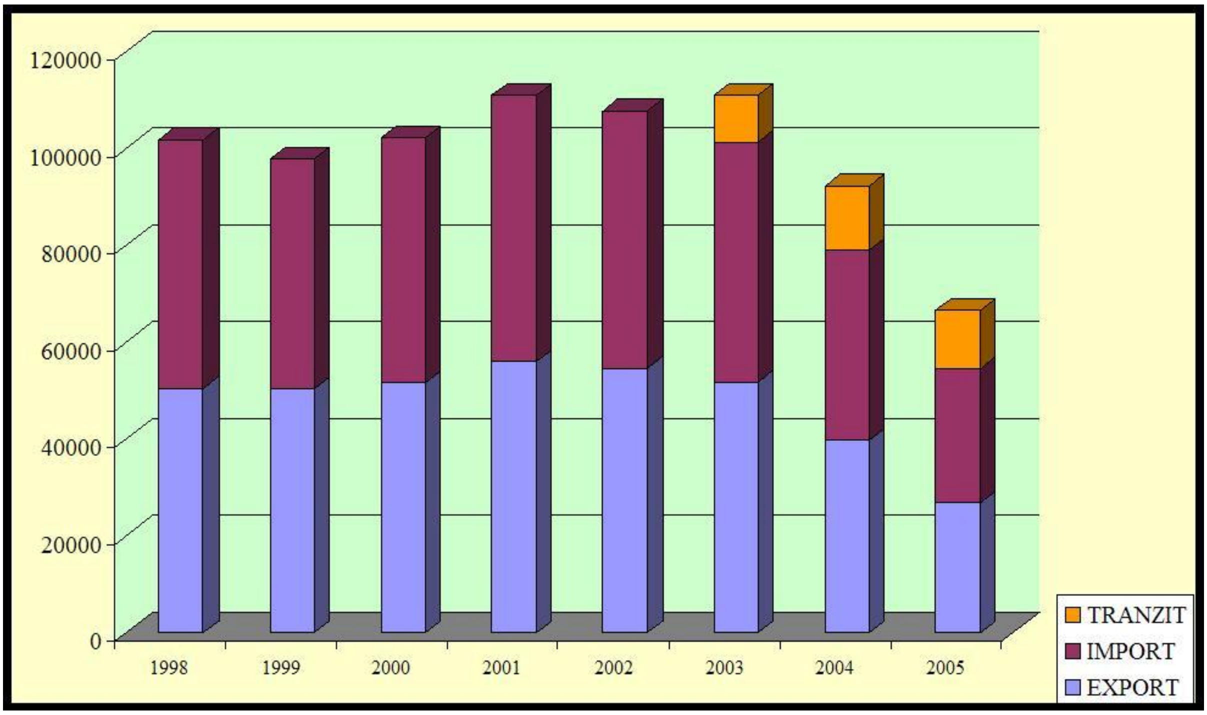


*Figure 1. Lorries transported via Hungary by Ro-La transportation system [pc]*

## 4. Theory of microeconomy model

Due to the positive externals of Ro-La transportation, in our researches we tried finding a new, in economic terms innovative solution for sustaining Ro-La combined transportation technique in an economic environment based on free competition.

It is a well known fact that access to Ro-La services was supported by macroeconomic arrangements which offend the principle of neutrality in competition:

- The Austrian transit regulations,
- Indirect state dotation

The market situation of Ro-La services have never been modelled under free market conditions.

We established an innovative microeconomic model (with road and rail transportation costs in any relations), which is suitable to show what conditions are worth being taken by a road transportation company when chosing services of the Ro-La system and what business strategy the partners of the railway company should apply.

The model focuses on the cost structure of road and rail transportation at microeconomic level, providing comparisons in numbers. The model allows using specific parametres with actual routes. This option enables the transporters to decide before the transportation activity whether to take Ro-La services or not. It also gives a unique opportunity for the railway company to examine under what conditions it can provide competitive prices.

Due to the fact that transporter companies disregard the positive effects of Ro-La system on the environment and take solely economic aspects – price and other factors of costs – into account when making decisions, the model reflects just on the financial factors on both sides.

The model is suitable for comparing both systems, namely, only-road and Ro-La transportation. To make application of special parametres possible, transportation activities are devided into three parts concerning distance, driving time and speed.

The first phase shows the change of distance and time, taking speed into account. This is the normal road running of the lorry, and the phase of getting the lorry on the Ro-La..

The second phase contains two varieties: On the one hand, distance is continuously increased but the driving time does not change. This can be Ro-La or Ro-La traffic. On the other hand, either driving time and distance do not change, that is, the lorry is in a standing position. This variety can occur at weekends when lorry traffic on roads is forbidden. Also in the third phase driving time and distance change depending on speed. In Ro-La traffic the first and the third phase are identical with transportation on and off the Ro-La system. In road transportation only the first phase can ocuur.

The model contains cost components of road transporter companies, showing both constant and changing costs. Personal expenditures were calculated according to the number of drivers per one lorry taking part in transportation activities, and by defining driving time we considered the international regulations AETR. The railway companies are given the possibility to make calculations according to Ro-La cost types.

## 5. The model in practice

In the following table we demonstrate the costs of road transport and Ro-La traffic (by examining a transportantion activity between Istambul /Turkey/ and Dortmund /Germany/) with current market conditions.

Basic data are shown in the two tables below. The first one contains solutions for only-road transport, the second one shows Ro-La applications.

Table 1. Basic data of only-road transport and Ro-La traffic

| Version 1 | | | | |
|---|---|---|---|---|
| 1. | Number of drivers: | 1 | | |
| Road section | | 1 | 2 | 3 |
| 2. | Within built-up areas [km] | 90 | | 0 |
| | Outside built-up areas | 100 | | 0 |
| | motorway [km] | 2, 200 | | 0 |
| | Distance covered per road sections [km] | 2, 410 | 0 | 0 |
| | Total distance [km] | 2, 410 | | |
| 3. | Loading time [h] | 4 | | 0 |
| 4. | Calculated standing time [h] | 10 | | 0 |
| 5. | Number of weekends/holidays during transport activity [day] | 0 | 0 | 0 |
| 6. | Days spent in homeland | 1 | 0 | 0 |
| 7. | AETR factor [%] | 1 | | 1 |

| Version 2 | | | | |
|---|---|---|---|---|
| 1. | Number of drivers: | 1 | | |
| Road section | | 1 | 2 | 3 |
| 2. | Within ibuilt-up areas [km] | 90 | | 0 |
| | Outside built-up areas | 100 | | 0 |
| | motorway [km] | 770 | | 790 |
| | Distance covered per road sections [km] | 960 | 656 | 790 |
| | Total distance [km] | 2406 | | |
| 3. | Loading time [h] | 2 | | 2 |
| 4. | Calculated standing time [h] | 5 | 6 | 0 |
| 5. | Number of weekends/holidays during transport activity [day] | 0 | 0 | 0 |
| 6. | Days spent in homeland | 1 | 0 | 0 |
| 7. | AETR factor [%] | 1 | | 1 |

Expenses of the single varieties:

Table 2. Comparison of road transport and Ro-La traffic expenses under current market conditions

| Version 1 | | | | |
|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Total |
| Personal expenses | 183,05 € | 0,00 € | 0,00 € | 183,05 € |
| Constant expenses | 246,89 € | 0,00 € | 0,00 € | 246,89 € |
| Expenses depending on km | 851,91 € | | 0,00 € | 851,91 € |
| Toll | 363,21 € | | 0,00 € | 363,21 € |
| Ro-La charges | | 0,00 € | | 0,00 € |
| Total | 1 645,06 € | 0,00 € | 0,00 € | 1 645,06 € |
| Kms run | 2 410 km | 0 km | 0 km | 2 410 km |
| Specific expenses [€/km] | 0,68 € | 0,00 € | 0,00 € | 0,68 € |

| Version 2 | | | | |
|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Total |
| Personal expenses | 48,56 € | 26,53 € | 54,40 € | 129,48 € |
| Constant expenses | 95,00 € | 47,71 € | 37,53 € | 180,24 € |
| Expenses depending on km | 339,35 € | | 279,26 € | 618,61 € |
| Toll | 162,60 € | | 103,98 € | 266,58 € |
| Ro-La charges | | 504,00 € | | 504,00 € |
| Total | 645,51 € | 578,24 € | 475,17 € | 1 698,91 € |
| Kms run | 960 km | 656 km | 790 km | 2 406 km |
| Specific expenses [€/km] | 0,67 € | 0,88 € | 0,60 € | 0,71 € |

Table 3 shows the differences between only-road and Ro-La traffic expenses. Sums marked '+' indicate Ro-La cost advantages, sums marked '-' indicate the amount how much Ro-La traffic is more expensive.

Table 3. Differences between expenses of only-road transport and Ro-La traffic with current market conditions

| Difference | Total |
|---|---|
| Prsonal exenses | 53,57 € |
| Constant expenses | 66,65 € |
| Expenses depending on km | 233,30 € |
| Toll | 96,63 € |
| Ro-La charges | -504,00 € |
| Total | -53,85 € |
| Difference of specific expenses [/km] | -0,02 € |

After the comparison of the two version we concluded that road transportation costs for a lorry amounts to 53,85 €- less than that by Ro-La. This fact requires an improvement of competitiveness of Ro-La to become a potential alternative to only-road transportation.

How can the competitiveness of R-La be improved?

One possibility is introducing toll charges: Ro-La trains are obliged to pay toll charges on railways, while lorries do not pay any charges on roads (that is actual kms run on roads) when crossing Hungary. This situation does not meet the conditions of equal competition. Lorries are required to pay only charges (a lump sum set according to time) that makes a law percentage of normal toll. According to the modified regulation of 11119/62/EC toll charges will be introduced as obligatory in all EU counries from 1 July 2008.

We also examined, what specific road charges are needed to equalise the costs of both variations. As a result we can state that it is possible by charges of 0,23 €/km, which is less than that in Austria (0,273 €) but more than that in Germany (0,12 €), by taking current railway charges into account.

The regulation mentioned above allows supporting alternative, environment friendlier solutions using the income from toll charges. The support may be given to Ro-La traffic, depending on performance.

Concerning the same conditions shown in the previous, (except: raising the number of standing time to 12 in Table 1. version 2.) starting tables above, introduction of the above toll charges has the effects on costs as follows:

Table 4. Comparison of road transport and Ro-La traffic expenses after introducing toll charges

| Version 1 | | | | |
|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Total |
| Personal expenses | 183,05 € | 0,00 € | 0,00 € | 183,05 € |
| Constant expenses | 246,89 € | 0,00 € | 0,00 € | 246,89 € |
| Expenses depending on km | 851,91 € | | 0,00 € | 851,91 € |
| Toll | 438,80 € | | 0,00 € | 438,80 € |
| Ro-La charges | | 0,00 € | | 0,00 € |
| Total | 1 720,65 € | 0,00 € | 0,00 € | 1 720,65 € |
| Kms run | 2 410 km | 0 km | 0 km | 2 410 km |
| Specific expenses [€/km] | 0,71 € | 0,00 € | 0,00 € | 0,71 € |

| Version 2 | | | | |
|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Total |
| Personal expenses | 71,25 € | 6,53 € | 54,40 € | 132,17 € |
| Constant expenses | 114,64 € | 47,71 € | 37,53 € | 199,88 € |
| Expenses depending on km | 339,35 € | | 279,26 € | 618,61 € |
| Toll | 162,60 € | | 103,98 € | 266,58 € |
| Ro-La charges | | 504,00 € | | 504,00 € |
| Total | 687,84 € | 558,24 € | 475,17 € | 1 721,24 € |
| Kms run | 960 km | 656 km | 790 km | 2 406 km |
| Specific expenses [€/km] | 0,72 € | 0,85 € | 0,60 € | 0,72 € |

Table 5. Differences between expenses of only-road transport and Ro-La trafic after introducing toll charges

| Difference | Total |
|---|---|
| Prsonal exenses | 50,88 € |
| Constant expenses | 47,00 € |
| Expenses depending on km | 233,30 € |
| Toll | 172,22 € |
| Ro-La charges | -504,00 € |
| Total | -0,60 € |
| Difference of specific expenses [/km] | -0,00 € |

Referring to the comparison it is obvious that the amount of road charges indicated above is enough to equalise transportation costs.

In the future, unfortunately, we can expect the gasolin prices to increase, which, however, can improve the competitiveness of the Ro-La system automatically.

It is also important to mention that the present railway charging system involves anomalies, which requires revision.

Given the oportunity by our model, we examined the case when a road transportation activity is interrupted by a one-day lorry prohibition at the weekend, extending performance time. Data on Ro-La are not changed as it is not affected by any lorry prohibition. (We disregarded toll charges on roads in Hungary for this period.)

Table 6. Comparison of road transport and Ro-La traffic expenses concerning one-day lorry prohibition

| Version 1 | | | | |
|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Total |
| Personal expenses | 212,27 € | 0,00 € | 0,00 € | 212,27 € |
| Constant expenses | 314,24 € | 0,00 € | 0,00 € | 314,24 € |
| Expenses depending on km | 851,91 € | | 0,00 € | 851,91 € |
| Toll | 363,21 € | | 0,00 € | 363,21 € |
| Ro-La charges | | 0,00 € | | 0,00 € |
| Total | 1 741,62 € | 0,00 € | 0,00 € | 1 741,62 € |
| Kms run | 2 410 km | 0 km | 0 km | 2 410 km |
| Specific expenses [€/km] | 0,72 € | 0,00 € | 0,00 € | 0,72 € |

| Version 2 | | | | |
|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Total |
| Personal expenses | 48,56 € | 26,53 € | 54,40 € | 129,48 € |
| Constant expenses | 95,00 € | 47,71 € | 37,53 € | 180,24 € |
| Expenses depending on km | 339,35 € | | 279,26 € | 618,61 € |
| Toll | 162,60 € | | 103,98 € | 266,58 € |
| Ro-La charges | | 504,00 € | | 504,00 € |
| Total | 645,51 € | 578,24 € | 475,17 € | 1 698,91 € |
| Kms run | 960 km | 656 km | 790 km | 2 406 km |
| Specific expenses [€/km] | 0,67 € | 0,88 € | 0,60 € | 0,71 € |

Table 7. Differences between expenses of only-road transport and Ro-La trafic concerning one-day lorry prohibition

| Difference | Total |
|---|---|
| Personel expenses | 82,78 € |
| Constant expenses | 134,00 € |
| Expenses depending on km | 233,30 € |
| Toll | 96,63 € |
| Ro-La charge | -504,00 € |
| Total | 42,71 € |
| Difference of specific expenses [/km] | 0,02 € |

As a result of the comparison we can state that, concerning one-day lorry prohibition, Ro-La traffic is definitely more advantageous to take. It is worh thinking of how to start weekend trains.

## 6. Summary, proposals

Some features of Ro-La techniques are behind the advantages provided by uncompanied combined traffic in some respects, though, there are conditions which make Ro-La a determining factor to repress or moderate the extremely expanding road transportation, which is also supported by the EU. This necessity can be proved with several cases in Europe.

The authors of this study are convinced that declining processes of Ro-La are not irreversible, these are only a temporary outcome of inappropriate regulating of market relations. This tendency can change into the opposite way by adapting to market changes and thoughtful cooperation of partners (including regulative authorities) taking part in sustainable improvement of transportation, which must raise the number of lorries transported on trains. This is a basic public interest, as well.

To define the necessary steps, it is necessary to analyse and create a model (more detailed than ever) of the environment with all its various factors. The most important objective of the innovation desribed is to develop the most appropriate range of means.

The advantage of the model is that it is optimally detailed, variable and it its parametres are based on actual market conditions. This way the cost structure of a given transportation activity can be provided with much more details than transporters using Ro-La have ever attained. This is of high importance when decision making is based on solely rough data showing the positive features of only-road traffic, while the new detailed model proves the cost effeciency and competitiveness of the Ro-La system.

Should the calculated prices of any relations be unacceptable for most transportation activities, the model is suitable to define the potential solutions.

Planning new relations may be another possible area of applying the cost model. Knowing the parametres of the potential market, an ideal relation can be defined where the Ro-La system is the most efficient and competitive alternative.

A cost simulation analyis of the present Szeged-Wels Ro-La service, namely a transportation activity between Istanbul and Dortmund, showed that the Ro-La system is prevailing its competitiveness, even after clearing permission requirements (expected after the EU accessions).

This can be attained by the following – EU conform – (combined or single) steps:

Introducing road charges according to actual road usage. According to the calculations road charges of 0,23 €/km are needed in the present economic situation to equalize the differences between Ro-La and road transport costs. Experience and practice show that equalizing is not enough. The road charges to be inroduced should reach the amount of at least 0,25 €/km so that transporters switch to the Ro-La services 'voluntary', instead of chosing road transportation as usual before. Concerning the prevalance of the Ro-La system it is a serious issue that road charges are unfortunately expected to be introduced in Hungary no sooner than the beginning of 2008, despite having EU regulations and the idea accepted..

Revision of charges of rail usage. This component is a determining factor in Ro-La cost structure. According to the available information, charges of rail usage, compared to other charges in Europe, are relatively high in Hungary, semmingly without any reason. It is even more irrational, knowing that lorries in transition pay a negligible sum for the same function. Consequently, road charging system needs an urgent intervention.

Temporary budget support of companied combined transportation. This method is also approved, by the EU, provided the amount is used to sustain market neutrality. Moreover, the EU turned it into practice in the frame of its own program 'Marco Polo'. Most Ro-La traffic systems working in Europe successfully attain budget or county supports. Prevalance of the system is rooted in the consideration that this kind of budget support intensively returns due to decreasing road maintanance costs, and external costs omitted having no accidents and congestions, furthermore lower costs spent on keeping and developing living standard provided by the natural and social environment. If rail usage charges cannot be decreased as necessary, maintanance support is essential to be introduced in 2007 in the aspect of sustaining the Ro-La system.

An optimal solution would be the realisation of each potential described above. In case any of them can not be achieved, compensation is necessary by using other means more intensively.

Beside the above introduced interventions targeting equal chances on the market, Ro-La suppliers – with organising authorities – have to take steps to improve the competitiveness of the service, such as improving present services and cost efficiency, widening supply, discounts and renewing sales system. The model serves as a practical starting point to define all these requirements.

## 7. References


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Law IX/2001 on announcing European Agreement concerning the work of crews of vehicles engaged in international road transport (AETR).

Council regulation 3820/85/EEC, December 20, 1985, on alignment of social legislation concerning road transport

# MODELLING OF INTERMODAL TERMINALS NETWORK: SERBIAN CASE

Slobodan Zecevic[1], Milorad Vidovic[2], Milorad Kilibarda[3], Jelena Vlajic[4], Nenad Bjelic[5], Snezana Tadic[6]

## Abstract

*Intermodal transport is defined as the carriage of goods by at least two different modes of transport in the same loading unit (Intermodal Transport Unit) without stuffing or stripping operations when changing modes. The major part of the journey is done by rail, inland waterway or sea, and any initial and/or final legs carried out by road are as short as possible. Hence, intermodal transportation is characterized by the combination of the advantages of rail and road, rail for long distances, and road for the initial and the final leg.*

*This paper deals with the problem of optimally locating multimodal terminals for freight transportation in Serbia. It suggests methodology for the transport flows analysis, and modeling approach, and illustrates its operationality for bimodal, and three modal terminals locating In Serbia. The purpose of this application is also to present results of the IMOD-X project (Intermodal Solutions for Competitive Transport in Serbia) where this research was realized, as the one of project's phases.*

*Keywords: freight flows, intermodal terminal location, case study*

## 1. Introduction

The rise of intermodal transport has resulted in dramatic changes in the pattern of freight transport. Particularly in Europe, stimulated by the removal of national borders, intermodal transport affected the spatial economic structure of the transport industry in general and from there the position of transport nodes.

Volume of the freight transport flows, in general, has increased 30% only in the last decade, mostly through road transport increase, which had, and still has significant consequences both environmental, and economic. Because of those negative impacts (noise, pollution, traffic accidents, congestion, costs,...) (Nijkamp, P., 1994), only solution for environment friendly transportation system is in integration of different modes into the intermodal transport concept.

Hence, the intermodal solutions development could be alternative for the increase of the negative externalities by substituting less resource-consuming transport modes to road (Arnold, et.al 2004). These solutions will hopefully enable future growth in transport demand to be partially absorbed by non-road alternatives.

Intermodal transport is defined by the European Conference of Ministers of Transport (ECMT) as the carriage of goods by at least two different modes of transport in the same loading unit (an Intermodal Transport Unit or ITU) without stuffing or stripping operations when changing modes. The major part of the journey is done by rail, inland waterway or sea, and any initial and/or final legs carried out by road are as short as possible. In this contribution, intermodal transportation is characterized by the combination of the advantages of rail and road, rail for long distances and large quantities, road for collecting and distributing over short or medium distances (Arnold, et.al 2004).

Since the most important elements of intermodal transport network are terminals, i.e. intermodal nodes, as places of connection two or more transport modes, main objective of this paper is related with problems in the area of optimal intermodal terminal location. Solving those strategic level problems is of crucial importance particularly for regions and countries with low level of intermodalism, where Serbia may be labeled as typical example.

Remaining of the paper is organized as follows. Section 2 describes briefly modeling approaches to solving optimal location of intermodal terminals problem. The same section presents also short literature overview in the field of solving intermodal terminal location problems. Quantitative techniques, and methodological approach to

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input data estimation, are presented in the section 3. Section 4 describes simulation model for optimal locating of intermodal terminals. In the section 5, two formulations for the p-HUB location problem are shown, respectively for the cases without terminal gravity zones existence, and with their existence. Section 6 presents computational results, and in the section 7 some conclusion remarks are given.

## 2. Modeling approach

Because of the nature of intermodal services, where the major part of the journey is done by rail, inland waterway or sea, and where initial and final legs are carried out by road, problem of locating intermodal terminals may be described as HUB location problem, as it is shown in Fig. 1 below.

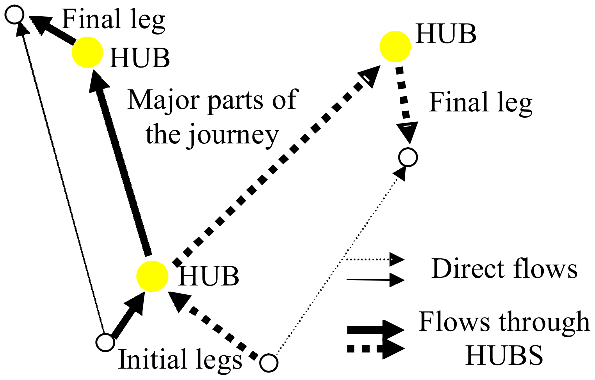


*Fig. 1 – Flows through hubs vs. traditional direct flows*

The first hub location model was defined as a quadratic integer program, and was presented by (O'Kelly, 1987) and later by (Klincewicz, 1991). Since then, the problem has been studied extensively and numerous linear formulations and algorithms has been proposed. For example, (O'Kelly et al. 1995), (Skorin-Kapov et al. 1996), (Klincewicz, 1996), (Ernst and Krishnamoorthy 1998), (Sohn and Park 2000) and (Hamacher et al. 2000), use linear objective function and variables.

The problem of optimally located of hubs in a network has received attention over the past decade due to its importance in air transportation, and in telecommunications. Also, since the hub location problem can easily be extended to the location of intermodal terminals, voluminous literature cover this hub location problem segment. For more detailed insight in the state of the art, two recent papers are proposed: (Arnold et al. 2004), and (Racunica I., Wynter L., 2005).

In this paper, model of locating intermodal terminals was based on the idea of multiple assignment hub-network designing approach, described in (O'Kelly et al., 1996). However, this model had to be modified accordingly to the specific problem being solved. Namely, transport flows in rail-road intermodal transportation networks are routed through two terminals (hubs), where the first is close to the origin, and the second to the destination node. Since our objective was to find optimal locations of intermodal terminals only in Serbia, while locations of terminals abroad was known, it was necessary to addopt approach proposed in above cited paper, and to reformulate problem accordingly to our network configuration.

Furthermore, as our idea was to analyze intermodal terminals gravity zones impact to the terminals' location, it was necessary to implement this idea into the model as well.

Beside that, because of the problem's nature, and because of current situation characterized with the ballast from the previous decade which has been shading Serbian economy, it was of crucial importance to overcome two main problems that impede traditional approach in flows prediction:

- *uncertainty of future flows prediction, imposed by almost unpredictable socio-economic development of specific regions, and unavailability of reliable statistical data*
- *unpredictability of future trade structure, in sense of directions, intensities, and different intermodal units share*

Respecting of mentioned uncertainties and stochasticity of input data imposed necessity for additional analysis based on simulation modeling approach.

Based on all previously mentioned, process of intermodal transport network designing was based on three modelling approaches:

- *simulation modelling approach respecting transport costs, transport time, and environmental effects (CO, VOC, and NOx emission)*
- *mixed integer deterministic multiple assignment p-HUB network location model – objective is to minimize transportation costs*
- *mixed integer deterministic multiple assignment p-HUB network location model with terminals' gravity zone constraints – objective is to minimize transportation costs*

## 3. Input data determination

Approach used in input data determination was based on the idea of quantification of all relevant impacts and influences. This was the main reason for defining several possible scenarios, using several data sources, and expert estimates, beside all available official statistical data.

Input data used in the intermodal network modelling process can be divided into seven groups:

- *Potential locations for intermodal transport terminals*
- *Intermodal transport flows volumes in Serbia in 2015.*
- *Distribution of flows across inbound/outbound relations*
- *Distribution of flows across districts in Serbia*
- *Demand elasticity in respect to the number of terminals and terminal catchments area*
- *Transport tariffs and operation times in the transport process*
- *Data regarding the environmental impact of the transport system*

In order to present input data on the most suitable way they are organized and presented in seven separate groups, according to their use in the model.

### 3.1.1 Potential locations of intermodal transport terminals

Three possible scenarios of intermodal terminal development, with the few alternatives within them were considered. Scenarios are based on the idea of having small number of terminals in larger towns and cities. several terminals along the Corridors X and VII, and wide network of the terminals. Potential locations defining process was based on the "Freight traffic network plan", included in the spatial plan of Republic of Serbia, as well as in the "Strategy of the economic development Republic of Serbia until 2010" - development programme 47.

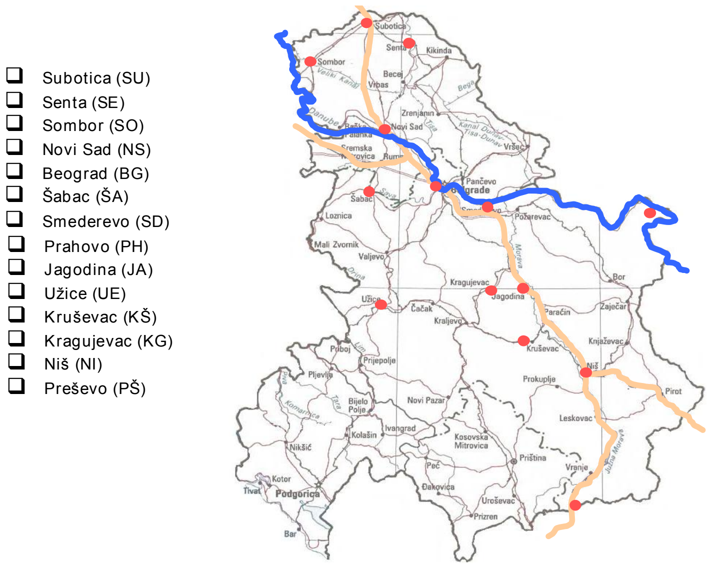


*Fig. 2 – Potential locations of intermodal terminals*

### 3.1.2 Intermodal Transport Flows Volumes in Serbia for 2015.

Development of the intermodal transport in Serbia for 2015 depends on several direct and indirect factors. However, impact of some factors is very difficult to be analyzed, particularly for the case of their future behavior. Also, numerous obstacles come from the fact that statistical data from the previous periods are not reliable nor relevant. Because of that, and because of limited availability of relevant data (especially those related to the intermodal transport flows), the estimates for the intermodal transport development were done on the basis of economic development of Serbia for 2015, and estimates for the intermodal flows in European countries.

Results of analysis gave 57 different volumes for the total intermodal transport flows ranging from 58490 to 264891 TEU, with 131756 TEU as the mean value.

Based on results of statistical analysis of those 57 values, as the most probably are observed those between 80000 and 160000 TEU, "covering" almost 72% of all estimated values. From there, in the quantitative analysis three alternatives of intermodal transport flows were used:

- *Pessimistic alternative for the import/export flows volume- 80000 TEU*
- *Realistic alternative for the import export flows volume- 120000 TEU*
- *Optimistic alternative for the import export flows volume- 160000 TEU*

### 3.1.3 Distribution of Flows across Inbound/Outbound Directions

Distribution of flows across inbound/outbound directions was determined on the basis of present average annual share of import-export flows, where transport statistics for 2002., were used as a basis.

All of source/destination countries are divided into four groups, based on their participation in total flows, and distances. The first group comprises two countries (Italy and Germany), in the second are exYU countries, third group comprises overseas countries (Canada, USA, Africa, Asia, Australia and other countries), and all other countries are in the fourth group. Participation of groups in total flows is described by uniform distributions for each group of countries, but with different parameters. Participation of flows inside each group is divided between each group member, except for the first group, accordingly to probabilities assumed.

In the first group, participation of Italy is assumed to follow Uniform distribution between 44 up to 66%, and what remains to 100% is participation of Germany.

Second group represents all countries arose from the former Yugoslavia without further separation of flows.

Third group covers overseas countries, and has Port Koper as a source/destination point. All effects are calculated for this node, since even now overseas flows are containerized. Flows intensities to different directions inside the same group are shared equally.

The fourth group has five distance classes:

1. *Countries on distance about 400km (Bulgaria, Hungary)*
2. *Countries on distance about 600km (Austria, Slovakia, Romania)*
3. *Countries on distance about 900km (Greece, Poland, Czech, Other European countries)*
4. *Countries on distance about 1500km (Ukraine, France)*
5. *Countries on distance about 2000km (Russia, Other EU countries)*

Specific origin/destinations inside the certain group were not considered individually, but they represented by the centers of larger zones, rested to the certain intermodal terminal (Fig. 3). Depending on the source/destination country, zone radius was between 50 and 300km, depending on the density of intermodal terminal network in certain area. In the same time, that distance was used for the "last leg" transportation costs calculation realized by road transportation.

Here, it is important to be noted that mentioned ranges of values were used in simulation, while p-HUB models application was based on their average values.

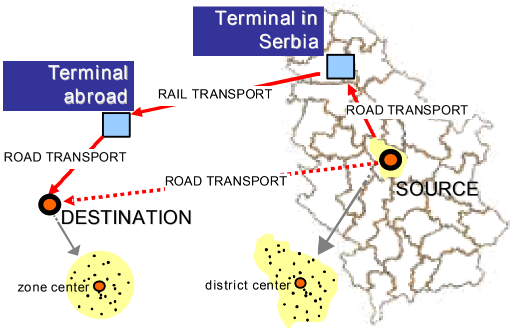


*Fig. 3 – Concept used for source/destination nodes defining*

3.1.4 Distribution of Flows across Districts in Serbia

Similarly to introduction of the uncertainty in the distribution of flows over relations, perspective share between Serbian districts in the total export/import intermodal flows was also considered as stochastic values.

Based on the analysis so far and similar studies, it was noticed that the districts in Serbia can be clustered into 4 groups according to their size, GDP, degree of development, etc. Thus, the first group comprises Belgrade district. The second group comprises some of less developed districts in Vojvodina and the district of Nis. The third group consists of still less developed districts and the fourth group underdeveloped districts.

In the simulation, the staring assumption was that the district of Belgrade will keep the leadership position regarding the development in the time period of up to 2015, but that changes in the relative degree of development among the districts are possible. Regarding the districts in the groups II and III, certain probability that districts from the group II can go over to the group III, and vice versa was supposed. Beside that, it was supposed that the changes in the relative degrees of development among districts in the groups II, III, and IV are also possible.

Hence, the approach to the simulation was two-phase approach. In the first phase, it was simulated change among the groups. In the second, it was simulated change of relative share of a specific district in the total transport flows.

In the simulation, the probability for a district to go from the group III over to the group II is fixed to 35%, and the probability that the two districts will change the status in the given time frame (of up to 2015) is fixed to 5%. Similarly to the previous group of input values, p-HUB models application was based on average values.

In this way, the internal distribution of flows over distances and quantities is also taken into account and one more step is made in avoiding traps of mirroring of the existing relations into the future.

Similarly to the zone concept applied to origin/destinations abroad, sources and delivery points inside Serbian districts were not considered individually as well (Fig. 3). They've been represented by the matched districts centers. In this way, average distance inside a districts was used as a measure for the "first leg" transportation costs, realized by road transportation, and intermodal flows volume were related to the district as a whole.

### 3.1.5 Demand Elasticity and Terminal Catchments Area

Based on the similar studies, in the simulation model is adopted small impact of the number of terminals on the increase of demand for intermodal transport. It is assumed 2-3% for increase of flows volumes when number of terminals increase from 6 to 14.

The definition of terminal gravity zone, in case of simulation approach was based on the premise that the volume of transport flows which gravitate to the specific terminal is inversely proportional to the distance to that terminal.

In case of p-HUB models, districts allocation was realized on the base of minimal distance, having in mind that the first formulation permits flows realization between districts and terminals independently from distance, while the second formulation restrained flows from distances larger than the gravity zone radius.

### 3.1.6 Transport tariffs and transport operation times

Transport tariffs and operational times used in the transport processes are based on real market prices and tariffs of transport service providers as well as on the realistic estimates of operation times.

In the analysis, the ratio of costs of road and railway transport had been varied. The analysis run for the current costs ratio of of road and railway transport, as well as for other two alternatives: when the railway costs are decreased for 20%, and for 30%.

### 3.1.7 Data related to the transport system environmental impact

The data needed, as well as the related methodology are adopted from the web portal „Environment, Energy, and Transport PORTAL" (www.eu-portal.net).

## 4. Simulation modeling approach

Simulation model used has developed with aim to observe impact of uncertainty in input data, through the analysis of three groups of stochastic values:

- Stochastic distribution of import – export flows between terminals in Serbia and destinations abroad. – Transport flows between all OD pairs were classified into four groups. In the first step the model simulates participation of each group, and then simulates transport flow for source or destination country inside the group. In this way, in fact, realization of two-dimensional quantity-distance distribution is simulated. In the same time, the problem of current state replication is also avoided, since flows intensities, and distance patterns are not in fixed proportion, but defined by ranges of stochastic variables parameters.
- Stochastic distribution of import – export flows between terminals and regions in Serbia. – Transport flows between all those OD pairs were also classified into four groups. In the first step the model also simulates participation of each group, and then simulates transport flow between source or destination region inside the group, and the terminals which pull up flows in predefined proportion, having in mind terminal type (container, huckepack, Ro-Ro). However, position of the region in the certain group isn't fixed, and region can move from the current group to the group with the lower or higher level (in sense of flows intensity, which means economical increase, or decrease for the region) with the certain probability. In this way, in fact, realization of two-dimensional quantity-distance distribution is simulated again. Similarly to the previous concept current state replication is avoided as well, since flows intensities, and distance patterns are not in fixed proportion, but defined by ranges of stochastic variables parameters. In this case related to geographical positions of regions, and stochastic flows intensities between regions and terminals.
- Stochastic distribution of intermodal technologies participation in total transport flows (containers, hucke-pack, Ro-Ro)

From there, the model may be considered as a tool that can give as reliable as possible basics to estimate effects of intermodal terminals development. Because ranges of stochastic input values are used, results obtained – effects, are also given as ranges of output values.

The central part of the model was the module in which effects of application both traditional, and intermodal transportation chains are calculated. Namely, for each pair of source-destination points, where transportation distance and transport flow volume are randomly generated from previously defined probability distributions, six performances are calculated: costs of road and intermodal transportation, transit times of road and intermodal chain, and pollutant emissions for those two concepts of transport chains realization. Those performances were calculated for ten predefined potential terminal location scenarios:

- *Four alternatives, based on the idea of having one to three bimodal and/or trimodal terminals located in the strong economic centers. Following four alternatives were analyzed: {BG}; {BG,NS}, {BG,NI}, and {BG,NS,NI}*
- *Two alternatives, based on the idea of having six bimodal and/or trimodal terminals located in the vicinity or along Corridors VII and X. Following alternatives were analysed: {BG,NS,NI,SU,SD}, and {BG,NS,NI,SU,SD,UE}.*

- *Four alternatives, based on the idea of having twelve to fourteen bimodal and/or trimodal terminals located in the economic centers. Following alternatives were analysed: {BG,NS,NI,SU,SD,SE,SO,ŠA, JA,PŠ,UE,KG}, {BG,NS,NI,SU,SD,SE,SO,ŠA,JA,PŠ,UE,KG,PH}, {BG,NS,NI,SU,SD,SE,SO,ŠA, JA,PŠ,UE,KŠ,PH}.*

Beside different location scenarios, by the concept of the simulation model that has been realized in VBasic 6, and MS Excel software, additional possibilities for analyzing different transport volumes scenarios, as well as different tariffs, and other parameters modification have been also provided.

The main concept of the simulation model in simplified form is shown in Fig.4 below.

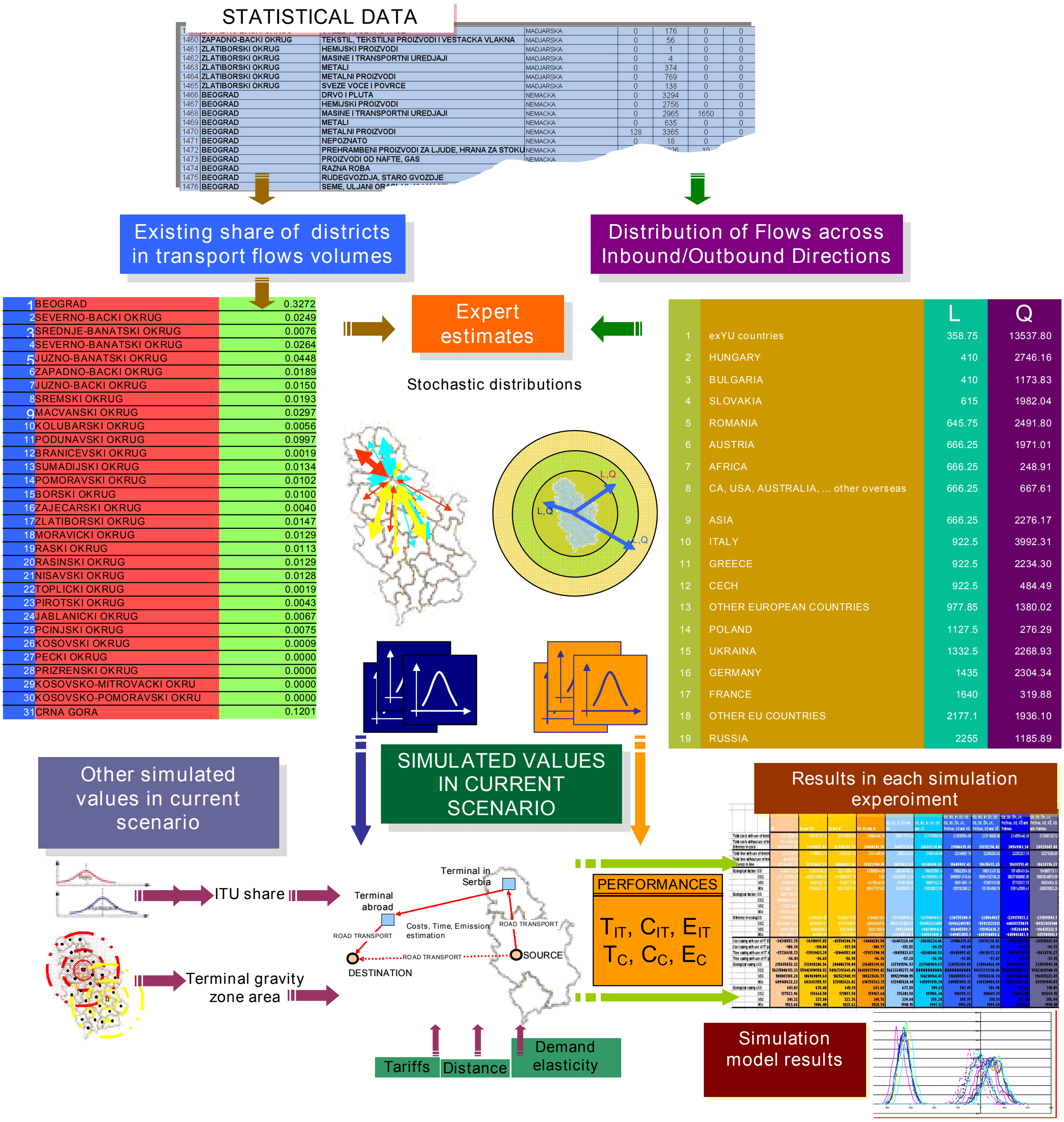


Fig. 4 – Logic of the simulation model in simplified form

## 5. Multiple assignment p-HUB network location model

As it is mentioned before, linear programming model for locating intermodal terminals was based on the idea of multiple assignment hub-network designing approach, described in (O'Kelly et al., 1996).

However, this model had to be modified accordingly to the objective of finding optimal locations of intermodal terminals only in Serbia, while locations of terminals abroad was known. Having that in mind, mentioned approach had to be reformulate as it is shown below.

$$Z = \sum_{i \in O} \sum_{j \in D} \sum_{k \in H} W_{ij} (C_{ik} + C_{kj} + C_j) \cdot X_{ijk} \rightarrow \min \qquad (1)$$

subject to:

$$\sum_{k \in H} X_{ijk} = 1 \quad ,\forall i \in O, j \in D \qquad (2)$$

$$X_{ijk} - Y_k \leq 0 \quad ,\forall i \in O, j \in D, k \in H \quad (3)$$

$$\sum_{k \in H} Y_k = p \quad ,Y_k \{0,1\} \qquad (4)$$

where:

p – number of hubs to be opened

$W_{ij}$ – flow from origin i to destination j

$C_{ik}$ – transport costs of the first leg per unit of flow (from origin i to hub k)

$C_{kj}$ – intermodal transport costs per unit of flow (between hub k and terminal close to the destination j)

$C_j$ – transport costs of the second leg per unit of flow (from terminal near the destination j to destination j)

$X_{ijk}$ – fraction of flow from origin i to destination j routed through the hub k

$Y_k$ – binary variable, $Y_k$=1 if hub k is opened, otherwise $Y_k$=0

Constraints (2) ensures that the flow between every origin-destination pair (i,j) is routed via some hub. Constraints (3) ensure that the O-D flows are only routed via locations that are hubs, and constraint (4) specifies the number of hubs to be opened.

Expressions given by Eqs. (1) ~ (4) formulate multiple assignment p-HUB network location model without respecting any terminal gravity zone. To make problem much closer to reality, by including terminal gravity zones, previous formulation is modified by adding one more group of constraints, and by changing constraint (4) in the form given by Eq. (6). Hence, multiple assignment p-HUB network location model which respects terminal gravity zone of radius $R_k$ can be formulated by using Eqs. (1) ~ (3), and by adding following two constraints given by Eq. (5), and Eq. (6).

$$(d_{ik} - R_k) \cdot X_{ijk} \leq 0 \qquad (5)$$

$$\sum_{k \in H \cup \{D\}} Y_k = p + 1 \quad ,Y_k \{0,1\} \qquad (6)$$

where:

D – dummy node

$d_{ik}$ – distance between the from origin i to hub k, ($d_{iD} \approx 0$)

$R_k$ – radius of the gravity zone for hub k

Dummy node was included to collect transport flows from districts are on the distance greater than $R_k$, from any opened hub (terminal node). In this way it was possible to ensure that the flow between every origin-destination pair (i,j) is routed via some hub, as it is stated by constraint (2). Transport costs via the dummy node are chosen to be large enough to prevent directing flows through this hub, except in the case when there is no other node to be used, regarding the constraint given by Eq. (5). To solve multiple assignment p-HUB network location models, shown formulations were adopted to LPsolve IDE v5.1 which is under GNU license.

## 6. Computational results

In this paper only main results, and conclusions are shown, with objective to illustrate both of solution approaches used. More wider set of results with more detailed analysis is presented in the project (IMOD-X, 2006).

### 6.1 Results obtained by simulation model

The results of quantitative analysis of effects of development of the intermodal terminals obtained by simulation model are shown in the following figures and tables. These results are obtained under the supposition of three scenarios of transport flows volumes for 2015- 80 000, 120 000, and 160 000 TEU.

The results in the table are presented in the form of unit effects, i.e. total effects divided with the total volume of goods, expressed in tones, accordingly to the authors opinion that simplest way to understand effects is when they are expressed in this way.

On the following figures and tables, it is obvious that the development of intermodal transport for the current ratio of costs of road and railway transport is not justifiable from the economic point of view. However, development of intermodal transport becomes economically justifiable with the decrease in the railway transport costs for 20% or more.

Note that nominal economic effect can be simply calculated from the given unit effects, as product of tones volumes in scenarios, and those unit effects.

Simulation model results (Fig. 5, and Tab. 1) show that the best economic effects are achieved with the development of terminals in Belgrade, Novi Sad and Nis. The second best location scenario in the case of economic effects is the location scenario with the terminals in Belgrade, Novi Sad, Nis, Subotica, Smederevo, Senta, Sombor, Sabac, Jagodina, Presevo, Uzice, and Krusevac, which may be explained with the demand growth when number of terminal increases. However, closer analysis of these results reveals high sensitivity of outputs on the selection of input values.

It is worth mentioning that the greater number of terminals assumes greater initial infrastructure investments. If the necessary investments are provided from the state and taxpayers (state budget), the size of infrastructural investments then needs to be considered as an additional criterion in the process of selection of the best location scenario. On the other hand, if the results of this analysis are to be understood as a basis for creation of necessary conditions (e.g. legal, urban, etc.) for development of terminals on specific locations, then infrastructural investments of potential logistic providers can not be taken as an additional criterion in the process of selection of the best location scenario.

Finally, the two aforementioned location scenarios are very close to the best in terms of the time saving and environmental effects.

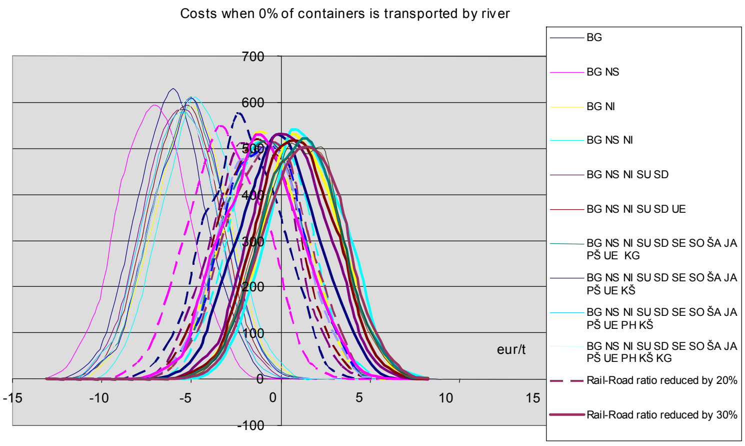


*Figure 5. Results of the analysis of economic effects*

Table 1. Average effects of implementation of intermodal transportation – simulation model output

| Location scenario | Average values of cost savings (eur/t) | | | | | | | | | Average time savings (hour/t) | | | Average savings in emission (g/t) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current ratio of Rail/Road tarrifs | | | Ratio of Rail/Road tarrifs reduced by 20% | | | Ratio of Rail/Road tarrifs reduced by 30% | | | | | | CO | | | NOx | | | VOC | | |
| | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river | 0% cont lows by river | 5% cont lows by river | 10% cont lows by river |
| BG | -6,6 | -6,7 | -6,8 | -2,2 | -2,4 | -2,5 | -0,1 | -0,2 | -0,4 | -3,37 | -3,38 | -3,39 | 49,7 | 49,6 | 49,6 | 26,2 | 26,1 | 26,1 | 130,2 | 129,9 | 130,0 |
| BG, NS | -7,6 | -7,7 | -7,8 | -3,2 | -3,4 | -3,5 | -1,1 | -1,2 | -1,4 | -3,39 | -3,40 | -3,41 | 48,4 | 48,3 | 48,3 | 25,5 | 25,4 | 25,4 | 126,5 | 126,2 | 126,3 |
| BG, NI | -5,5 | -5,6 | -5,7 | -1,0 | -1,2 | -1,2 | 1,2 | 1,1 | 1,0 | -3,41 | -3,41 | -3,42 | 52,3 | 52,2 | 52,2 | 27,5 | 27,4 | 27,4 | 137,4 | 137,0 | 137,2 |
| BG, NS, NI | -5,1 | -5,1 | -4,9 | -0,6 | -0,7 | -0,6 | 1,5 | 1,6 | 1,5 | -3,39 | -3,38 | -3,38 | 52,7 | 52,6 | 52,6 | 27,7 | 27,6 | 27,6 | 138,5 | 138,2 | 138,3 |
| BG, NS, NI, SU, SD | -6,2 | -6,3 | -6,3 | -1,6 | -1,8 | -1,9 | 0,5 | 0,5 | 0,3 | -3,39 | -3,40 | -3,41 | 51,0 | 50,8 | 50,9 | 26,9 | 26,8 | 26,8 | 133,9 | 133,5 | 133,6 |
| BG, NS, NI, SU, SD, UE | -5,9 | -5,9 | -5,8 | -1,3 | -1,4 | -1,4 | 0,8 | 0,9 | 0,8 | -3,40 | -3,39 | -3,40 | 51,6 | 51,4 | 51,5 | 27,2 | 27,1 | 27,1 | 135,5 | 135,1 | 135,3 |
| BG, NS, NI, SU, SD, SE, SO, ŠA, JA, Preševo, UE, KG | -5,7 | -5,7 | -5,6 | -1,0 | -1,1 | -1,1 | 1,1 | 1,2 | 1,1 | -3,40 | -3,40 | -3,40 | 51,8 | 51,7 | 51,7 | 27,4 | 27,3 | 27,4 | 136,5 | 136,1 | 136,2 |
| BG, NS, NI, SU, SD, SE, SO, ŠA, JA, Preševo, UE, KŠ | -5,7 | -5,7 | -5,6 | -1,0 | -1,1 | -1,1 | 1,2 | 1,2 | 1,1 | -3,40 | -3,40 | -3,40 | 51,9 | 51,7 | 51,8 | 27,4 | 27,3 | 27,4 | 136,6 | 136,2 | 136,3 |
| BG, NS, NI, SU, SD, SE, SO, ŠA, JA, Preševo, UE, KŠ, Prahovo | -5,8 | -5,9 | -5,8 | -1,1 | -1,2 | -1,2 | 1,1 | 1,1 | 1,0 | -3,41 | -3,41 | -3,41 | 51,8 | 51,7 | 51,7 | 27,4 | 27,3 | 27,3 | 136,4 | 136,0 | 136,1 |
| BG, NS, NI, SU, SD, SE, SO, ŠA, JA, Preš. UE, KŠ, KG, Prahovo | -5,4 | -5,5 | -5,4 | -0,8 | -0,9 | -0,9 | 1,4 | 1,4 | 1,3 | -3,41 | -3,41 | -3,41 | 52,2 | 52,1 | 52,1 | 27,6 | 27,5 | 27,6 | 137,6 | 137,2 | 137,3 |

6.2 Results obtained by p-HUB modelling approach

Results of analysis obtained by using both formulated p-HUB network location models that show optimal locations for any of p≤14 terminals are shown in the Tab. 2. Terminal gravity zone has the radius of 100 km.

Table 2. Results of p-HUB network location models

| p-HUB model | NUMBER OF TERMINALS TO BE OPENED | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Without terminal gravity zones | BG | BG,NI | BG,NI, NS | BG,NI,NS, UE | BG,NI,NS, UE,SD | BG,NI,NS, UE,SD,JA | BG,NI,NS, UE,SD,JA, SE | BG,NI,NS, UE,SD,JA, SE,ŠA | BG,NI,NS, UE,SD,JA, SE,ŠA,SO | BG,NI,NS, UE,SD,JA, SE,ŠA,SO, PŠ | BG,NI,NS, UE,SD,JA, SE,ŠA,SO, PŠ,KŠ | BG,NI,NS, UE,SD,JA, SE,ŠA,SO, PŠ,KŠ,SU | BG,NI,NS,UE, SD,JA, SE,ŠA,SO,PŠ, KŠ,SU,KG | BG,NI,NS,UE ,SD,JA, SE,ŠA,SO,PŠ ,KŠ,SU,KG,P H |
| With terminal gravity zones | NS | NS,BG | NS,BG,KŠ | NS,BG,KŠ ,PŠ | NS,BG,KŠ ,PŠ,PH | NS,BG,KŠ ,PŠ,PH,UE | NS,BG,KŠ ,PŠ,PH,UE ,NI | NS,BG,PŠ, PH,UE,NI, SD,SE | NS,BG,PŠ, PH,UE,NI, SD,SE,ŠA | NS,BG,PŠ, PH,UE,NI, SD,SE,ŠA, KŠ | NS,BG,PŠ, PH,UE,NI, SD,SE,ŠA, KŠ,SO | NS,BG,PŠ, PH,UE,NI, SD,SE,ŠA, KŠ,SO,JA | NS,BG,PŠ,PH, UE,NI,SD,SE, ŠA,KŠ,SO,JA, SU | NS,BG,PŠ,PH ,UE,NI,SD,S E,ŠA,KŠ,SO, JA,SU,KG |

In the case of applying LP optimization approach, objective function is monotonous decreasing with increase of number of nodes, as a consequence of transport distance decreasing, and because costs of opening terminals were not considered. In the same time, another reason of monotonic objective function lies in fact that optimization approach didn't respect increase of flows volumes when number of terminals increase from 6 to 14 as in the simulation model.

Optimization approach gives, also, additional opportunity for analysis of percentage of flows which could be realized in case of gravity zones existence. In the same time, inbound/outbound flows to/from districts which are not allocated to any of opened terminals, have to be realized by direct road transportation, that will increase transportation costs. Tab. 3 shows results of that analysis.

Table 3. Impacts of terminal gravity zone impact

| No. of HUBS | Transport costs in case when gravity zones don't exist [mil. EUR] | Transport costs in case when gravity zone exists [mil. EUR] | Percentage of flows realized through terminals, when gravity zone exist [%] | Transport costs of direct road transportation [mil. EUR] | Total costs of road and intermodal transportation [mil. EUR] |
|---|---|---|---|---|---|
| 1 | 107.27 | 57.01 | 54 | 55.16 | 112.17 |
| 2 | 101.28 | 73.73 | 78 | 28.92 | 102.65 |
| 3 | 98.53 | 80.63 | 85 | 20.53 | 101.16 |
| 4 | 97.56 | 83.60 | 88 | 16.68 | 100.28 |
| 5 | 96.90 | 85.95 | 90 | 13.92 | 99.87 |
| 6 | 96.46 | 87.54 | 92 | 11.59 | 99.13 |
| 7 | 96.17 | 87.08 | 92 | 11.35 | 98.43 |
| 8 | 95.98 | 86.80 | 92 | 11.35 | 98.15 |
| 9 | 95.81 | 86.60 | 92 | 11.35 | 97.95 |
| 10 | 95.65 | 86.43 | 92 | 11.35 | 97.78 |
| 11 | 95.52 | 86.26 | 92 | 11.35 | 97.61 |
| 12 | 95.42 | 86.12 | 92 | 11.35 | 97.47 |
| 13 | 95.37 | 86.02 | 92 | 11.35 | 97.37 |
| 14 | 95.36 | 85.93 | 92 | 11.35 | 97.28 |

It is interesting to be noted that in case when the radius of gravity zone is 100 km, it is possible to serve only 92% of estimated demand, and this can be done with six opened terminals. However, this proportion isn't change even in case of 14 opened terminals. Of course, very important question is the accuracy of the gravity zone radius, but LP modelling approach gives powerful tool for further analysis.

Performances of the p-HUB network location model, solved by LPsolve IDE v5.1, Windows version, on the AMD Turion 64 Mobile technology 1.6 GHz, are shown in Tab. 4.

Table 4. Computational performances

| p-HUB model | | No. of variables | No. of constraints | Number of iterations | Processing time [sec] |
|---|---|---|---|---|---|
| Without terminal gravity zones | p=14 | 7392 | 7906 | 548 | 0.984 |
| | p=1 | | | 2650 | 6.282 |
| With terminal gravity zones | p=15 | 7920 | 8433 | 549 | 0.828 |
| | p=2 | | | 1514 | 3.156 |

## 7. Conclusion remarks

In this paper two modeling approaches to solving intermodal terminals location problem were developed, and applied on the real problem. Results obtained show that both approaches can be used as a tool which may help in making decision on the optimal locations of terminals. Beside that, paper also presented main concepts used in the process of input data estimation, which was probably the most complex part of the research conducted during the IMOD X project realization. Quality of results obtained through application both of approaches show that databases which are developed give good foundation for the analysis, although results of analysis will be much more reliable if a comprehensive analysis of transport flows is done, since comprehensive analysis of transport flows in Serbia was not done in the last 15 years.

Simulation model proposed calculates three kinds of logistics performances for defined location scenario: costs, time, and emission effects in case of realization both, traditional and intermodal transport chains.

Optimization model is based on two LP formulations: which respect terminal gravity zones, and which neglect zones. It is shown that both formulations give very good results in short time, and from there can be used for comprehensive analysis. Of course, although results obtained are encouraging, there are several possible directions in further research. One should be related to additional analysis of demand, while other should be induced from the improvements in modeling approaches, which may include even multicriteria analysis, particularly because of different nature of logistics performances that are used in different scenarios and solutions evaluation.

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# POLICY ANALYSIS MODEL FOR THE BELGIAN INTERMODAL TERMINAL LANDSCAPE

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## Abstract

*During the last decade a variety of investments were diverted towards promoting intermodal transport in Europe, including Belgium. Today over ten intermodal barge terminals are operational in Belgium and new projects are underway. This paper analyses the location of these new terminals and the impact on the market area of the existing ones by the use of a GIS network model, consisting of the inland waterways and road networks. Considering the current freight data and transport prices, market potentials of terminals and impact of the new terminals on the existing ones are shown. Furthermore, simulations are developed in order to analyze the impact of different policy measures like price differentiations and the internalization of the externals costs.*

Keywords: Intermodal policies, Location analysis, Network model, GIS

## 1. Introduction

Europe has witnessed a significant growth in freight transport over the past thirty years, mainly parallel to its economic growth. Considering the last decade between 1994 and 2004, volume of freight transport increased with 28 per cent (Eurostat, 2005). Unfortunately, the reflection of this growth on individual transport modes is not even. As seen in Figure 1, the domination of road transport and maritime transport is coupled by a stable inland waterway transport and a slight recovery in declining railway transport. The increase in market share of road transport is explained by its growth rate above the growth rate of total freight transport.

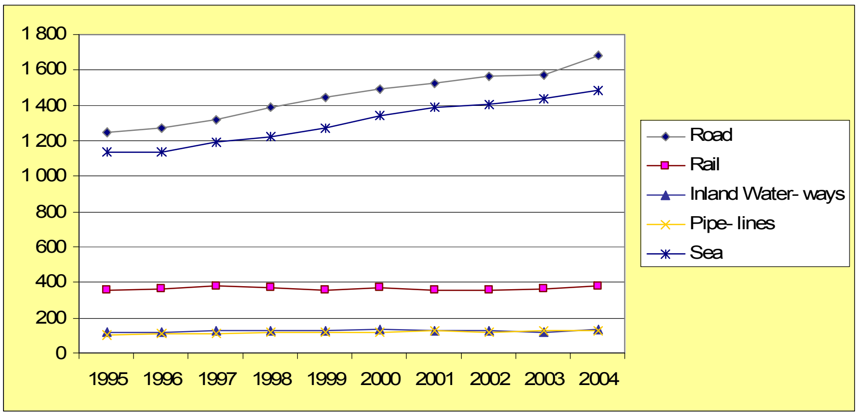


Figure 1: Performance by Mode for Freight Transport EU-25 (Eurostat, 2005)

Throughout history, transport has served to and evolved with humans. The uneven development in transport by the evolution of road freight transport lead to various problems with its external costs, such as pollution, climate change and accidents. Today, the socio-economic environment that the transport is serving has altered and will keep changing continuously. Transport has to face these challenges by providing proper product requirements through sophistication. In general there is a need for meeting the growing expectations on transport services and at the same time reducing its negative effects on the society, which can be accomplished by a modal shift. Unfortunately a shift in modal split will not happen by itself (Vrenken et al., 2005).

Within this business environment, intermodal transport will find its market niche as a tool to have a balance between transport modes by directing freight transport from road to rail, inland waterways and short sea shipping. According to a recent overview of the external effects of intermodal transport against road transport, intermodal transport is more environmental friendly than unimodal road transport in most cases and can help reducing congestion (Kreutzberger, et al., 2004).

During the last decade, under the supervision of the European Commission and with the help of government programs, many terminal investments were conducted in Belgium. These capital intensive transport investments can

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be evaluated for future situation of intermodal transport with policy analysis tools, including a geographic information system (GIS) based network model.

The main objective of this paper is to develop this policy analysis model for the Belgian intermodal terminal landscape. Deriving from the importance of intermodal transport, the concept of transport policies is introduced. The core aim is to construct a GIS network model to analyze various policy options, such as the introduction of new terminals and price scenarios. The model comparing intermodal transport with unimodal road transport is a tool that can be used by policy makers to analyze the effectiveness of their policies.

This paper is split into five main parts. Following the introduction, intermodal transport is discussed in Part 2. The concept of policy analysis model is introduced in Part 3 along with our network model. Part 4 is summarizing the results of several scenarios and the impact of different policy measures. Finally general conclusions are drawn in Part 5.

## 2. Intermodal Transport

### 2.1 Definitions and characteristics of intermodal transport

The development of the intermodal freight transport sector is followed by an increase in myriad of academic research. Despite the prevailing interest on intermodal transportation by government and industry, a common definition of intermodal transport does not exist. In a broader horizon, intermodal transport systems involve more than one mode of transportation during a single seamless journey. Intermodal transport combines this multimodality with the use of load units (containers, swap bodies, etc). On the other hand, the European Conference of Ministers of Transport defines intermodal freight transport as "the movement of goods in one and the same loading unit or vehicle which uses successive, various modes of transport without any handling of the goods themselves during transfers between modes" (ECMT, 1993). In this paper intermodal transport will be defined as the combination of at least two modes of transport in a single transport chain, without a change of loading unit for the goods, with most of the route traveled by rail, inland waterway or ocean-going vessel, and with the shortest possible final journey by road (World Bank).

Figure 2 describes the intermodal transport process, which can be divided into three distinct operations: drayage, transshipment and long haulage. Drayage is done by road transport from the origin to the intermodal terminal and from the intermodal terminal to the final destination. Transshipment takes place in the intermodal terminals, moving the loading unit from/to truck to/from train/barge/ocean-going vessel. Finally, the long haulage between intermodal terminals is done by rail, inland waterways or an ocean-going vessel. The long haulage benefits from the economies of scale. But compared to this long haul leg of intermodal transport, drayage operations constitute a higher share of the total cost in intermodal transport. Therefore centrally planned operations pose an opportunity for relatively large cost savings (Morlok et al., 1995).

Figure 2: Intermodal transport process (Own setup)

A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is worthwhile to reveal the attractiveness of intermodal transport (Van Duin, 2003). Summarized in Table1, intermodal transport system is very important because of its environmental friendliness and its capacity to meet the expected transport growth in the future.

Table 1: SWOT analysis for intermodal transport (Van Duin, 2003)

| *Strengths* | *Weaknesses* |
|---|---|
| · Adaptation of capacity growth<br>· A low price per unit distance<br>· Environmental-friendliness<br>· Adaptable to new transport units<br>· Delivery reliability | · Detour factor by fixed railway system or waterway networks<br>· Always dependent on final delivery by truck<br>· Inflexible due to fixed time-schedules<br>· Extra transshipment is necessary |
| *Opportunities* | *Threats* |
| · Road transport will become soon more expensive due to restricted capacity of the roads<br>· Trans European Transport Networks | · Design of new turnaround technologies<br>· Skepticism (many projects have failed)<br>· Unknown, hence unpopular |

Intermodal transport systems include a variety of different transport modes like short sea shipping, inland waterways, rail and even air transport. Road transport is used only in pre or end haulage. Due to the globalization and the increase in international trade, more and more cargo is transported by sea. Thinking about the future, this cargo can very well be transported by road or other transport modes towards the hinterland of the seaports. Shipping can not exist without other modes. Inland waterways transport can benefit from this situation especially in countries that are abundant with inland waterways network, like Belgium. Short sea shipping and inland navigation can be integrated in the intermodal transport systems. Combination of the strengths of the two modes can be used in order to compete effectively for businesses (Marchal, 1995). Terminal design for a smooth functioning transport system is a top priority issue in increasing the flexibility of services provided, thus reducing the costs for customers.

### 2.2 Intermodal inland waterways transport

Inland waterways transport has certain advantages compared to other transport modes. First of all, its energy consumption per ton-kilometer of transported goods is 1/6 of the consumption on the road and half of that of rail transport. Furthermore, the total external costs of inland waterways transport in terms of accidents, congestion and both air and noise pollution are 7 times lower than those of road transport (EC Website). Directly linked to the economies of scale, one Europa ship[1] transports the same load as 50 railway wagons or 60 lorries (Van Duin, 2003). Lastly, inland waterways transport offers a safe journey especially for the transport of dangerous goods.

Cost is one the most vital criterion in defining the competitiveness of a service. This is also valid in transport sector; a transport solution is only attractive and sustainable, if it contributes to reducing the total logistics costs (Vrenken et al., 2005). A detailed cost model can be developed in order to determine the costs of transshipment, cargo handling equipment, ground, and personnel requirements at a terminal (Van Ham and Van Duin, 1997). In theory, the sum of the costs of the different services in the transport chain makes the intermodal transport costs. Figure 3 depicts the cost structure of intermodal transport, which is composed by the following costs:

- *Main haulage:* Rail, inland waterways or short-sea shipping.
- *Pre and end haulage:* Road transport between the terminals and the customers.
- *Terminal:* Handling and transhipment between the main haul vehicle and the truck.
- *The intermodal loading unit:* The transfer of a container.
- *Infrastructure:* Services and charges related to using the infrastructure.
- *Other:* Costs associated to all activities of chain management.

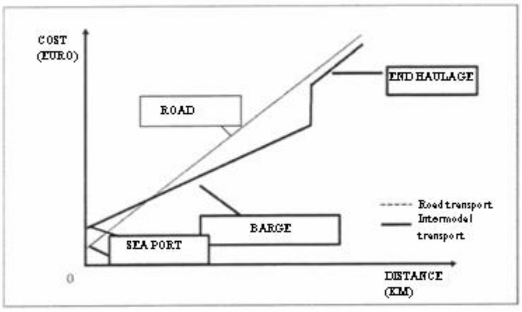


Figure 3: Intermodal cost structure (Macharis and Verbeke, 2004)

It has to be acknowledged that the costs (both fixed and the variable costs) charged for the pre/end haulage differs from the ones in the main haulage. In short distance, pre/end haulage costs are defined more by time rather than distance.

## 3. Policy Analysis Model

Intermodal transport has been promoted at various policy levels especially over the last decade. These policy levels include the European, national and regional level with the aim of contributing to the modal shift by diverting freight from road to the other transport modes like inland waterways. Authorities seek to have well calibrated evaluation methods to analyze various policy options to decide on vital transport investment projects, which have a direct strategic role in any countries' socio-economic development.

Looking back to the developments in research on freight transport models within a time scale; we observe simple models that are not sensitive for policy as a starting point in the seventies, when strong discussions on models in macro-economic level were conducted. In the eighties, larger models are developed with an attention to micro-economic level due to new theorems but were mostly qualitative. Later in nineties, models with practical usage were developed through various techniques such as simulations, data management and geographic information systems (GIS) but were lacking the necessary data to have a desired application (Tavasszy et al, 1998).

GIS technology is offering critical competence in transport policy analysis. The GIS allows processing and updating spatial data storage in transport modeling along with displaying results on visually attractive maps. Overall, transport model can be used as a decision support system in transportation planning and policy development (Arampatsiz et al, 2004). Intermodal transport also benefits from the GIS systems, which improves the realistic representation of the multi-modal transport network (Peng, 1997).

A GIS model, consisting of road network and inland waterways network, enables to see the impact of new terminals on the market area of the existing ones. Looking at the literature, the network approach is seen in the work of Rutten (1995), Arnold and Thomas (1999), Groothedde and Tavasszy (1999) and Macharis (2000). Both Rutten

[1] Europa ship: This ship is especially designed for the larger European rivers and canals. With the capacity of 1500tons, 85X9.50 meters ship is a standard for the future waterway network in Europe.

and Arnold and Thomas focused on rail and road intermodal transport. Possible locations for the intermodal terminals are analyzed and effects of these new terminals on the existing terminal landscape are evaluated. Groothedde and Tavasszy on the other hand seek to find the optimal locations of terminals. The model of Macharis on the location analysis model of Belgian intermodal barge terminals serves as a starting point for this research.

Reliable data is a requirement in order to have reliable results from the policy analysis model. Statistics from the National Institute of Statistics (NIS) are used in this analysis. NIS data are collected each year by a survey conducted among companies who are involved in logistics. Within the scope of this research, only containers from/to Antwerp from/to each Belgian municipality have been extracted.

As a second vital data, reliable transport costs were obtained by contacting transport companies. Costs for inland waterways transport are composed of a transshipment cost in the port of Antwerp to a barge, a fixed and a variable cost of intermodal long haul of the inland waterways transport and a transshipment cost in the inland terminal to a truck for the end haulage. Total intermodal transport cost is obtained by adding all of the fixed and variable costs.

The network model used in policy analysis is built upon two pillars: setting up the network and the cost function. In order to make a real world application for the analysis in this paper, a GIS network was set up by including three layers: inland waterways, road network and end haulage. The network for Belgium was obtained from the maps of TELE ATLAS from Dolmen. Figure 4 depicts the four layers of the network.

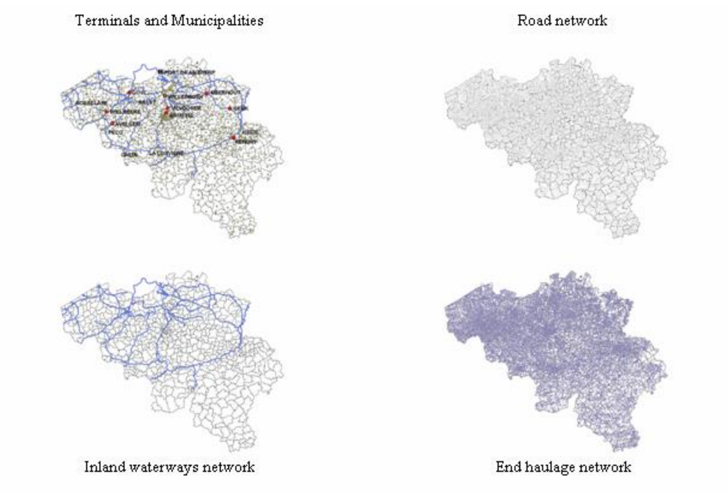


Figure 4: Network in Arc/GIS (Own setup)

As a second step, transport costs associated with unimodal road and inland waterways transport are included in the network. The variable costs for road, inland waterways and end haulage were uploaded by the calculate function in Arc/GIS to each network layer. The fixed costs are saved in stop-files, which indicate the origin and destination for each route.

Once the construction of the model is finalized, the shortest path algorithm[1] in Arc/Info was applied to conduct runs in order to find the shortest path and the attached transport costs from the port of Antwerp to each Belgian municipality via inland barge terminals. All possible routes were collected in stop-files for each municipality. Using Excel spreadsheets, unimodal road transport and intermodal transport costs are compared and the cheapest option is selected.

The data attributes are exported to Arc/GIS in order to highlight the market area of each inland barge terminal. These visualizations help us to see if a terminal has a market area compared to road transport. As a further step, the NIS data on the number of containers currently transported are matched with the municipalities in the market area of a terminal to derive the final potential of inland terminals.

The model enables to assess different policy options. First of all, the current terminal landscape will be obtained, which will be used as a reference point in the policy analysis. As a second step, six new terminals are added in to the network to analyze the effects of these new terminals on the existing terminal landscape.

The model also allows visualizing the effects of price scenarios. Table 2 lists the simulation of policy options applied in this paper. Policy A and Policy B is a reduction of the fixed cost of intermodal inland waterways transport. It is interesting to analyze the effects of more favorable transport costs of intermodal transport. In economics external cost refers to negative effects of an economic transaction. Estimated at about 8 per cent of EU GDP, the external costs of transport are very important especially for air pollution and climate change. There is a variation of the marginal external costs within transport modes depending on the type of vehicle used. With Policy C, internalization of the external costs is conducted to have a better idea about the effects of transport.

[1] In ARCINFO the algoritm of Dijkstra is used.

Table 2: Simulation of policy options

| Policy | Measure |
|---|---|
| Policy A | Price reduction of the intermodal inland waterways transport 12.5 Euro |
| Policy B | Price reduction of the intermodal inland waterways transport 25.0 Euro |
| Policy C | Internalization of the external costs |

## 4. Results Of The Analysis

In Figure 5, the current Belgian terminal landscape is visualized. The map summarizes the market area of each terminal by highlighting the municipalities that are surrounding the terminal if intermodal transport is more attractive compared to unimodal road transport based on the current market prices.

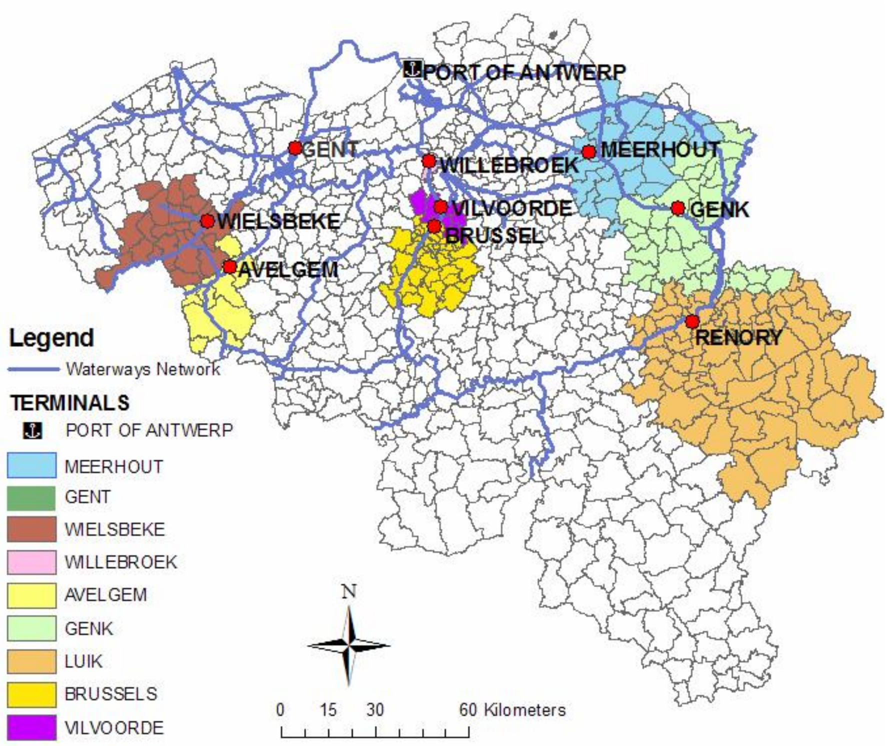


Figure 5: Market areas of the terminals: End of 2005

At the moment eleven terminals are operational in Belgium: WCT in Meerhout, AVCT in Avelgem, CT Gent in Gent, TCT in Willebroek, ECE in Luik, CCT in Grimbergen, BCT in Brussels, Trimodale Terminal in Genk, the RTW in Wielsbeke, Cargill in Herent and Gosselin in Deurne. The latter two have only one user at the moment, so are not included in our analysis.

As shown in Figure 5, all of the terminals except Gent have a market area. It is necessary to indicate that other modal choice criteria, apart from the price are also important, such as reliability, customer satisfaction and transport time. This model only takes account of the transport costs, and such can only give an indication of the real market area. The terminals in Renory, Brussels and Genk can reach several municipalities but the ones in Vilvoorde, Willebroek and Gent are not able to offer an attractive price compared to road transport and thus have smaller market area. Their proximity to the port of Antwerp limits them to profit more from the scale advantage of the inland waterways (see Figure 3).

Belgium, with its federal political system, constitutes a unique case for the transport policies. The recent developments in intermodal transport in Flemish region will be followed by intensive investments in Wallonia, which mainly are focusing on the construction of intermodal terminals.

Six new terminals are added into the network model in Figure 6. Four of these terminals are in the Walloon region. The terminal in Ghlin will be in operation by 2007 and the construction in La Louviere will be finished by 2009.

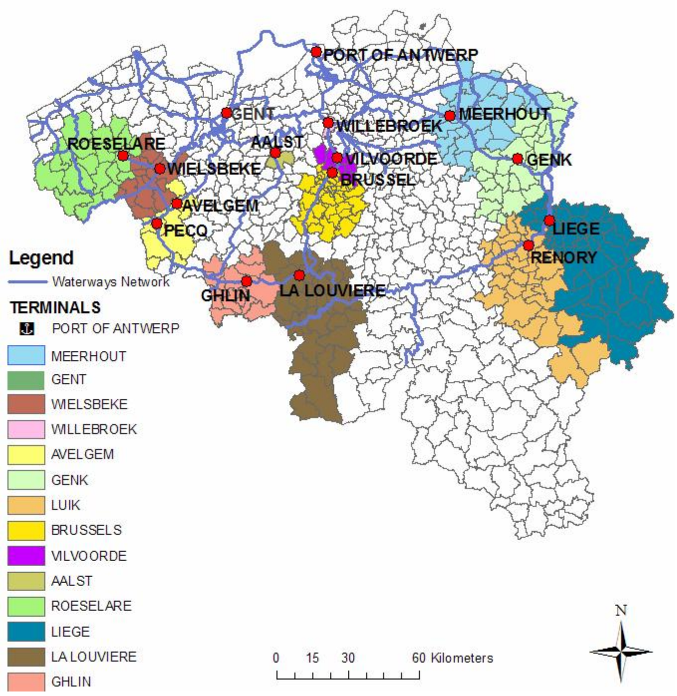

Figure 6: Market areas of the terminals: Future situation

A comparison of Figure 5 with Figure 6 leads to interesting results for the future situation in the Belgian intermodal landscape. A possible future situation concludes a 21 per cent increase in intermodal transport meaning a modal shift of 477,024 tons. The new terminals in Ghlin and La Loiviere will have a considerable market area, but when taking the current container traffic into the account, their final potential are lower compared to the terminals in the Flemish region (see table 3). The industrial activity in Flemish region is denser compared to the south Walloon region, leading to a lower amount of containers for a same number of municipalities. The new trimodal terminal investment in Liège brings another problem. As a result of its proximity to Renory and Genk, it will take market area from the two terminals. There is especially a common market area between Renory and Liege. This situation is also seen in Roeselare, which takes a market area from Wielsbeke. The terminal in Pecq is not able to take any market area. Pecq is only 12 kilometers away from Avelgem. Finally, the terminal in Aalst will have a small market area.

Table 3: Potential of the terminals: Future situation

| | THE NUMBER OF MUNICIPALITIES | VOLUME |
|---|---|---|
| Road | 327 | 9,157,744 |
| Meerhout | 22 | 380,405 |
| Gent | 0 | 0 |
| Wielsbeke | 17 | 653,991 |
| Willebroek | 2 | 215,587 |
| Avelgem | 11 | 106,427 |
| Genk | 24 | 227,819 |
| Renory | 32 | 161,929 |
| Brussels | 39 | 222,686 |
| Vilvoorde | 6 | 94,622 |
| Aalst | 1 | 63,271 |
| Roeselare | 21 | 251,578 |
| Liege | 40 | 139,891 |
| La Louviere | 32 | 159,238 |
| Ghlin | 15 | 93,071 |
| Pecq | 0 | 0 |
| TOTAL | 589 | 11,928,259 |

The Network model allows the simulation of several policy options including price reductions of the intermodal transport. In Figure 7, the two simulations of price reductions for intermodal transport are presented, respectively a total fixed cost reduction of the intermodal inland waterways transport by 12.5 Euro in the first scenario (I) and 25 Euro in the latter (II).

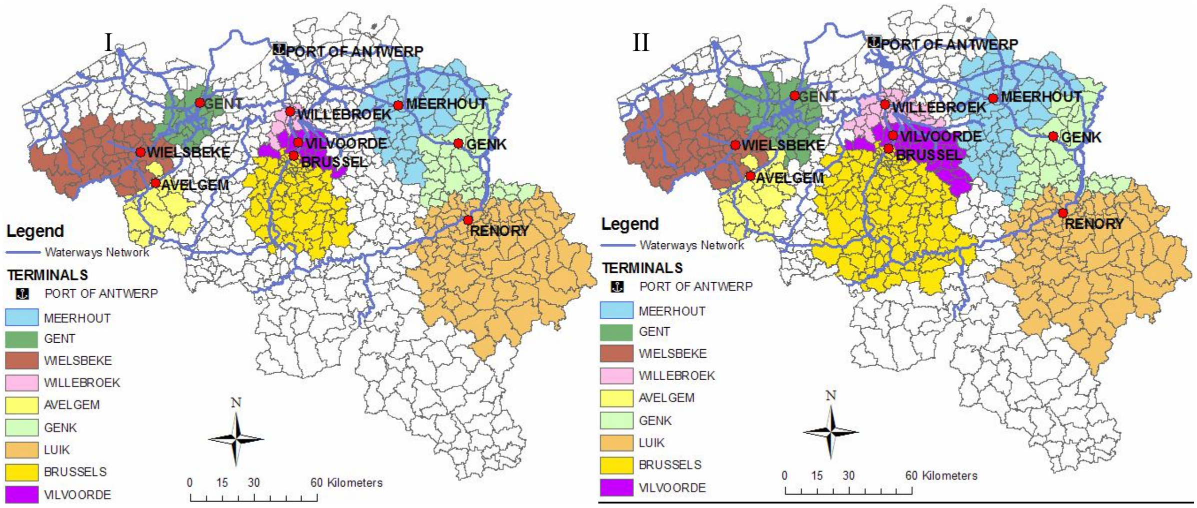


Figure 7: Market areas of the terminals: Price scenarios

There is a direct link between the cost and market area of intermodal transport. The policy options of price reductions results in an increase of up to 96 per cent market area for the intermodal transport. Theoretically, over 2 million tons can be shifted to intermodal transport with a reduction in the intermodal transport prices. The amount of increase is higher in Brussels and Renory, when considering the final potential of the terminals, as summarized in Table 4. Referring to the cost structure of intermodal transport, the decrease up to 25 Euro will cover the higher fixed costs of inland waterways leg of intermodal barge transport.

Table 4: Potential of the terminals: Policy A and B

| | REDUCTION OF 12.5 EURO | | REDUCTION OF 25 EURO | |
|---|---|---|---|---|
| | THE NUMBER OF MUNICIPALITIES | VOLUME | THE NUMBER OF MUNICIPALITIES | VOLUME |
| Road | 291 | 8,370,880 | 180 | 7,431,764 |
| Meerhout | 34 | 457,902 | 46 | 591,328 |
| Gent | 14 | 540,900 | 28 | 625,083 |
| Wielsbeke | 38 | 975,140 | 46 | 986,241 |
| Willebroek | 9 | 380,721 | 25 | 661,120 |
| Avelgem | 15 | 141,978 | 19 | 184,755 |
| Genk | 34 | 246,647 | 35 | 248,656 |
| Renory | 76 | 302,315 | 80 | 312,944 |
| Brussels | 65 | 385,344 | 105 | 674,636 |
| Vilvoorde | 13 | 126,432 | 25 | 211,732 |
| TOTAL | 589 | 11,928,259 | 589 | 11,928,259 |

The network model can also simulate the internalization of the external costs. The environmental costs of freight transport for each mode (De Vlieger et al., 2005), as seen in Table 5, were included in the network model for the years 2000 and 2010 to analyze the changes in the market areas of terminals.

Table 5: Marginal environmental costs of freight transport

| Year | Road 32-40 ton | Train | Barge |
|---|---|---|---|
| 2000 | 27,62 | 7,28 | 7,93 |
| 2010 | 15,22 | 5,98 | 6,86 |

Depicted in the upper two maps (I and II) in Figure 8, the current situation and the possible future situation with the current market prices are taken as a starting point. The left down corner (III) shows the internalization of the external costs with the values of marginal external costs in 2000 and the right down corner (IV) with the values of 2010.

Internalization of the external costs also point out a market area increase of 63 per cent with the prices of 2000 and 45 per cent with the prices of 2010 for intermodal transport. The external costs analysis is made from a future perspective by the inclusion of new terminals. Therefore it is necessary to take their effects on the future market area of terminals into consideration. There will be a 21 per cent increase in the market area of intermodal terminals when the new terminals are added into the model with the current market prices. After the external costs for each transport mode are taken into account, there is still an extension of the market areas. For instance with the internalization of 2010 external costs, an 11 per cent increase in the market areas of current terminals is noticed in addition to the effect of the new terminals. The final potential of the terminals are summarized in Table 6.

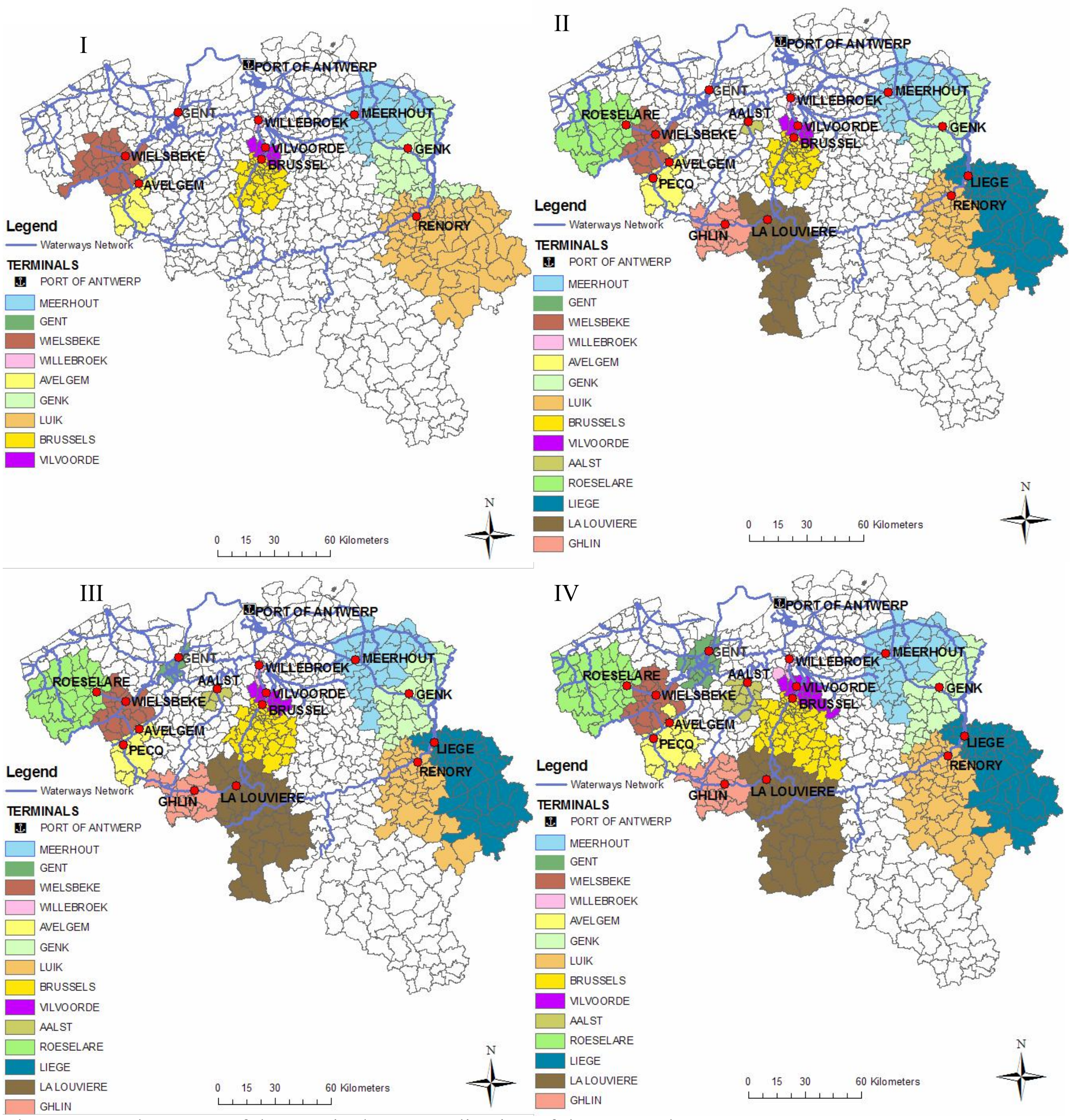

Figure 8: Market areas of the terminals: Internalization of the external costs

Table 6: Potential of the terminals: Policy C

| | (EXTERNAL COSTS 2000) | | (EXTERNAL COSTS 2010) | |
|---|---|---|---|---|
| | THE NUMBER OF MUNICIPALITIES | VOLUME | THE NUMBER OF MUNICIPALITIES | VOLUME |
| Road | 231 | 8,190,806 | 291 | 8,611,544 |
| Meerhout | 32 | 420,356 | 28 | 419,924 |
| Gent | 9 | 500036 | 1 | 423,840 |
| Wielsbeke | 20 | 667,541 | 19 | 658,802 |
| Willebroek | 4 | 242,789 | 3 | 221,858 |
| Avelgem | 15 | 141,978 | 12 | 101,832 |
| Genk | 27 | 232,892 | 26 | 227,819 |
| Renory | 45 | 186,866 | 35 | 161,929 |
| Brussels | 56 | 283,807 | 46 | 238,416 |
| Vilvoorde | 11 | 107,454 | 7 | 98,699 |
| Aalst | 10 | 79,066 | 3 | 74,053 |
| Roeselare | 26 | 287,525 | 24 | 255,781 |
| Liege | 40 | 139,891 | 39 | 139,891 |
| La Louviere | 45 | 349,804 | 39 | 196,423 |
| Ghlin | 18 | 97,448 | 16 | 97,448 |
| Pecq | 0 | 0 | 0 | 0 |
| TOTAL | 589 | 11,928,259 | 589 | 11,928,259 |

## 5. Conclusions

The significant growth in transport is an illustration of the importance of mobility in our daily lives. Unfortunately the growth in transport is uneven. This uneven reflection of transport growth on individual transport modes brings a threat for our globe from the point of view of sustainability. Continuously altering socio-economic environment constitutes a challenge for transport policy makers to face in the 21st century. In general, there is a need to meet the growing expectations on transport services and at the same time, reducing its negative effects on society, which can be accomplished by a modal shift.

Intermodal transport is one of the tools to tackle these problems. During the last decade many intermodal transport policies were formulated in Europe, including in Belgium. In intermodal transport policy, the choice of an optimal location for an intermodal terminal is a very important decision for the private investor as well as the government. The investor has to obtain a realistic idea of the traffic potential before investing any considerable amount of money into the projects. In this context, there is a need for policy analysis instruments to analyze possible policy options.

This paper aims to develop a policy analysis model for the Belgian intermodal terminal landscape. A GIS network model is constructed on the real road and inland waterways networks of Belgium. On the basis of real market prices of transport and the freight volumes that are currently transported on the road, the model is a realistic tool, capable of analyzing policy options.

The current terminal landscape was depicted and taken as a basis point. Policy options such as the introduction of new terminals and price scenarios, including a reduction of intermodal transport prices and the internalization of the external costs, were analyzed in the model. For each policy option, the network model was used to compare the total costs of unimodal road transport and the intermodal barge transport.

Some interesting remarks from the results include that when deciding on new terminal locations, individual policies on local and regional level can have a negative effect if one does not look over the borders (terminal in Pecq). Positioned too close to Flemish terminal Avelgem, this terminal investment in Wallonia is facing a clear disadvantage. Considering the price scenarios, a reduction in the intermodal transport prices leads to considerable increases in the market areas of the terminals but the intensity of the final potential depends on the industrial characteristics of the region. Investments in new terminal initiatives should be supported by such policies in order to stimulate the development of intermodal transport. Finally, if the external costs are internalized for each transport mode, intermodal transport is still gaining a market share compared to the current situation. Although road transport is gaining a relative advantage in external costs due to continuous technological improvements and more strict environmental norms, intermodal transport still has a potential to shift usage to the more sustainable modes in the future.

The policy analysis model, composed of a reliable network, transport prices and data is yet not a perfect one, thus has a room for improvement. The model can be progressed by considering other criteria apart from transport costs in determining transport mode choice and other transport modes such as rail transport and short sea shipping should be included in order to have the broader picture of the transport system.

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# PROMOTING INTERMODALITY IN HUNGARIAN TRANSPORT-LOGISTICS SYSTEM

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## Abstract

*The Hungarian transport policy has identified intermodal logistics as one of the tools enabling sustainable transport systems. At the same time logistics has become also an important factor of Hungarian economic policy. This is supported by the fact that logistics has been included into the key programs of the $2^{nd}$ Hungarian National Development Plan. The development of logistics service centers and combined transport solutions has been carried out for a decade. However, the improvement of intermodal logistics networks can not be considered as finished yet. The overall aim of this paper is to analyze the current situation of intermodality and logistics, identify development principles and elaborate policy packages/tools with special regard to their applicability under Hungarian circumstances. The analysis covers international as well as national trends and tendencies while the concrete recommendations are derived from best practices and also from former domestic experiences. The basic idea is to make advantages of Hungary's favorable geographical position – considering also environmental issues – by making available appropriate intermodal logistics infrastructures and services.*

*Keywords: Intermodality, Strategic planning, Logistics centers, Combined transport*

## 1. Introduction

The EU transport policy prefers to strengthen the co-operation between transport modes and rebalancing the modal split to the detriment of road transport. Intermodal transport-logistics solutions – connecting and integrating different kinds of goods transport – play a significant role in reaching these goals.

The share of transport-logistics sector in GDP is growing continuously (estimated share of EU GDP: 8-13%). It proves the fact that logistics has became one of the factors determining competitiveness. However, efficient logistics services can not operate without well organized, integrated transport chains. Intermodality means that more transport modes participate in door-to-door supply chains ensuring a high level of interoperability. In case of combined transport adequate loading units (e.g. containers, swap bodies, semi trailers) are handled without disrupting them during the whole process.

Developing and managing logistics services are the tasks mainly of private market actors. However, considering also the socio-economic impacts the public sector has to ensure a suitable regulation and promotion framework for complex logistics-supply systems using intermodal transport services.

## 2. Trends influencing the Hungarian transport-logistics system

International R&D projects have identified several trends influencing the future development of transport-logistics services. The most important trends are summarized in table 1. These factors and their effects will be determining for the Hungarian transport-logistics sector, too.

Due to the consequences of former tendencies further modal shift in favor of road transport can be anticipated in Hungary, mainly in the field of national goods movements. At the same time supply chain organization procedures contributing to consolidation of goods flows, furthermore hub and spoke systems operating extensive terminal networks emphasize the role of intermodality combining short distance road transport with long distance rail or waterborne transport, mainly in the case of international goods flows. Rail and inland waterway transport will also be viable when bulk goods are transported. Air transport may be applied by business sectors demanding fast and long distance movement of high value goods. It can be a great opportunity also for Hungarian companies e.g. operating in electronic machinery industry. Pipelines can be used for limited sorts of goods (e.g. oil, natural gas). The increase of their performance level can be anticipated only if the planned additional pipelines forwarding natural gas are built.

Figure 1 illustrates the modal split in goods transport in case of EU and Hungary. Comparing the values it can be stated that the Hungarian case is more favorable from the point of sustainability: higher share of rail transport, lower share of road transport. However, this situation may be worsened unless measures preferring environmental friendly modes are introduced. The different scenarios – set by Hungarian national transport policy – and their expected results are showed in figure 2.

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Table 1. Trends influencing transport-logistics systems/services (SULOGTRA, 2002)

| | |
|---|---|
| Restructuring distribution systems | Territorial concentration of production |
| | Territorial concentration of inventory |
| | Establishment of break-bulk systems |
| | Establishment of hub-satellite systems |
| Reorganizing supply chains | Vertical desintegration of production |
| | Rationalization of supply base |
| | Application of postponement strategies |
| | Increase the share of direct deliveries |
| | Widening the supply base in space |
| | Widespread distribution of products |
| | Concentration of international trade to certain transport nodes |
| Rescheduling goods flows | Applying time saving principles in trade and production |
| | Increase the share of on-time deliveries |
| | Reverse/inverse logistics |

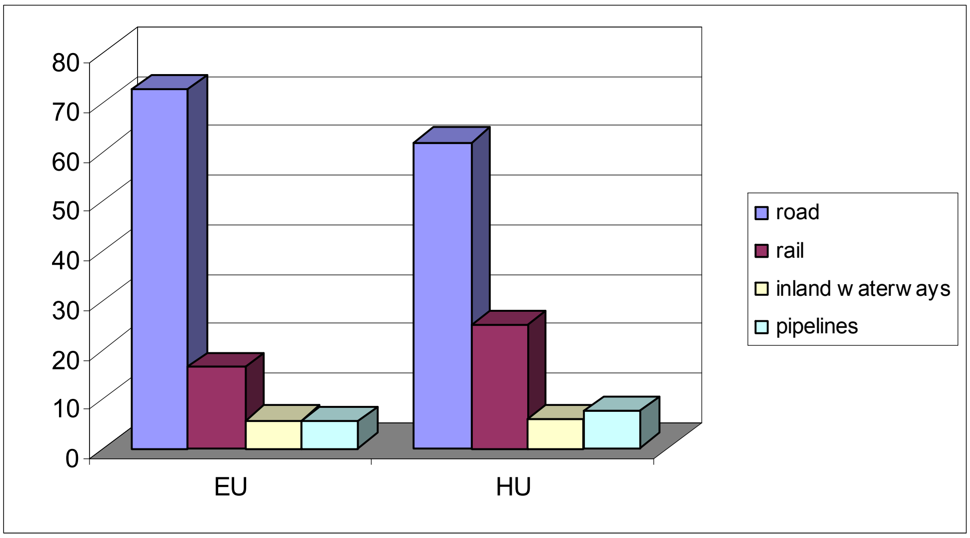
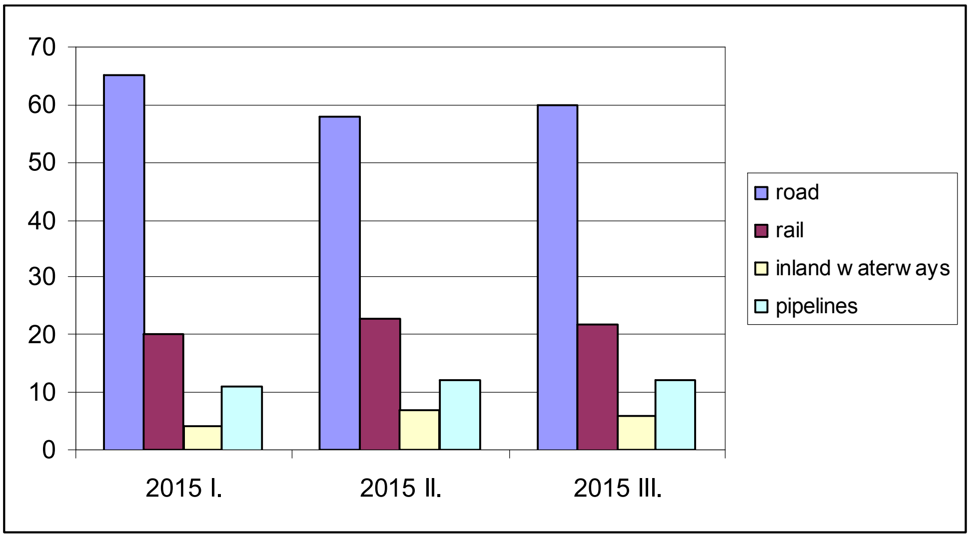



*Figure 1. Modal split in inland goods transport 2004 (% based on tonkm performance) – EU vs. Hungary (source: EU statistics)*




2015 I.: ‘business as usual’ scenario; 2015 II.: ‘radical’ scenario preferring environmental friendly modes; 2015 III.: ‘moderate changes’ scenario combining I. and II.

*Figure 2. Alternatives of expected goods transport modal split for 2015 (% based on tonkm performance) in Hungary (Ministry of Economy and Transport, 2003)*

When elaborating logistics development priorities attention has to be paid to international/regional competitors of Hungary. Hungary has a very good geopolitical status: common borders with several countries, four Trans-European corridors, more than any of the neighboring countries. It has special opportunities for the transit traffic to Balkan and Middle-East, while to these destinations Hungary is "the gate of EU". Nevertheless, this favorable geographical position may be threatened by several factors when transport-logistics infrastructures/services and the adequate regulation background promoting them are not available or in force in time. The insufficient or delayed availability of domestic market conditions may make forwarders use alternative routes and distribution centers, e.g. via/in the Slovak Republic, Austria or the successor countries of former Yugoslavia.

Another important international tendency influencing the Hungarian freight-logistics market is the upgrading of East and South European seaports (mainly Constant and the Adriatic ports) due to the capacity problems of Western European sea terminals. Another reason for using these ports is that goods flows coming from Far-East can reach their destinations by saving considerable time and costs. It may result in additional goods flows using Hungary as transit country.

## 3. Evaluating the current situation of intermodal transport and logistics in Hungary

### 3.1 Regulation

The development of logistics service centers, combined terminals and combined transport technology are organic parts of current Hungarian transport policy. In the program of developing transportation three subprograms are involved in intermodal logistics. In the „Sustainable development" subprogram preferring environmental friendly transportation modes, combined transportation is mentioned as an influencing instrument for sustainable development of transport policy. „The improvement of quality and the exploitation of current transport systems" subprogram emphasizes that before generating new capacities one should aspire to increase the efficiency of current transport systems, among these the synchronization of road, rail, and inland shipping. „The missing infrastructure elements" subprogram states that development of transportation has a really important point: the development of interfaces between different transportation modes. For that reason the terminals are important elements of interfaces in goods transport, especially preferred – in environmental and economic political ways – are the multimodal transportation systems.

The Hungarian preference system giving advantages to combined transport is harmonized with EU common rules: ensures exemptions from HGV stops, permissions and road vehicle taxes in case of short distance road freight integrated into combined transport chains.

### 3.2 Combined transport

The result of successful application of combined goods transport in Hungary – launched in 1992 – is that approx. 9-10 thousand tons pollutant emission has been cut back on or not emitted to the environment. Due to trucks being transported on railway or by inland shipping the environmental impacts have been decreased, this resulted in lower noise levels, abrasion, accidents and fuel consumption. The performances and their tendencies characterizing the Hungarian combined transport system are described in table 2.

Table 2. Performance of Hungarian combined transport system (source: Ministry of Economy and Transport)

| Forms of combined transport | | 1992 | 1998 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|
| *Ro-La (truck)* | | 16,180 | 101,924 | 107,819 | 101,251 | 79,071 | 54,440 |
| *Non-accompanied transport* | *(thousand tons)* | 995 | 2,288 | 3,322 | 4,700 | 5,100 | 5,200 |
| | *(unit)* | 104,700 | 241,000 | 265,760 | 303,230 | 303,400 | 309,400 |
| *Ro-Ro (unit)* | | 1,767 | 20,528 | 13,190 | 10,644 | 20,800 | 11,555 |

Hungary has four equipped Ro-La terminals: Szeged (Kiskundorozsma), Sopron, BILC, Zahony. Currently this form of combined transport is handled mainly in Szeged. The performance level of Ro-La transport has never reached the share of 10% of road transit and has been decreasing significantly last years due to the liberalization of international road haulage in consequence of joining the EU.

The performance of non-accompanied combined (road-rail) transport amounts to about 10% of MAV (Hungarian State Railway Company) and one third of GySEV (Austrian-Hungarian regional railway company) performances. The performance level is growing at a moderate rate. The highest levels of traffic can be observed in BILC, Freeport Csepel and Sopron (mainly containers) with approx. 100 thousand TEU per year respectively. Other terminals are operating at a turnover of about 10 thousand TEU per year.

The share of Ro-Ro transport is rather low, its tendency is varying. Hungary has three equipped Ro-Ro port: Freeport Csepel, Gyor-Gonyu and Baja. Currently only Freeport Csepel is operating. Inland waterway transport and so Ro-Ro transport is hindered by the fact that Hungarian forwarding companies don't have suitable vehicles and furthermore the navigability of the Danube (at least 2,5 m dive) is not sufficient the whole year (periodic restrictions due to low water levels).

### 3.3 Intermodal logistics centers

Among thirteen Hungarian intermodal – or by using the former categorization label accepted in 1998: “national” – logistics centers (see figure 3) there are three trimodal terminals – Csepel, Gyor-Gonyu and Baja, each situated at the Danube – while the others are bimodal. These centers have been supported also by public grants but the operators are private or public-private companies. The most developed/utilized “national” logistics centers are the BILC (7), Freeport Csepel (6), Prologis Harbor Park (5) – each situated in Budapest – and furthermore Debrecen (12), Szekesfehervar (4) and Sopron (1). The other selected centers are developing in different ways. In Gyor-Gonyu new equipment is established. In Szolnok (10) and Szeged (9) large scale investments have just started. In Nagykanizsa (3), Miskolc (11) and Baja (8) the low demand hampers further improvements, although the basic infrastructure is already available. At last but not least Zahony (13) has large capacities but deteriorated infrastructure which needs to be improved significantly.

Other logistics facilities have been established and operated by private actors. These are dominantly unimodal terminals based on road transport but some of them may be able to meet the requirements of intermodality in the near future.

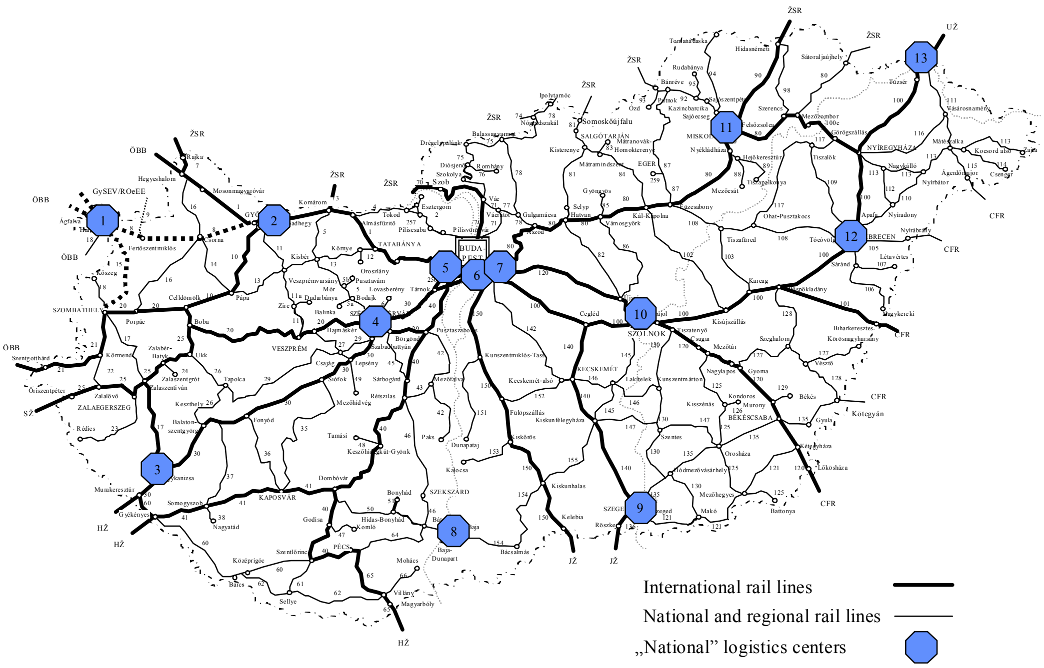



*Figure 3. Railway lines and current intermodal (so called “national”) logistics centers in Hungary (source of basic map: Hungarian State Railways)*

### 3.4 SWOT analysis

The results of Strengths-Weaknesses and Opportunities-Threats (SWOT) analysis applied to Hungarian intermodal transport-logistics system are synthesized in table 3.

Table 3. SWOT analysis of Hungarian intermodal transport-logistics system (Bokor, 2006)

| Strengths | Weaknesses |
|---|---|
| • decennial experiences, preliminaries in the field of combined transport and logistics | • not fully built up logistics infrastructure, missing service elements |
| • continuously updated development conceptions and promotion programs | • low service/quality levels in freight transport, mainly in case of rail or waterborne transport |
| • partly operating intermodal logistics network using also up-to-date techniques | • insufficient demand on modern, environment friendly logistics services – low awareness of environmental issues |
| • motivated and committed experts among logistics service providers | • too centralized (capital city based) and only partly complex supply of logistics services |
| • advanced higher education in logistics | |

Opportunities

- favorable geopolitical position (TEN and TINA corridors and nodes, “the gate of EU”)
- expanding industry and (foreign) trade
- relatively low price levels or costs in the field of logistics resources (workforce, land, services, etc.)
- in general good opinion about investment possibilities and the regulation framework

Threats

- lagging behind in logistics service quality, infrastructure, promoting regulation, etc. in comparison with surrounding countries offering alternative solutions to forwarders
- the strict competition may supersede non-adaptive domestic actors from the market
- the “diverting” effect of current Hungarian taxation and customs practice
- gradual reduction of comparative price or cost advantages

## 4. Elaboration of high-level policy packages promoting intermodality

According to the latest research results and practical experiences transport and economic policies shall establish a framework which ensures that providers willing to develop and operate intermodal transport-logistics services are able to offer their integrated solutions as relevant alternative to traditional, unimodal services. The main elements of this framework can be summarized as follows:

1. directly applicable tools:
   - building up – in a subsidised way – the basic infrastructure of logistics service centres (especially intermodal terminals and connected inland shipping, railway, road elements) or providing territories under good conditions;
   - expansion and modernisation of combined transport vehicle pool (mainly in case of non-accompanied forms);
   - adequate regulation giving preferences to intermodal transport-logistics business activities;
2. tasks to be tackled in international framework:
   - active intermodal marketing/promotion;
   - standardisation, harmonisation:
     - intermodal transport units;
     - contract conditions, documentation, responsibility relations;
     - exchange of information, data models/bases;
     - training methods, working requirements;
3. necessary additional regulation and developments:
   - adequate regulation (taxation, customs, etc.) ensuring efficient and effective operation of transport-logistics market;
   - development of rail infrastructure and free access to it, improvement of the conditions of alternative solutions provided by rail or inland waterway transport and efficient use of infrastructure capacity;
4. long term solutions:
   - internalisation of externalities, use of unified transportation tolls based on the usage which leads to choosing transport modes based on the real costs;
   - stricter measures in the field of environment protection, technical and social controlling in goods transport.

Pre evaluating the development demands it can be stated that one part – especially the fulfilment of monitoring and harmonisation tasks – can only be done in the frame of international co-ordination. Here the domestic policy should play receiver or adapter roles to local conditions. In other cases – for example in the case of the priorities of logistic infrastructure development – domestic policy can be initiative, but it should pay attention to the international connection points, too (Pan-European goods flows, Trans-European Network preferences). The implementation of development should be carried out after wide-scale preparation and communication activities between transport modes/actors and it prerequisites also the sound evaluation and contemplation of macro economic impacts.

The former approach concentrates on the tasks of state/public contributions. Nevertheless, it is obvious that the participation of private actors is also required in developing intermodal transport-logistics systems – the public contribution shall serve as complementary toolset. Logistics service providers are namely the ones who are able to enhance the efficiency and effectiveness of intermodal supply chains by integrating planning, organisation and completion activities of related procedures. Their main tasks shall include steady technological and administrative improvements, internal investments and operation of consolidation points (terminals), the management of special loading units applicable for combined transport (e.g. container or swap body pooling) and first of all undertaking the role of freight integrator (as defined in EU common transport policy).

## 5. Application of recommended measures under Hungarian circumstances

The overall aim of Hungarian strategy is to establish a transport-logistics system which exploits the good geopolitical situation of the country in an environmentally friendly way and is capable of becoming a distribution centre of goods transit to East and South Europe with an added-value approach. To reach these aims the Hungarian development conception shall rely mainly on the tools identified by the international R&D and business practice. Of course these tools and policies shall be adapted to the special circumstances of Hungarian economic and transport system before implementing them. The followings give an overview about these considerations but they are concentrating on the tasks of the public sector only.

### 5.1 Development tools

The basic principle in the case of intermodal logistics investments is that the state shall participate in ensuring basic operation conditions which can not be realized by private actors – due to efficiency, technology, etc. factors –, although these elements are essential form the point of view of high-quality and less environment polluting transport-logistics services.

When considering financing possibilities special attention has to be paid to EU structural and cohesion funds allocated in the frame of 2nd National Development Plan (NDP) 2007-2013. These funds – and the complementary domestic contributions – will be the main sources of development programs because of the strict barriers of national state budget.

#### 5.1.1 Direct measures

The state shall support or contribute to the establishment or improvement of further logistics facilities in Hungary:

- development of extern logistics infrastructure: improving the accessibility of intermodal logistics centres by road and rail;
- development of intern logistics infrastructure: building up transshipment terminals and public works, extending warehouse capacities, improving IT networks within intermodal logistics centers;
- development of intermodal vehicle fleet: procurement of special vehicles (rail or waterborne) applicable for combined freight transport.

The planned logistics related development policy in 2nd NDP can be characterized as complementary support of market initiations promoting intermodality. It means that the state takes part in (or contributes to) making available the necessary infrastructure while private actors/investors are responsible for improving logistics services by utilizing the tools provided by state contribution. Proposals are required to ensure new/additional transport performances on rail or inland waterways. Projects launched in priority regions (near to long term EU borders) are of primary importance.

General logistics considerations have been placed into two development programs of 2nd NDP:

- in "Transport" development program the building up of external transport infrastructure (rail or road connections) of logistics centers is supported. Here pre-selection of large scale projects is envisaged by taking into account the opinion of representative professional organizations in the field of logistics;
- in "Competitive economy" development program internal infrastructure and services (e.g. warehouses, public works, IT systems, etc.) of logistics centers can be supported. Projects will be chosen by competition based on evaluating submitted proposals.

The subsidies of 2nd NDP shall be differentiated by taking into account what role/function a certain logistics center can play in Hungarian logistics network. Table 4 gives details on a possible new categorization scheme sophisticating/extending the old ranking system (network of "national" logistics centers) approved in 1998. It is agreed between authorities and professionals that public intermodal logistics service centers – or public centers managing to fulfill the requirements of intermodality in the near future – shall have priority when allocating available sources for grants.

#### 5.1.2 Indirect measures

The former (direct) measures concentrate on the nodes (centers and terminals) of logistics network and don't deal with transport networks. However, it is obvious that intermodal logistics services can be competitive only if the service quality of rail and inland waterborne freight transport increases. It requires additional infrastructure and vehicle park developments – harmonized with logistics demand and supply – as well as the effective utilization of capacities, mainly in rail transport. Integrated improvement of logistics centers, their connections and the network services can ensure the desired results. The necessary infrastructure improvements of Hungarian transport network have been placed into the "Transport" development program of 2nd NDP, too.

The basic idea in case of rail transport is that the infrastructure will be open for all railway undertakings meeting the requirements of accessibility. To provide a competitive rail infrastructure network, however, additional improvements are envisaged:

- reconstruction of the trunk rail network with special regard to international (TEN) lines;
- implementing electronic rail traffic management & control systems (ERMTS/ETCS), mainly on international lines;
- improving the commercial speed of rail freight transport by eliminating bottlenecks (line sections with low allowed speed) and applying better business organization methods.

Intermodal logistics centers shall be served by high capacity trains operated on agreed schedules. That's why the share of reliable block trains in total rail traffic is to be increased significantly – this is an important expectation set by potential partners willing to use intermodal services.

Table 4. The proposed – and recently accepted – new categorization system for logistics service centers (LSC) in Hungary

| Accessibility | Types of LSC | Criteria: *Common criteria* | Criteria: *Specific criteria* |
|---|---|---|---|
| Public | Intermodal | • basic infrastructure<br>• basic (including customs related) logistics services<br>• security services<br>• information services | • access to more transport modes (rail or waterborne is a must)<br>• operating combined transport services<br>• min. 15 ha territory<br>• min. 10,000 sq m warehouse capacity<br>• customs office I.<br>• serves also international transport<br>• open for settling companies |
| Public | Regional | | • access to more transport modes can be built<br>• min. 10 ha territory<br>• min. 5,000 sq m warehouse capacity<br>• customs office I. or II.<br>• serves also international transport<br>• open for settling companies |
| Public | Local | | • min. 3 ha territory<br>• min. 3,000 sq m warehouse capacity<br>• open for settling companies |
| Non-public | Company | | • serves a certain company or a certain group of companies |

Investments in the field of Hungarian inland waterway transport have to serve first of all the better navigability of the Danube: 2,5 m dive capacity has to be ensured during low water levels, too. It can contribute to attract more transport volumes to the main Hungarian international inland navigation route.

Beyond enhancing the navigability of the Danube service conditions of inland ports are to made better, too. Here mainly rail connections with high carrying capacity shall be built to promote trimodality.

At last, figure 4 shows what key (territorial) development directions have been identified for Hungary to develop its railway and inland waterway infrastructure network.

5.2 Regulation and co-ordination tools

An effective promoting measure could be to introduce an EU-conform operational grant system for intermodal services or their providers. It can be justified by the fact that social cost based pricing systems have not been implemented in transport sector yet, which distorts decisions regarding mode choices. The application of such public grants may be, however, complicated because of the EU authorization mechanism. Additional preferences can be granted when the new electronic toll collection system starts working. Here lower or even zero road charges can be applied to road freight movements connected to combined transport.

The EU common transport policy is committed to introduce (gradually) the social cost based pricing system in transport – Hungary has to prepare for it, too. The new electronic toll collect (ETC) system based on these principles is intended to be gradually introduced from 2008. Such pricing systems favor lower social cost transport and logistics solutions – e.g. integrated intermodal chains – and will probably change transport-logistics related business decisions. To be able to implement these new pricing principles determined by the transport policy commonly used internalization methods for external costs and revenues shall be elaborated and applied. The reorganization of transport cost and price structure shall be realized in such a way which does not weaken the international competitiveness of Hungarian market actors.

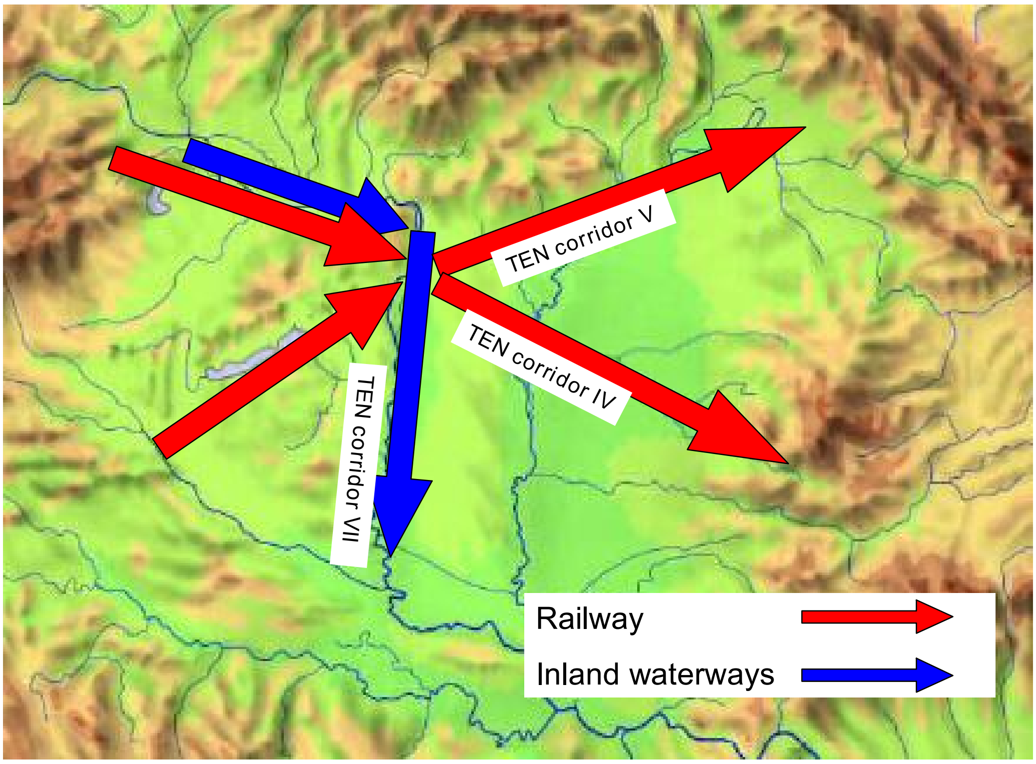



*Figure 4. Key – schematic – development directions (territorial preferences) of Hungarian railway and inland waterway transport infrastructure (based on: Ministry of Economy and Transport)*

Effective participation and representation of country's interests shall be carried out in the platforms of international co-ordination and innovation of intermodality. The scope of bilateral agreements promoting combined transport shall be extended by taking also into account that multilateral agreements may be more common in the future. Hungary intends to contribute to the work of dedicated EU and UNECE committees responsible for standardization and interoperability and at the same time facilitates the domestic adoption of international/common directives.

It is also important that Hungarian enterprises take advantages from EU Marco Polo II and the 7th R&D Framework programs by joining different consortiums or pilot projects so that they can have access to state of the art intermodal knowledge. Intermodality and related innovative topics shall be included into different levels of educational and vocational training systems, too.

The factors determining the competitiveness of Hungarian logistics services or service providers have to be revised among complementary issues. Here customs procedures and taxation rules are to be mentioned which can be influenced by the sate. Problem areas are: immediate and direct VAT for import transactions, difficult customs procedures not (really) supported by efficient IT tools. These problems shall be solved by continuous collaboration of interested parties.

## 6. Conclusions

What conclusions can be drawn in the field of intermodal logistics based on international and Hungarian policy experiences?

It is important to harmonize transport infrastructure developments and logistics demand derived form market requirements: it is the wrong way when logistics infrastructure development priorities are determined by central government without considering business plans of private investors and operators.

State contributions shall be restricted to solving problems – e.g. making available the basic infrastructure – which can not be handled by market forces: because public resources are limited and logistics shall be driven mainly by business decisions.

Supply chains using intermodal transport solutions shall be preferred: because these – less environment polluting, but more complex – modes of transport are often not considered by the freight forwarders so they need additional state interventions.

It can also be stated that the identified development and regulation tools can be applied effectively only if they are combined with each other based on synergic and complementary effects. Action plans adapted to national, regional or local circumstances, and at the end to certain complex intermodal supply chains have to be worked out and then implemented by drawing all interested parties – service providers, supplier and suppliants, researchers, professional associations, authorities and public bodies, etc. – into common planning procedures.

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# RFID IMPLEMENTATION – THEORETICAL AND PRACTICAL QUESTIONS

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## Abstract

*In this paper we discuss the main differences between barcode and RFId systems, the framework of their implementation in the special case of Hungarian SME's. In the second part of the paper, we discuss our research regarding practical questions of RFId implementation at a Hungarian logistics distributions center. The main result of our research is a common view of both theoretical and practical questions regarding the implementation of RFId systems. After analyzing the possible RFId trends and possibilities, we elaborated a simple framework for choosing the best RFId system to use at the given company.*

Keywords: RFId systems, SME's, Supply Chain Management, Hungary

## 1. Introduction

The Department of Logistics and Forwarding at the Széchenyi István University in Győr, Hungary started a project in the framework Interreg IIIC REGINS (REGional standardized Interfaces for a better integration of regional SMEs in the European Economy – http://www.regins.org ) with the name "Promotion of RFId (Radio Frequency Identification)". The project started in June 2005, ended in June 2006. Our partners are situated in Upper Austria, Stuttgart Region, and from Lombardy Region. Our project screens the state of the art and the ongoing development of RFId technology and processes. Special focus is on the needs of SMEs. In this paper we discuss the main differences between barcode and RFId systems, the framework of their implementation in the special case of Hungarian SME's. In the second part of the paper, we discuss our research regarding practical questions of RFId implementation at a Hungarian logistics distributions center. The main result of our research is a common view of both theoretical and practical questions regarding the implementation of RFId systems. After analysing the possible RFId trends and possibilities, we elaborated a simple framework for choosing the best RFId system to use at the given company.

## 2. RFId technology

Radio Frequency Identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. An RFID tag is a small object that can be attached to or incorporated into a product, animal, or person. RFID tags contain chips and antennas to enable them to receive and respond to radio-frequency queries from an RFID transceiver. RFId tag integrated circuit is designed and manufactured using advanced and small geometry silicon processes. New advances in manufacturing process are making possible different approaches based on polymers, as a low cost alternative to the former chips. In terms of computational power, RFId tags are quite poor and contain only basic logic capable of decoding simple instructions. However, they are difficult to design, because of the challenges to manage very low power consumption, noisy RF signals or keep it operating within the strict emission regulations. When the tag enters the field generated by the antenna, it starts interacting with it and thus with the reader. The reader (mobile or fixed) emits an electromagnetic interrogation signal, which, if the tag is of passive type, charges components of transponder power supply. Following this request, tag sends to the reader its unique ID code and in case others data recorder in the memory chip.

The communication can happen in two directions (reading or writing mode) and it use radio frequency signals. When the reader receives information from RFId tag, it can temporally store them, but usually as soon as impossible all data are transmitted to the host with wire or wireless infrastructure.

## 3. RFId versus Barcodes

Compared to barcode inventory control systems RFId technology has both advantages and disadvantages, many of which are outside of product manufacture and distribution chain applications. The main advantages are the following:

- Not requiring line of sight access to be read.
- The tag can trigger security alarm systems if removed from its correct location.
- Scanner/reader and RFId tag are not (so) orientation sensitive.

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- Automatic scanning and data logging is possible without Operator intervention.
- Each tag can hold more than just a unique product code.
- Each item can be individually 'labeled'.
- Tag data can be comprehensive, unique in parts/common in parts, and is compatible with data processing.
- With the right technology a plurality of tags can be concurrently read
- It can be read only or read-write.
- There is a very high level of data integrity (character check sum encoding).
- Provides a high degree of security and product authentication – a tag is more difficult to counterfeit than a barcode.
- The supporting data infrastructure can allow data retrieval and product tracking anywhere provided the scanner/reader is close enough to the tag.
- Combined with its authentication is the ability to monitor shelf life – a societal advantage in the pharmaceutical and food industry.
- Since each tag can be unique they can act as a security feature if lost or stolen e.g. a stolen smart travel card can be cancelled.
- The technology is rugged and can be used in hostile environments such as down oil wells (heat and pressure) to carry data to remote equipment.
- The technology lends itself to being updated, for example, as a car goes through its life its service record can be electronically logged with the car.

The main disadvantages are the following:

- There is a high cost (long pay-back) for integrating RFId technology into existing inventory control systems.
- External influences such as metalwork, material dielectric properties and radio interference can constrain RFId remote reading.
- If a significant number of RFId's greater systems capabilities are implemented then the host system and infrastructure have a higher capital cost and complexity than for barcode systems.
- There are currently a range of RFId application numbering systems which need unifying to increase uptake. [The International Standards Organisation (ISO) and Electronic Product Code [EPC] Global consortium, amongst others, are working to address this issue.]
- Currently there are not internationally agreed frequencies for RFId operation (other than 13.56 MHz, which is primarily used by smart cards but can also be used by other RFId tags) and permitted scanner/reader powers differ between countries. This limits product take-up. [For example, there are significant differences between the USA and European UHF frequencies.]

Nowadays, RFID technology is still under development, standards are still converging, and costs are still being sank down in order to make the attachment of tags to individual consumer products available. However, the barcode system is deeply entrenched and will not be replaced anytime soon. This means that both barcodes and RFID systems have to exist in parallel for a long time in the future. The migration from barcodes to the RFID system will not only increase demands on system capabilities and compatibilities but also increase costs on maintenance and operation of both systems.

## 4. Standards in RFId technology

Nowadays two major organizations are working to develop international standards for RFID technologies in the UHF spectrum. These two organizations are EPCglobal and International Standards Organization (ISO). EPCglobal released its EPC class 1 G2 protocol for the UHF band at the end of 2004, and the ISO released its 18000-6 in August of 2004. Both standards are still under development and are not completely compatible with each other. A unified, globally interoperable RFID standard is ideal to realize the full benefits of RFID applications. The lack of a complete and unified RFID standard has caused many companies to hesitate in adopting the RFID systems; these companies were afraid of making a commitment that might render their entire RFID system investment worthless in the future.

Regulations on radio spectrum allocation for RFID use are not unified among nations. A large portion of the UHF spectrum has already been auctioned to cellular phone service providers for high license fees by a few countries. It would be difficult, if not impossible, to buy that portion of spectrum back for RFID use. This adds complexity to the adoption of RFID for global supply chain management applications where tagged goods must often travel across borders. RFID tags which respond only to a specific UHF frequency range cannot be read in countries where different spectrum bands are allocated for RFID use. The United States and Canada can allocate the frequency band from 902 to 928MHz for UHF RFID systems because their GSM bandwidths are not located within this band. Outside North America, however, the frequency band around 915MHz is almost exclusively used for wireless communications services such as GSM, PHS, GPRS or 3G. The European Telecommunications Standards Institute

(ETSI) has released a 2MHz band ranging from 865.6 to 867.6MHz for Europe's UHF RFID use in July 2004. Japan has allocated a 2MHz UHF band ranging from 953 to 954MHz for RFID use in May 2005. The diversity in national spectrum allocation for RFID adds more hurdles to the growth of RFID systems in the world market. In addition to the unavailability of common spectrum bandwidths for RFID systems, power regulations and certification procedures are also incompatible from country to country.

## 5. Benefits of the RFId technology for each department

The application of RFId in execution of logistics activities made evidence of benefit. In the following the possible results are listed for each department:

For the purchase departments:

- Better productivity
- Reduced labour costs
- Faster throughput at the receiving
- Eliminates the need of physical checks of BOL/Packaging slip
- Indicates the needs for Cross-Docking
- Case/item placement on conveyors

For storage:

- Put away accuracy & efficiency
- Less Bar Coding required
- No need to scan palettes & storage bins
- Better storage space utilisation (random location system)
- Product compatibility (e.g. Hazardous products)

For packaging:

- Picking accuracy (items and amounts)
- Productivity measurement
- Time motion measurement
- No manual scans of products

For shipping:

- More accurate shipping process
- Automatic verification through the portal of outbound dock door
- All items leaving the premises are accounted.

## 6. Implementation in a Hungarian distribution centre

The chosen distribution centre for our survey is situated near Budapest. It is the distribution center for food and non-food products of a single supermarket-chain. This chain operates 150 supermarkets in Hungary. The storing ground is 35.000 $m^2$, where 1.300 different goods are stored. Every day 4.000 pallets, containing 120.000 packages, containing 3.400.000 products are leaving the centre, through 126 gates.

For the next step, we have to discuss the possible place of the tags. In our research the three possibilities are: one tag on the pallet or on the package, or on every product. Of course the most secure solution is to place a tag on every product. It would be approx. 750 million tags pro year. If we use one tag for one package, we need approx. 26,5 million tags pro year. If tags were placed only on the pallets/transport units, 990.000 tags were needed yearly.

If we take into account, for what we need the tags, and if we see the required number of tags, the use of passive tags are obvious. On the next table we compared tag prices to the value of the product in case of all three possible levels and type of tags.

From that table it is obvious, that by the current price level only the use on transport unit is economic. That means, that the goods are controlled by RFId technology between the distribution center and the shops.

We have to take into account some additional costs. As we said before, the center has 126 gates. To place a reader on every gate would cost approx. 700-800.000 €. An other possibility is to buy handheld readers. For the center 20 handheld readers were enough. The costs are 20.000 €.

The best solution for the distribution centre is to have passive RFId tags on the transport units, the reading process made with handheld readers.

| RFID-tag | Price € | Level | Value € | Share in value value |
|---|---|---|---|---|
| active | 10,00 | product | 0,45 | 2222,22% |
| active | 10,00 | package | 12,57 | 79,57% |
| active | 10,00 | transport | 426,00 | 2,35% |
| passive | 0,10 | product | 0,45 | 22,22% |
| passive | 0,10 | package | 12,57 | 0,80% |
| passive | 0,10 | transport | 426,00 | 0,02% |

1. table: Different tag prices compared to product value

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# EVALUATING THE RADIO FEQUENCY IDENTIFICATION (RFID) INVESTMENTS: A REAL OPTIONS APPROACH

Alp Ustundag[1]and Mehmet Tanyas[2]

## Abstract

*Radio Frequency Identification (RFID) is an Auto-ID system consisting of a microchip with a coiled antenna and a reader. Data and energy are transmitted without any contact between the microchip and the reader. The reader sends out electromagnetic waves that form a magnetic field so the microchip's circuits are powered. The chip modulates the waves and sends back to the reader. The reader converts the new waves into digital data. RFID provides efficiency, accuracy and security on the supply chain. Real time inventory and logistics information is shared at any stage of the supply chain by the supplier, manufacturer, distributor and retailer. An RFID investment is a strategic decision for a company. Calculating return on investments (ROI), cost and benefit analysis should be done accurately. In this study, the factors influencing the ROI of an RFID investment are examined. Real options approach is used to evaluate an RFID investment.*

*Keywords: Radio Frequency Identification (RFID), return on investment (ROI), cost-benefit analysis, real options*

## 1. Introduction

Radio Frequency Identification (RFID) systems gain more importance in the mobile and wireless communication technologies and influence various industries. RFID is an automatic identification system (Auto-ID) which uses radio waves to identify the products and materials. According to Mcfarlane and Sarma (2003), an RFID-based Auto-ID system comprises the following elements.

- A unique identification number which is assigned to a particular item
- An identity tag which is attached to the item with a chip capable of storing - at a minimum - a unique identification number. The tag is capable of communicating this number electronically.
- Networked RFID readers and data processing systems which are capable of collecting signals from multiple tags at high speed (100s per second) and of preprocessing this data in order to eliminate duplications and misreads.
- One or more networked data bases that store the product information.

RFID labels can store large data. They are read and written in bulk very quickly without any mistakes. They are used in different environmental conditions and data communication can be done in long distances. These characteristics are the advantages of RFID over Barcode technology. As the costs in the semiconductor industry decrease and the data communication standards improve, the use of RFID technology increases.

IDTechEx ,the research company, expects the size of the RFID market, including systems and services, to grow from roughly $2.7 billion in 2006 to $12.3 billion in 2010. By 2016, it expects the market to be worth $26.2 billion. It expects 1.3 billion RFID tags to be sold in 2006, with the majority going to a range of diverse markets from baggage and passports to contactless payment cards and drugs. The firm said it expects about 500 million RFID tags to be used for pallet- and case-level tagging in 2006.

All these developments indicate that RFID system investments should be considered as a strategic decision. Because the high value of the investment and the necessity of process reengineering, the cost and benefit analysis must be done carefully. In this study, the tangible and intangible cost and benefits will be examined. Return on Investment (ROI) analysis and implementation process of RFID projects will be pointed out. Real options approach is used to evaluate an RFID investment.

## 2.Literature Survey

As the interest of the business world on RFID increases, the academic studies are developing. The most published research papers about RFID are focused on the explanation of what the technology is and what is not. Wu et al. examine the existing challenges that RFID technology is facing, its future development directions and the likely migration paths to realize its promises. In McFarlane's paper on "The Intelligent Product in Manufacturing Control", the basic concepts of RFID and its implications on discrete event control are examined. Sheffi speculates on the possible future adoption of RFID technology considering the innovation cycles of several technologies.

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Kärkkäinen discusses the potential of utilizing RFID technology for increasing efficiency in the supply chain of short shelf life products.

RFID based system designs for specific applications are also examined in some research papers. Chow et al. propose an RFID-based warehouse resource management system. Ngai et al. propose system architecture capable of integrating mobile commerce and RFID applications in a container depot. Ni et al. present a location sensing prototype system that uses RFID technology for locating objects inside buildings. Goodrum et al propose an RFID based tool tracking and inventory system which is capable of storing and maintenance (O&M) data on construction job sites.

An RFID system implementation can be seen as an IT/IS investment. There are a lot of studies about IT/IS investment evaluation in the literature. However, it is really difficult to calculate the returns of an RFID system deployment. Patil discusses that Discounted Cash Flow (DCF) and Net Present Value (NPV) calculations are too limited a basis on which to make RFID investment decisions because they undervalue returns and focus management attention on short term cash flow.

## 3. Cost – Benefit Analysis for RFID Investments

RFID technology changes the business processes of a company. Investing in RFID systems, the companies need a new IT infrastructure. In this sense, RFID investments should be seen as a strategic decision. The following implementation steps are considered in RFID projects.

- Determining the potential application areas of RFID system.
- Analyzing the potential business processes.
- Estimating the benefits of the RFID implementation.
- Deciding the technical and organizational requirements for test and pilot studies.
- Determining the implementation risks.
- Making a detailed cost and benefit analysis for the whole system and calculating the return on investment.

The cost factors can be examined in three areas:

- Hardware: Tags, readers, antennas, computers and network equipment
- Software: Middleware and other application softwares
- Service: Installation, system integration, training, maintenance, and process reengineering (BPR)

The decreasing costs and the increasing sales are the benefits of an RFID system. Process automation increases operational efficiency and decreases inventory and labor costs. Besides, increasing customer satisfaction and decreasing shrinkage level boost the sales.

It is an important decision at which level RFID technology should be implemented in business processes. (Figure 1). At the product and case level, the benefits and investments costs are higher in comparison to pallet level. The manager can decide starting the RFID project at pallet or case level, thereafter in second phase, he can start the RFID project at product level.

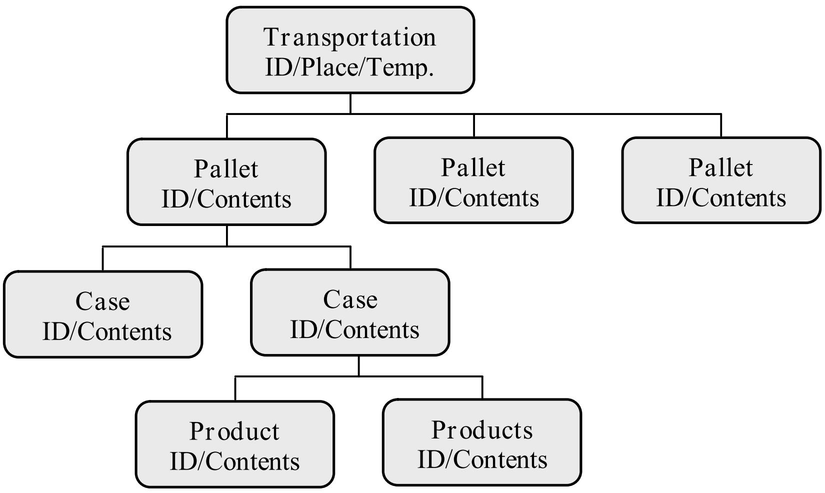


Figure 1. RFID Implemenation Levels

RFID provides efficiency, accuracy and security on the supply chain. Real time inventory and logistics information is shared at any stage of the supply chain by the supplier, manufacturer, distributor and retailer. (Table 1).

Table 1 Benefits in supply chain

| Manufacturer | Logistics Providers | Retailer |
|---|---|---|
| Shorter shipment loading times | More efficient order selection | Better store planning, programming, and merchandising with real time data |
| Greater shipment accuracy | Better order fill rates | Improved point-of-sale productivity and accuracy at checkout |
| Better consumer sales data from retailers | Less inventory shrinkage | More accurate returns |
| Reduced counterfeiting/diversion | Fewer administrative and other human errors | Improved reverse logistics |
| Improved support for vendor-managed inventory | Lower labor requirements | Greater inventory accuracy and velocity |
| Easier product safety recalls | Less vendor fraud | Optimized store in-stock levels |
| More accurate demand planning | More accurate inventory | Reduced internal and external shrinkage |
| Shorter order lead times | Less time and lower cost for managing inventory | Lower labor requirements |
| Less need for safety stock | Higher routing efficiency | Automated receiving, vendor payments, and shipments to store |
| Better use of labor | Better security for distributing medical products | Better use of reusable assets |
| Higher sales | Automated receiving, vendor payments, and shipments | Lower detention/demurrage charges |
| Less time and lower cost of cycle counting, receiving, picking and shipping | Increased capacity through more efficient operations | Better gray-market containment |
| Fewer charge-backs for inaccurate deliveries | Fewer penalties for execution errors | Better ways to measure the execution and effectiveness of display programs |

## 4. An Application Example – Real Options Approach

We assume that a company will have an RFID project for the distribution center at pallet level. The company will have cost reductions in labor and inventory, and sales increase.

Table 2 RFID ROI Table

| Cost (USD) | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| Hardware | *100.000* | *50.000* | *50.000* | *50.000* | *50.000* |
| - Tag | 50.000 | 50.000 | 50.000 | 50.000 | 50.000 |
| - Reader, Antenna | 50.000 | | | | |
| Software | *100.000* | | | | |
| Service | *50.000* | *40.000* | *40.000* | *40.000* | *40.000* |
| - System Integration | 20.000 | | | | |
| - Training | 30.000 | 30.000 | 30.000 | 30.000 | 30.000 |
| - Maintanence / Support | - | 10.000 | 10.000 | 10.000 | 10.000 |
| *Total Cost* | *250.000* | *90.000* | *90.000* | *90.000* | *90.000* |
| Benefit (USD) | | | | | |
| Inventory Cost Reduction | *30.000* | *30.000* | *30.000* | *30.000* | *30.000* |
| Labor Cost Reduction | *100.000* | *100.000* | *100.000* | *100.000* | *100.000* |
| Sales Increase | | *20.000* | *50.000* | *50.000* | *50.000* |
| Shrinkage Cost Reduction | *10.000* | *10.000* | *10.000* | *10.000* | *10.000* |
| *Total Benefit* | *140.000* | *160.000* | *190.000* | *190.000* | *190.000* |
| TOTAL | *-110.000* | *70.000* | *100.000* | *100.000* | *100.000* |

In the above example, the investment returns in 2 years. The manager can decide to start the RFID project. The question is, what the manager decides, if the NPV of such an investment would be negative (for an example NPV= – $100.000). RFID investments have expansion opportunities. The option value of extending to case or product level should also be considered before making the end decision.

Real options valuation will help organization to arrive at a decision to invest into RFID technology if they consider the embedded options available in future. For example, a European call option, which offers its holder the right but not obligation, to buy at maturity the underlying share of stock for a specified strike price. Similarly, an application that can be implemented using RFID technology offers the firm the opportunity (but not obligation) to obtain the benefits of the application (underlying asset) by investing a given implementation cost (strike price) at certain implementation decision points (maturity). So the NPV with options value taken into account will be:

Expanded NPV = (NPV of Expected Cash Flows) + (Value of Options*)* (1)

*In this RFID case;*

*Value of RFID Implementation = (NPV of Applying Only at Pallet Level) + (Option Value of Extending to Case Level) (2)*

*Calculating the option value using Black Scholes Model for the expansion decision, the expanded NPV will be positive. Following steps will show how to calculate the option value for above example:*

*We assume that,*

S = The present value of expansion potential (as assessed today) = $500.000

$\sigma^2$ = The annualized standard deviation (present value of CF) = 40%

K = The initial investment needed for expansion option (in PV $) = $800.000

t = The number of years you have rights to project = 5 years

C = The cost associated with waiting an extra year to expand = 0.00%

r = The risk-less rate that corresponds to the option lifetime = 8%

So in terms of option pricing:

Stock Price = 500.000 , riskless rate = 8 % , Strike Price = 800.000 , Variance (Volatility) = 0.16 , Expiration (in years) = 5 , Cost of delay = 0%

Value of Option = $$SN(d_1) - K(e^{rt})N(d_2) \quad (3)$$

Where, $$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}} \quad (4)$$

$$d_2 = d_1 - \sigma\sqrt{t} \quad (5)$$

In Eq. (3), N indicates the cumulative normal distribution and ln natural logarithm. So, using Eqs. (3)~(5), value of the option is obtained. It equals to $161.283. Using Eq. (2), expanded NPV is calculated. So, it equals to $61.283 ($161.283 - $100.000).

## 4. Conclusion

Deploying RFID technology in an enterprise is a strategic business decision. The cost – benefit analysis is a key component of this decision. To measure the value of an RFID investment, we have to understand the elements of cost as well as the business- and customer-related benefits comprehensively. Net Present Value (NPV) calculations are useful but not sufficient to make complex RFID investment decisions. Real Options approach is a better structured decision making process for complex investment decisions in uncertainty. In this study using the real options approach, we tried to measure the value of an RFID investment which has expansion opportunity. In further research, a decision support system can be developed which helps the managers to decide about the RFID investment in a specific business process.

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# A MANAGEMENT INFORMATION SYSTEM: INTEGRATING GIS, GPS AND ERP[1]

Ali Orhan Aydin[2] and Sedat Sarman[3]

## Abstract

*Emerging market conditions causes manufacturing and service systems to utilize better managerial approaches in increasing efficiency of their systems in order to survive. With this respect, Management Information Systems that are providing framework of Supply Chain Management are being used to get competition advantage. By this study a Management Information System to provide a framework for modelling business processes is introduced. While proposing such a system newly emerging technologies are tried to be utilized. Therefore, proposed system provides integration with Geographic Information Systems, Global Positioning Systems and Enterprise Resource Planning System. Besides this integration system that is introduced is designed to track all goods movements from one place to another by using Radio Frequency Identification technology. In this manner, system is going to provide traceability to not only fleets but also goods. In this frame, context diagram and 0 level data flow diagram is proposed to realize such an information system.*

*Keywords: Supply Chain Management, Management Information System*

## 1. Introduction

Today logistic firms need to provide information to their vendors and customers. Resources for processing complex information and communication are required in the business world to assist global logistics. It is very important to plan a framework to manage materials, services, information and also capital flows of business. To increase the productivity of providing goods and/or services to the clients in Supply Chain Management (SCM) system, planning, organizing and managing activities become a vital issue (Majchrzak & Wang, 1996; Womack & Jones, 1996).

New approaches in multi modal transportation management are possible through the development of Information and Communication Technology (ICT) Using the modern ICT it is now possible to combine the programming techniques with the advanced techniques in object oriented graphics, use of relational databases, electronics maps, based on information provided by a Geographic Information Systems (GIS).

Because of existing new business processes related with ICT, business management systems in the logistic sector must be planned like a dynamic system with an objective function. The objective function must include the minimization of the total cost related to logistics activities. Management Information Systems (MIS) aid in managing the flow of information from the point of origin to the final consumer throughout the chain of suppliers which must adopt the modern logistics techniques (EURO-CASE, 2000).

In the frame of these references, proposed study aims to provide a framework for business model on such MIS application. With this respect, subsequently emerging technologies that can be utilized in Supply Chain Management activities are explained. In the third section of the study details of the proposed business process model are elaborated. Finally, study ends with conclusion.

## 2. Supply Chain Management through New Technologies

Today if the logistics and SCM firms need to access the world trading system, they must have a goal to integrate into the international economy and they have to increase their quality of the transportation and communication infrastructure.

It is fact that the logistics firms require shorter order cycles and more reliable deliveries in the global challenging world. Today most important factors for the logistic and transportation companies are “faster transit times” and “day-definite delivery” that is more efficient than air load transportation for example.

Because of the product shelf life, product customisation, production/retailing strategy, and the reliability of short term forecasting, there are more varied delivery patterns in the logistic sector. As Aydin et. al. states that “The business managers recognise that they have to meet today’s consumer expectations for increased product value, variety and availability in all markets. (Aydin, Onwuka, & Sarman, 2006).

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[1] This study is performed within the frame of the project titled as “Çok Türlü Taşımacılık için GPS Sistemine Uygun Filo Yönetimi Programı” which is supported by TUBİTAK - TİDEB with project number 3050267.

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Also most of the logistic managers prefer closer relationships with fewer suppliers. Because of the rapid developments in the Information and Communication Technology, requirements for a greater use of ICT become an important issue for global logistic firms.

Logistic firms also need to keep transport costs under control. Therefore, they need affordable but also comprehensive software to optimise their vehicle fleet planning, programming and control activities using and benefiting new communication and information transmitting tools.

There are various bottlenecks in the SCM. For example some bottlenecks of the point-to-point services at scheduled times and also more important bottlenecks for the guaranteed delivery times. As inter-modal transportation increase, the needs for the conveniently located and easily accessible inter-modal terminals also increase in this global environment.

Also it is vital for the logistic providers, to remove the logistics barriers which affect global trade. This is a real situation and a fact for European states too. Today there is a tendency for SCM strategies that there are some specific changes including worldwide reduction of trade barriers and development of regional, multi-country economic zones (Aydin et al., 2006).

Aydin and his colleagues states that "The inefficiencies and delays occur at the interchange points at border crossings and along the national transport network. These delays result from inadequate infrastructure, inappropriate cargo handling equipment and transport fleets, cumbersome trade procedures, inappropriate management procedures and lack of know-how." (Aydin et al., 2006).

As it can be seen the maritime sector has been accepted as the principal facilitator of trade flows in the world. It is also important to integrate land and sea transport to provide the potential to open hinterlands further. There are great potential for the developments of hinterlands in Turkey as the country on the way of international goods movements routes. Also Turkish Logistic sector begins to take a role for the partnership into the international trading system on a fair and equitable basis.

Turkey also needs to facilitate legislation related with the recognizing and encouraging freight forwarders, multimodal transport operators, the use of e-commerce through the use of IT, and encouraging the development of logistic services and supply chain management for the benefit of trade. As Aydin et. al. says "Global integration and regional initiatives have paced the way for successful global Supply Chain Management through reduction in trade barriers)." (Aydin et al., 2006). "Removing or minimizing the problems will reduce the costs and delays and thus improve the Supply Chain Management productivity. Therefore it is necessary for the logistic providers to prepare for the usage of applications of Information Technology such as Management Information Systems and Geographic Information Systems (GIS)" (Aydin et al., 2006).

Moreover, European Global Navigation Satellite System (GNSS) or Global Positioning System technologies can be beneficial in tracking goods not only at borders but also in all of the countries. (Aydin et al., 2006). Logistics managers are always on the lookout for software that can help them work smarter, faster, and cheaper. Because they always want to increase efficiency, save money, and maximize resource usage.

If the SCM and Logistic firms continue to work with their poor warehouse management and continue to use their current systems incapable of tracking their fleets, they can not able to handle the explosion of Radio Frequency Identification (RFID) data volume as the RFID revolution arrived and promise the high- resolution supply chain of the future (Angeles, 2005).

The electronics supply chain is playing tag with an inventory tracking system that could replace bar-code scanning in coming years. The ability of Radio Frequency Identification (RFID) tags to send data to RF readers up to 10 feet away could also eliminate warehouse or manufacturing floor personnel who manually swipe each item with a bar-code reader and in some cases reduce theft and counterfeiting.

Demand for the technology is real along all stops of the supply chain. Wal-Mart, for example, is indicated it wants pallet- and case-level RFID tagging available in January 2005, which is prompting its vendors upstream to investigate RFID-enabled goods as part of their external shipping procedures (Sullivan, 2003 #973; Angeles, 2005).

Carrier service provider DHL, for example, starts to equip its logistics centres with RFID to replace bar-code scanning at the end of 2004. The network will track packages from pickup to delivery at a cost of approximately $50 million for the first three years.

"We're also starting to look at how RFID can help us in the actual manufacturing process", says Robertson from HP and continues "This is to ensure you're using the correct components in manufacturing". Under its current system, an HP employee scans in-process products on the production line and then scans the component to make sure it's a match. The use of RFID tags would automatically ensure that the right part is being selected by verifying the component's serial number (Hartswick, 2006).

The logistic providers, logistic companies, fleet managements and all related sector firms must be ready to support these new RFID technology implementations. RFID tags are quite common in the toll collection gates since mid 90's.

Radio Frequency Identification continues to evolve as an adjunct to bar code solutions for supply chain management. One of the advantages of RFID is the ability to scan an entire pallet without having direct line of sight to each case. Major retailers, including Sears, Costco, Home Depot, Lowe's, Albertsons, Target and Wal-Mart, and the Department of Defence and U.S. Department of Agriculture have mandated RFID. More than 50 percent of the mandates involve case and pallet tagging.

There may be some differences for the national regulations about the rule of radio frequency usage. For example if you have tags for your goods and trucks, readable only for Global Positioning System (GPS) in a country, they can not readable in another region. Therefore it is useful to prepare necessary regulations to implement RFID strategy.

For the international supply chains, firstly, there are basic transformation processes in other words activities related with the conversion of raw materials into finished goods available for consumption. These activities are raw material extraction, component part production, finished goods assembly and location specific activities such as distribution.

Secondly, there are transportation processes which integrate these transformation processes into an international supply chain. These activities include the storage, access and routing of goods. Therefore there are specific interdependencies between these activities that operate under the global logistics network (Hamilton, 2005). Because international SCM requires the development of a frame work for both the transformation of raw materials into finished goods and the transportation of these materials across borders.

The use of Information and Communication Technology (ICT) speeds up the exchange of information and allows for more efficient customs operations including risk management techniques. It also provides management with advanced information for planning; gives shippers greater choice and improves the quality of service. The use of ICT especially integrated applications of MIS, GIS and GPS/GNSS are necessary to be introduced in multimodal transport and Supply Chain Management. (Aydin et al., 2006)

Therefore, in this paper it is tried to develop a new business process model which will benefit from the European Geostationary Overlay Service (EGNOS) - first venture into satellite navigation after the US GPS –Global Positioning System- and Russian GLONASS –Global Orbiting Navigation Satellite System- systems. It will be available for users in Europe and beyond to determine their position to within 2 metres (Feijoo, Ramos, & Perez, 1993).

The deployment of the European Geostationary Navigation Overlay Service (EGNOS) covers a large area and involves various countries and partner organisations. By correcting global positioning system signals, EGNOS gives an accuracy of down to 2 metres, compared to the less accurate 15 to 20 m provided by GPS. EGNOS achieves this through a network of ground elements. These are currently being installed all over Europe and architecture of EGNOS is shown in Figure 1.

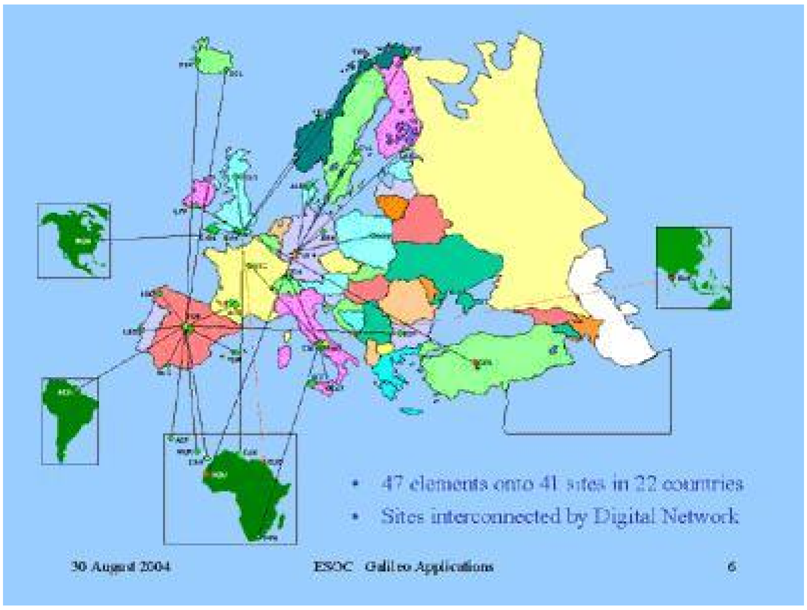


Figure 1. EGNOS Architecture (ESA, 2005a).

The elements that make up the EGNOS system include: Ranging and Integrity Monitoring Stations (RIMS) which pick up GPS signals, Master Control Centres (MCCs) to process the data delivered by the RIMS and uplink stations which send the signal to three geostationary satellites to then relay it back to users on the ground. Deployments so far include all MCCs, all Navigation Land Earth Stations (NLESs) and 31 of the 34 RIMS (ESA, 2005b).

A third European based satellite system called GALILEO has been approved in principle but is not expected to be fully operational before 2008. Designed with interoperability in mind, GALILEO in addition to the others could result in GPS users having access to almost 75 satellites for highly accurate navigation and positioning. These developments have many potential advantages for not only the data collection aspects for GPS users.

On the other hand, SISNeT is a new technology that combines the powerful capabilities of satellite navigation and the Internet. The highly accurate navigation information that comes from the EGNOS (European Geostationary Navigation Overlay Service) Signal-In-Space (SIS) is now available over the Internet and in real time via SISNeT

(ESA, 2005c). Specifically, SISNeT gives access to the wide-area differential corrections and the integrity information of EGNOS.

Since February 2002, the system has been pre-operational, broadcasting an EGNOS-like signal through the Internet, as generated by the EGNOS System Test Bed (ESTB). Any user with access to the Internet (usually through wireless networks - GSM or GPRS) can access EGNOS through SISNeT, irrespective of the GEO visibility conditions. No EGNOS receiver is needed.

The scientific and engineering communities can benefit hugely from SISNeT because they can exploit the ESTB (EGNOS System Test Bed) information simply via the Internet. The system will work shortly like that: There is a PC computer connected to an EGNOS receiver through a serial port.-Base Station-. Several software components are installed on the computer, allowing acquiring the EGNOS messages and sending it to a remote computer (data server) in real time. There is a Data server-a high performance computer, optimized for running server applications with a large amount of connected users. The data server functionality is implemented through a Software application called SDS. This software receives the EGNOS messages from the base station. Afterwards, transfers them to the remote SISNeT users in real time. There is a user application software in the system. It obtains the EGNOS messages in real time (1 message per second or 250 bps) from the data server.

## 3. Proposing a New Information and Communication System

By utilizing newly emerging technologies in this section of the study framework for business process model is proposed. While developing such a system activities are inspired form the proposal of Stet (Stet, 2006). These logistics activities using the new technologies are shown in Figure 2.

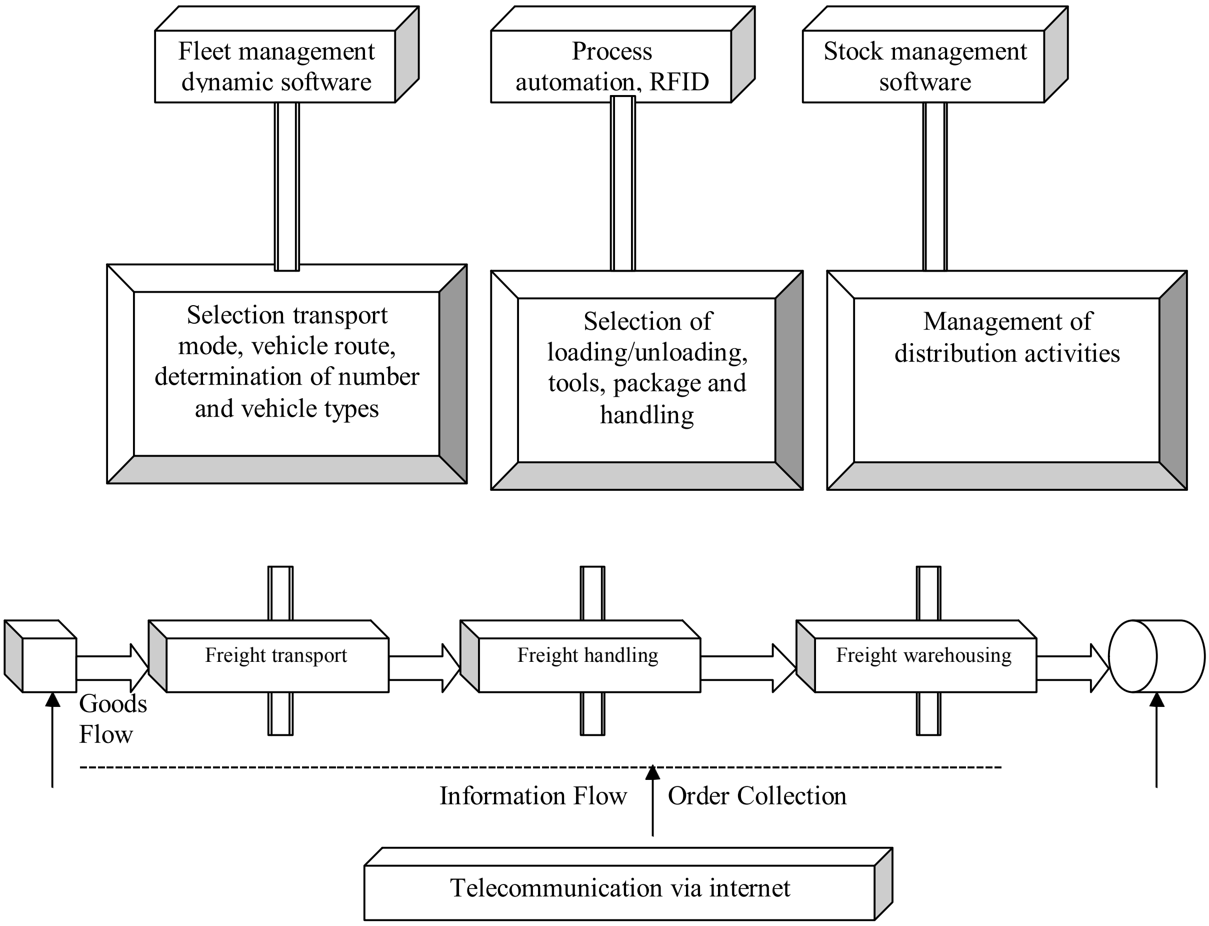


Figure 2. Logistic activities using the new technologies (Stet, 2006).

In the frame of this reference proposed information system integrates GIS, GPS/GNSS and RFID technologies. Proposed information system is denominated as Integrated-Supply Chain Manager (I-SCM). I-SCM covers six different entities: customers, RFID, GPRS, transportation service providers, storehouse providers and material providers. Customers and suppliers are third party entities but RFID and GPRS are tools that provide information to the system. In the frame of this reference, information flow between these entities is shown in Figure 3.

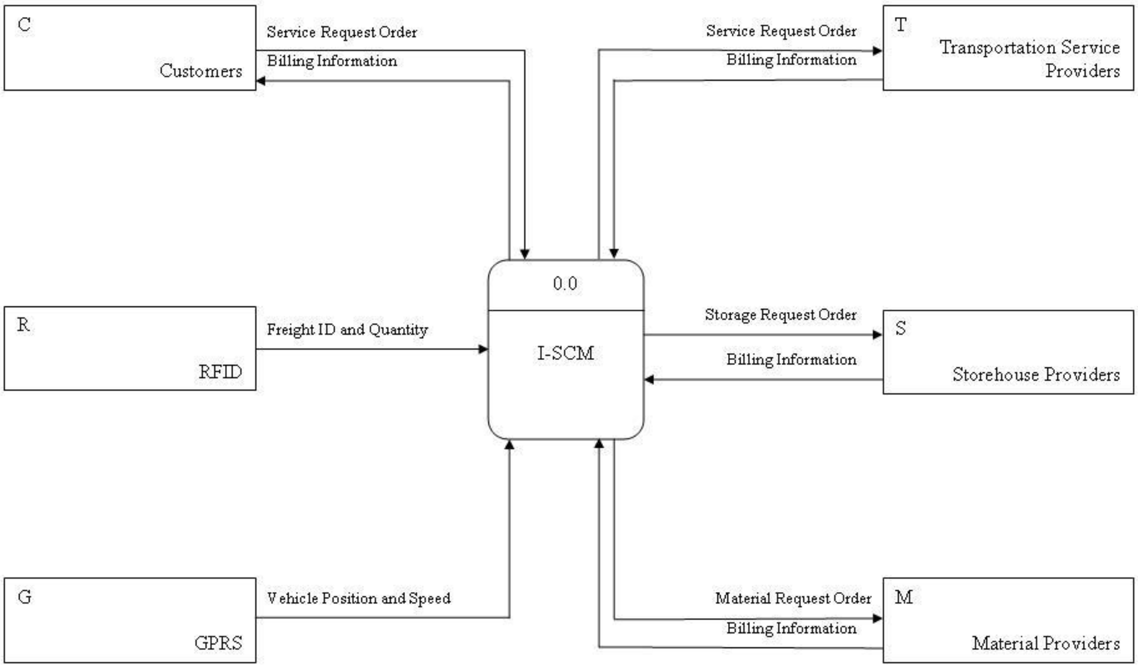


Figure 3. Context diagram of proposed MIS.

In this proposed system it is necessary to automate common warehouse tasks, such as sending advance shipping notices, or receiving of goods based on RFID data. Therefore entire MIS can be set up to alert a manager when warehouse inventory needs to be replenished based on how many products have been shipped.

Vehicle position and speed data comes from G module which depends on vehicle tracking system. Technologically advanced method of remote vehicle tracking and monitoring is based on GPS or GNSS systems. Each vehicle in any logistic fleet is equipped with GPS module that receives signals from series of satellites, calculates its current geographical location and, transmits to a central Server where it is displayed on a high resolution geographical map. The data is transmitted instantaneously after capturing (Real Time Tracking).

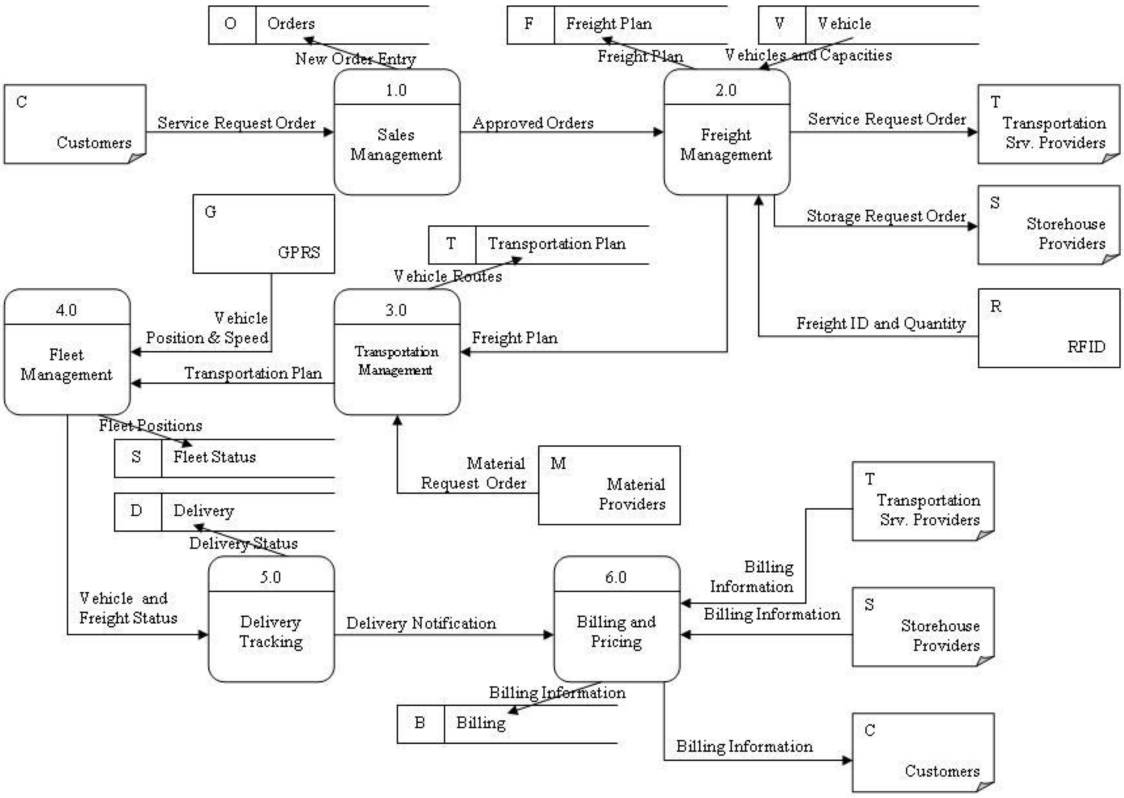


Figure 4. 0-level data flow diagram of proposed MIS.

I-SCM obtains the required data from those entities and lets managers and operators to process those data. Mainly there are six different processes: sales management, freight management, transportation management, fleet management, delivery tracking and billing and pricing. Data flow among these processes is shown in Figure 4. Proposed system, like the other applications of MIS, utilizes one database and tables of the database are also shown in the figure.

In SCM in any production facility, when an item is produced, each item is tagged with a RFID, packed in a batch and then it is stored at a warehouse location. For the transportation purpose, it is loaded on trucks to deliver the products to the dealers. Before loading each item, it is possible to register in data base of the system assuming each item passed through RFID interrogator.

The truck loading the product is equipped with GPS which helps to track its location during transit and all the location data of the truck is being transmitted to central server (Communication channel may be GPRS or RF). When trucks arrive to the warehouse of dealer, again all products are passed through RFID Interrogator passage and automatic entry/receiving of product is made in central database server.

One another requirement is that the software should be used to translate data from one format to another. Therefore, companies own ERP software systems must be integrated to the proposed system. The movement of assets from raw material warehouse to production unit and then to dealers can be easily monitored from any logistics integrated ERP software.

## 4. Conclusion

There are new approaches in logistic and Supply Chain Management through the development of Information and Communication Technologies. Now it is quite easy to process data provided by a Geographic Information System. It is possible to combine the programming techniques such as the object oriented graphics, use of relational databases, electronic maps, and radio frequency identification.

The need for the optimization efforts is always necessary for the logistic operations. In consequence, logistics managers should constantly be in search of finding opportunities to minimize costs. The logistic service providers have to involve better communication and increase use of information technology if they wish to operate efficient and keep supply chain costs to minimum level.

For the optimization of goods movements in supply chains, it is necessary to develop, implement and adopt new business processes, based on the new Information Technologies and Communications such as Radio Frequency Identification, Geographic Information System, and European Geostationary Overlay Service like it is proposed in this paper.

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# QUALITY FUNCTION DEPLOYMENT FOR DEVELOPING E-SUPPLY CHAIN SOFTWARE: AN EXAMPLE FOR TEXTILE ENTERPRISES

Süleyman BARUTÇU[1]

## Abstract

*In the highly competitive textile industry, competitive pressures are driving textile companies to take a new look at supply chain activities and their relationships among supply chain. In this competitive environment, a closer relationship with suppliers is very important. Therefore, textile companies need new tools to increase infrastructure of communication and relationship in supply chain. In order to develop better communication and relationship, companies need internet-based Supply Chain Management (SCM) systems and electronic supply chain software (e-supply chain software). E-supply chain software makes it easier for companies to select suppliers, to compare the different prices quickly and makes communication among supply chain partners. Any company using internet should comfortably work within internet-based SCM system via e-supply chain software. Therefore, the characteristics of e-supply chain software are very important in order to meet companies' needs in internet-based SCM. Although there is much different software about SCM, they are very expensive and complicated. Therefore, it is very important to learn and understand textile enterprises' real wants and expectations from e-supply chain software so as to offer more effective and cheaper e-supply chain software. The Quality Function Deployment (QFD) methodology will help software designer recognize managers' expectations from e-supply chain software and define e-supply chain design requirements to meet their needs. This paper explores the role of e-supply chain applications and software to improve effectiveness of supply chain management and highlights how e-supply chain software could be designed using QFD and House of Quality (HOQ) methodologies. This study has been resulted in some recommendations for developing effective e-supply chain software for textile companies.*

Keywords: E-supply Chain Software, Internet-Based Supply Chain Management, Quality Function Development, House of Quality

## 1. Introduction

Internet, Supply Chain Management, Internet-Based Supply Chain Management and E-Supply Chain (Electronic Supply Chain) Software have recently attracted tremendous interests from both academia and many industries. The internet and e-supply chain software provide a pervasive communication infrastructure as well as immense business opportunities for companies. This e-supply chain software can support companies in supply chain and allows the manufacturers, their suppliers and subcontractors to quickly and efficiently manufacture and deliver products and services. Therefore, e-supply chain software can contribute significantly to the communications across multiple supply chain partners.

There is different software about SCM and Customer Relationship Management. However, the problem is that software for SCM is very expensive and also very complicated for textile companies. Hence, being developed effective and cheap e-supply chain software is a crucial issue. In the e-supply chain software developing process, understanding manager's and user's expectations from this software is one of the most important issues. Quality Function Deployment (QFD) is an effective and important methodology to develop a product, service, process, and software from users' perspectives, because it looks for and prioritizes customer wants and maximizes positive quality that creates more customer satisfaction.

The aim of this study is to determine managers' wants and expectations from e-supply chain software for textile supply chain. In this paper, (1) concepts of e-supply chain, internet-based SCM and QFD are reviewed, (2) the benefits of QFD methodology to develop e-supply chain software are explained, (3) surveys and interviews conducted on 17 textile companies to find out what they expected from e-supply chain software using QFD methodology are presented.

## 2. Internet and Supply Chain Management

The new meeting point of companies is now internet. Nowadays, more and more companies are using it to communicate from suppliers to final customers. Internet allows manufactures, suppliers and customers to meet at electronic marketplace in order to search, order, sell products and services or communicate among them efficiently. Internet, internet marketing, e-commerce (electronic commerce), information technology have had a huge impact on

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business. They also have some effects on supply chain relationship. Information exchanges in supply chain can be made at the touch of a button in extranet or internet.

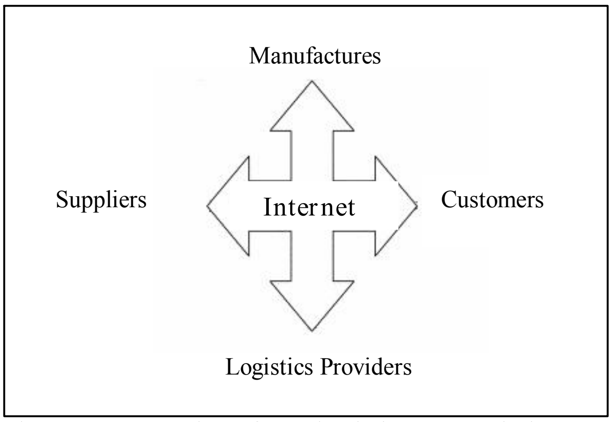



Figure 1. Connection of supply chain partners in internet

Companies are using internet technologies to reach out to their suppliers, manufacturers, logistics providers or customers and provide a point of contact 24 hours a day, 7 days a week. The internet has become a convenient and effective tool to communicate in real-time (Lancaster et al., 2006). As seen in Figure 1, internet provides communication infrastructure for companies in supply chain. With the communication and interactivity brought about by the internet, the physical locations of companies may no longer be important. The meeting place of supply chain members is now internet and internet-based SCM reshapes the supply chain activities. Manufacturing, as well as design and logistics, may be managed by other companies efficiently via internet. In another word, managers can keep a close watch on supply chain activities from internet. Many internet-based communication technologies represent relatively affordable solutions as compared to more traditional information systems for conducting electronically mediated exchange (Myhr & Spekman 2005: Helander & Jiao, 2002). Internet provides a real-time, dynamic and distributed platform for information and feedback to be exchanged for interactive supply chain applications. The primary advantages of internet utilization in SCM are speed, decreased cost, flexibility, and the potential to shorten the supply chain (Lancaster et al., 2006: Lankford, 2004). For example, it improves information participation, finds new suppliers and helps to reach new markets, customize their products and services by procurement some parts and sell them on the internet (Barutçu, 2005). Therefore, internet has changed the ways that supply chain activities and supplier-manufacture-customer-logistic provider relationships. The current internet revolution and internet-based technologies have created new opportunities for further improvements in SCM and increased technical opportunities for communication among companies, suppliers and customers.

Lancioni et al. (2000) discussed for the first time how the internet was being used in managing the major components of supply chain including transportation, purchasing, inventory management, customer service, production scheduling, warehousing, and customer relations. Garcia-Dastuque and Lambert (2003) discuss how the internet can lead to more efficient SCM. The internet cares for the integration of business processes across the supply by facilitating the information flows that are necessary to coordinate business activities. Electronic linkages have enabled companies to fundamentally alter supply chain relationships by enabling transaction cost reduction through electronic handling of orders, invoices, and payments (Garcia & Lambert, 2003).

A key point in successful SCM is that the entire process and supply chain must be viewed as one system. The performance of each member of the supply chain (suppliers, manufacturing plants, warehouses, customers, etc.) affects the overall performance of the supply chain (Duclos et al., 2003). Therefore, companies in supply chain need system to control entire supply chain. One of the system to follow, monitor and control supply chain system is internet-based SCM model and as technology has advanced, internet-based SCM has become an increasingly important topic to businesses.

### 2.1. Internet-Based Supply Chain Management and E-Relationship

With the emergence of the global economy, today's business environment is more competitive than in the past. Relationships throughout the supply chain are integral to a successful organization. Improved communications among trading partners can result in quicker diagnosis, feedback and solutions to inventory and customer service problems (Lancaster et al., 2006). Suppliers, manufactures, customers and logistics providers are part of the supply chain. Internet-based SCM looks at the relationship among them in the context of value added procedures or services via internet. In this point, electronic relationship (e-relationship) and communication are very important. O'Toole, (2003) analyzed e-relationship in internet-based SCM and examined the emergence of the e-relationship and the potential value it offers to a business. The emergence of e-relationships supported by technological developments aims at linking companies to their suppliers, manufactures, customers and logistics providers in internet-based SCM system.

Kulkarni (2001) defined internet-based SCM as a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Narasimhan (2001) defined internet-based SCM as the control of material and information flows, the structural and infrastructural processes relating to the transformation of the materials into value added products, and the delivery of the finished products through appropriate channels to customers and markets in order to maximize customer value and satisfaction.

Internet-based SCM is also an attempt by companies to increase the efficiency of their supplier relations. With an emphasis on automated communication, E-SCM limits the amount of paperwork, filing, and record keeping needed. The system also allows for companies to implement Just in Time or similar inventory systems, furthering the operational efficiency (Lancaster et al., 2006). An example of internet-based SCM can be found by looking at Wal-Mart and Procter&Gamble (P&G) or Aygaz (one of the gas provider for car in Turkey) and gas stations. P&G and Aygaz is able to monitor the inventory levels of its products at Wal-Mart distribution centers and gas station. Doing so assures that a Wal-Mart store will never run out of a P&G product. At the very least, the system provides early warning signs when that product is running low or online distribution route is determined the level of each gas station and their sales (Koch, 2002; Tanyeri & Barutçu, 2003). In 2000, Ford and General Motors announced the switching of their supply management system from electronic data interchange (EDI) to the Internet. They opened new web site; for example, Ford's system is Auto-Xchange (www.auto-xchange.com) and GM's TradeXchange (www.gmtradexchange. com) (O'Toole, 2003).

### 2.2. The Benefits and Opportunities of Internet-Based SCM System

By the 1990s, companies recognized the necessity of looking beyond the borders of their own companies to their suppliers, suppliers' suppliers, and customers to improve overall customer and consumer value (Duclos et al., 2003). Effectively managing your supplier relationships will reduce direct and indirect costs, improve quality, and speed your responsiveness to your customers. The company can dramatically improve the speed and quality of information flow through and beyond your organization to your supplier's suppliers (www.techsol.com).

There are many benefits associated with internet-based SCM, most centering on the speed and ability to communicate, the decreased costs of communication and carrying inventory, and customer service. Speed and ability to communicate can be seen throughout the supply chain (Lancaster et al., 2006). An internet-based supply chain is perceived as having many advantages: for example; increased business efficiency, enhanced information flows, improved transaction speed, wider geographical spread, increased temporal reach, cost reduction and competitive differentiation for companies in supply chain (Hoffman et al., 1995; Zank & Vokurka, 2003).

Rahman (2004) summarized some of the opportunities resulting from the inclusion of internet in the supply chain from the literatures (especially from Business World and Business Today) as following. Companies in supply chain have the ability; (1) to reduce service costs and response time, (2) to be more responsive to customer service problem, (3) to schedule pickups and deliveries, (4) to directly communicate with vendors, customers, etc. regarding supply issues on a seven-day/24 hour basis via e-mail, (5) to track equipment locations including rail, cars, trucks, and material handling equipment, (6) to pay invoices electronically and to check outstanding debit balances, (7) to notify vendors of changes in configurations in products that are produced to order, (8) to place bids on projects issued by government and industry buyers, (9) to check the status of orders placed with vendors, (10) to receive orders from international customers, (11) to provide 7-day/24-hour worldwide customer service, (12) to schedule outbound shipments from private and public distribution centers on a 24 hour basis, (13) to reserve space in public warehouses for anticipated deliveries to market locations, (14) to contact vendors or buyers regarding customer service problems from late deliveries, stock-outs, alterations in scheduled shipment dates, late arrivals, and wide variety of other services issues, (15) to track shipments using a wide variety of modes including truck, rail, and air transport, (16) to monitor online vendor catalogs from which buyer can find, select, and order items directly from suppliers without any human contact.

Lancaster et al., (2006) emphasized that internet-based SCM has allowed for a greater exchange of information throughout the supply chain, and companies can get benefits from lower inventory levels, quicker response to problems, higher quality levels, higher customer satisfaction, and more diverse product offerings. However, all these benefits remains to be seen if all companies in supply chain are willing to exchange that information and use e-supply chain software.

### 2.3. E-Supply Chain Software in Textile Supply Chain

Companies recognize that improved management of supply chains can be a source of competitive advantage. As a result, many of them have reorganized purchasing and logistics functions into SCM system and they have invested heavily in software to manage the information flows in the supply chain (Sherer, 2005). From 1999 to 2002, software development companies sold more than $15 billion in internet-based SCM software licenses. And this does not include the cost of installation and maintenance contracts (Kanakamedala et al., 2003). A common problem with many software implementations is the installation of software without reengineering the company business processes. Since the concept of SCM has been focused on fulfillment, often separate from the responsibility of marketing, opportunities for process redesign have been overlooked (Sherer, 2005).

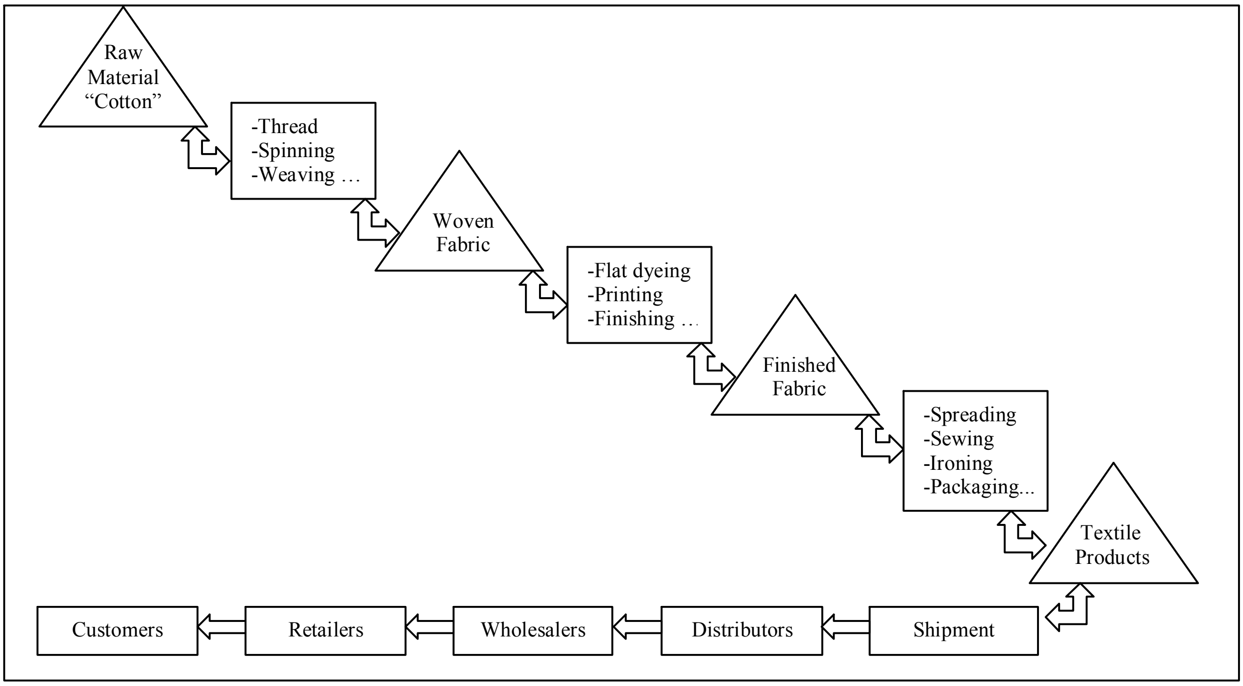


Figure 2. Some of the main stages in textile supply chain

As seen Figure 2, there can be many processes, suppliers and customers (final customers or hotels etc.) in textile supply chain. In this textile supply chain, information flows among them are very important. If textile manufactures or distributors have e-supply chain software in order to communicate among partners or monitor manufacturing process, they will have many advantages and get benefits from e-supply chain software. For example, using internet-based SCM and e-supply chain software can allow textile companies to select the most appropriate suppliers of the manufacturers to deliver the competitively priced, high quality textile products to their customers according to their demand. The e-supply chain software provides other benefits as well. Using internet-based SCM and e-supply chain software, textile companies can get following benefits and add value to companies; (1) improvement in overall performance, (2) design of global and local solutions efficiently, (3) control of costs easily, (4) greater flexibility, (5) monitor all companies in supply chain (6) control the complete supply chain, (7) compress cycle times, (8) build sustainable, workable supplier relationships. As a result, performance of suppliers can be monitored effectively using e-supply chain software. It increases the efficiency of processes associated with acquiring products and services, managing inventory, and processing materials. In order to get these benefits, companies in supply chain should use effective e-supply chain software. In this point, it is very important to develop e-supply chain software from users’ perspectives and QFD is a suitable methodology to expose users’ wants and needs.

## 3. Quality Function Deployment for Software Development and Design

Shigeru Mizuno and Yoji Akao developed QFD technique in Japan in the late 1960s. They wanted to develop a quality assurance method that would design customer satisfaction into a product before it was produced, because prior quality control methods were primarily aimed at fixing a problem during or after producing. Since 1966, QFD has been used world wide in many industries to (1) prioritize spoken and unspoken customers’ wants and needs, (2) translate these needs and wants into actions and designs such as technical characteristics and specifications, and (3) build and deliver a higher quality product or service by focusing various business functions toward achieving customer satisfaction (www.qfdi.org).

Akao (1990) defined QFD as “a method and technique used for developing a design quality aimed at satisfying the consumer, and then translating the consumer's requirements into design requirements and major quality assurance points to be used throughout the production stage”. House of Quality (HOQ) named by Hauser and Clausing provides a basic implementation tool for managing QFD throughout the design, development, and manufacturing of a product and service (Hauser & Clausing, 1988).

QFD can be applied to the software development (Haag et al., 1996: Herzwurm et al., 2003) website and e-store design. Haag et al. (1996) adapted QFD to software design and called Software Quality Function Deployment (SQFD) focused on improving the quality of the software development process by implementing users’ and company managers’ wants. Haag et al. (1996) defined SQFD as “a front end requirements solicitation technique, adaptable to any software engineering methodology that quantifiably solicits and defines critical customer requirements”. They described SQFD as an adaptation of the HOQ and a front end process that proceeds the software development life cycle. Although using QFD is not new to the software industry, QFD is important to develop e-supply chain software because it provides a methodology for handling the user wants for supply chain activities.

A number of activities must be conducted when carrying out QFD. Some of the typical activities are listed as follows: (1) analyzing customer requirements, (2) identifying design features, (3) establishing interactions between customer requirements and design features, (4) carrying out competitive benchmarking in technical and/or market terms, (5) analyzing the results and deriving implications (Huang & Mak, 2002). All activities in developing e-supply chain software using QFD and HOQ methodologies are arranged in order and the planning procedure for a QFD process to develop e-supply chain software is expressed step by step as follows in Figure 3.

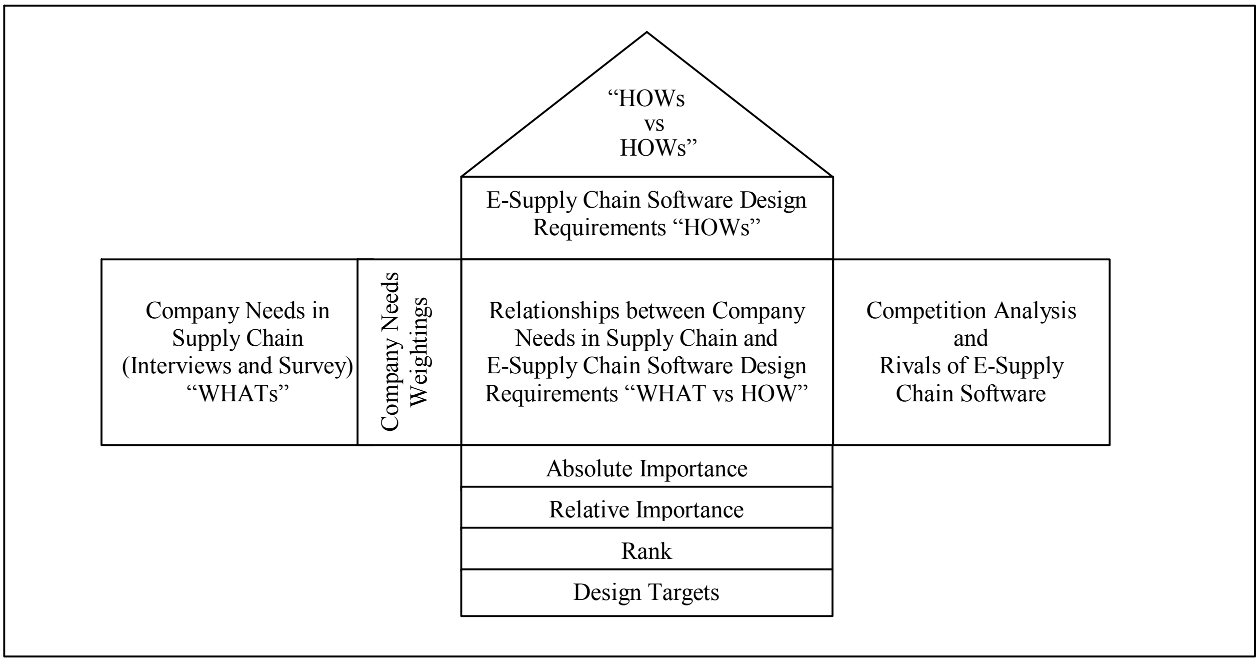



Figure 3. Steps to creating a HOQ for e-supply chain software development

In Figure 3, seven steps HOQ for developing e-supply chain software model are illustrated; (1) identify company wants and needs from e-supply chain software (WHATs), (2) determine the relative importance ratings of their wants and needs, (3) generate e-supply chain software design requirement (HOWs), (4) identify different of e-supply chain software and conduct competitive analysis among e-supply chain software developed before, (5) determine the relationships between HOWs and WHATs, (6) Determine relative importance of HOWs vs WHATs, (7) determine design targets for developing e-supply chain software. To apply QFD to e-supply chain software development for textile supply chain, all these steps are carried out successfully.

## 4. E-Supply Chain Software Development Process for Internet-Based Textile Supply Chain

To implement internet-based SCM can require some systems such as internet, software for supply chain member and networks. Internet and e-supply chain software are the interface among all side of supply chain. Therefore, companies used internet-based SCM need internet connection, e-supply chain software in order to share all information, direct communication and increase information flows through supply chain. Applying QFD to the software development process can control software quality and customer expectations. In this section, how e-supply chain software design features are determined using QFD methodology are explained step by step below.

### 4.1. Research Methodology

In questionnaire design stage, the interviews were conducted with five textile managers so as to expose their wants from e-supply chain software. According to interviews, a questionnaire was created to reveal textile managers' needs and wants from suppliers' web design and e-supply chain software for textile supply chain. Sample size of this research was determined 30 textile companies, because high sample size is not suitable for Analytic Hierarchy Process (AHP) to prioritize and calculate importance degrees of managers' wants from e-supply chain software.

In sampling stage, first, 30 textile companies were listed from Industry Inventory of Denizli using convenience sampling that is one of the nonprobability sampling methods. In this sampling method, the researcher selects the most accessible managers or owners from which to obtain information. Second, textile managers were approached for a questionnaire and managers from 17 companies agreed to participate and complete questionnaires. Third, textile managers who provided reasons such as no time, hard and irrelevant managers replaced new managers. Finally, 20 questionnaires in 17 textile companies were completed and analyzed for QFD for internet-based SCM software development process.

There were two questionnaires. In the first questionnaire, there were thirty questions. Four of them were about demographic characteristics of companies and respondents. Twenty-four of them were close ended questions (scaled from 1=extremely unimportant to 5=extremely important) to weight managers' needs and two of them were open ended question to reveal managers' opinions about internet-based SCM. The last two questions in the survey are "what do you think about e-supply chain software? and e-supply chain software is really necessary for your companies or not?. In the second questionnaire, there were thirteen questions to prioritize thirteen managers' wants and respondents were asked to compare their wants each others.

### 4.2. Results of the Research

As seen in Table1, most of respondents' ages are 46 years-old and above and they have undergraduate degrees. 8 of 17 companies are medium-sized company employed 251-1000 workers and most of respondents work as General Managers positions (Table 1).

Table 1. The characteristics of respondents and companies

| *Variable* | *Frequency* | *(%)* | *Variable* | *Frequency* | *(%)* |
|---|---|---|---|---|---|
| Respondents' Age | | | Company's Size (number of workers) | | |
| Below 30 | 4 | 20 | A big company (1001-1500) | 5 | 29,42 |
| 31-45 | 5 | 25 | A medium company (251-1000) | 8 | 47,05 |
| 46 and above | 11 | 55 | A small company (10-250) | 4 | 23,52 |
| Respondents' Education | | | Respondent's Positions | | |
| High School | 4 | 20 | General Manager | 10 | 50 |
| Undergraduate | 14 | 70 | Purchasing Manager | 4 | 20 |
| Graduate | 2 | 10 | Owners' of Company | 6 | 30 |

In the last two open ended questions, most of respondents (85%) thought that e-supply chain software and internet-based SCM systems were important for a better flow of information from suppliers, customers, and logistics providers to manufactures, however, just three respondents (15%) thought that e-supply chain software was necessary for them. In another word, they thought that e-supply chain software was not necessary for their textile companies nowadays, however, it would be very important in future so as to be very competitive.

Based on the survey result, some managers' wants were selected as listed in Table 2. In this process, the cut-off method was used to eliminate eleven managers' wants which were not very important in e-supply chain software design or the mean values ($\bar{x}$) of questions were lower than 3,5 ($\bar{x} \leq 3,5$). Finally, thirteen managers' wants were taken into consideration in e-supply chain software developing process. As seen in Table 2, the most important managers' wants are; (1) monitor all process in textile supply chain, (2) design for just textile manufacturing processes, (3) design for being used all supply chain activities like procurement, manufacturing, logistics, communication etc. in one software, (4) automatic notification of emergencies (for example, the notification of delays in order ship dates to suppliers, customers and logistics providers etc.) in textile supply chain, (5) simple order processing and purchasing from suppliers' inventory. Therefore, "WHATs" list of HOQ was obtained from the survey.

Table 2. Listing and weighing of managers wants from e-supply chain software

| Manager of companies wants from e-supply chain software (WHATs List) | Mean | SD | Total | Relative Importance | % |
|---|---|---|---|---|---|
| Monitor all process in textile supply chain | 4,55 | 0,89 | 23,433 | 0,1305 | 13,05 |
| Design for just textile manufacturing processes | 4,50 | 0,69 | 19,342 | 0,1077 | 10,77 |
| Design for being used all supply chain activities in one software | 4,50 | 0,76 | 21,211 | 0,1182 | 11,82 |
| Automatic notification of emergencies in textile supply chain | 4,25 | 0,91 | 16,219 | 0,0903 | 9,03 |
| Simple order processing and purchasing from suppliers' inventory | 4,20 | 0,95 | 9,342 | 0,0520 | 5,20 |
| Fast communication with all companies in textile supply chain | 4,10 | 0,91 | 13,397 | 0,0746 | 7,46 |
| Follow the order status in textile supply chain | 4,00 | 1,17 | 10,345 | 0,0576 | 5,76 |
| Reliable for every company in textile supply chain | 3,95 | 1,05 | 11,846 | 0,0660 | 6,60 |
| Send certain information to some suppliers or companies automatically | 3,95 | 1,15 | 12,359 | 0,0688 | 6,88 |
| Watched inventory levels of wholesalers, retailers and customers | 3,80 | 1,20 | 10,354 | 0,0577 | 5,77 |
| Simple and easy interface of e-supply chain software | 3,75 | 1,16 | 11,346 | 0,0632 | 6,32 |
| Enable supply chain partners to work together | 3,60 | 1,05 | 8,390 | 0,0467 | 4,67 |
| Modeled for a different textile supply chain easily | 3,50 | 1,10 | 11,942 | 0,0665 | 6,65 |
| Total | - | - | 179,526 | 1,0000 | 100 |

Identifying e-supply chain software design characteristics (HOWs) which would respond to managers' or users' expectations is the next step in HOQ model. The Design requirements (HOWs) representing the designer's responses to their wants. E-supply chain software should be designed to capture data about events and produce information in the form of reports so textile managers can evaluate their production, inventory, logistics and etc. operations. After determining managers' wants and expectations from e-supply chain software, e-supply chain software design characteristics are determined by QFD team and ordered as;

- Online automatic data capture system

- Using XML (The Extensible Markup Language) software for special information flow from different suppliers
- High speed computers and servers of companies in textile supply chain
- Simply customized for a different supply chain
- Integrating and synchronizing all supply chain activities
- Password protected and 128-bit SSL certificate
- Advance planning and scheduling systems of supply chain activities
- Contain only textile supply chain activities
- Using across in supply chain partners
- Good organized menu, toolbar and screen design

The next step in HOQ model is prioritizing managers' wants. AHP is used to calculate importance degrees of managers' wants from e-supply chain software. A second questionnaire to prioritize their wants was prepared. In this questionnaire, there were thirteen managers' wants and respondents were asked to compare their wants each others (13*13 matrix) using a five-point itemized rating scale from 1/5- extremely less unimportant to 5-extremely more important scales. Therefore, which managers' wants were more significant than the others and relative importance of each wants were determined as listed in Table 2.

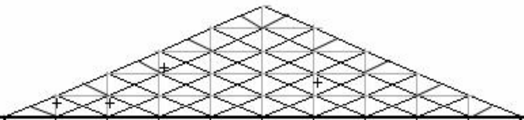
### 4.3. Developing House of Quality

In this stage, HOQ is developed from surveys results. HOQ for e-supply chain software design that involves 13 managers' wants (WHATs) and 10 e-supply chain software design characteristics "HOWs" in Figure 4 is presented. The next step of HOQ model is determining relationships between WHATs and HOWs. This stage is very important work in HOQ performed carefully and collectively by e-supply chain software designer. This relationship could be determined by analyzing to what extent the HOWs could technically relate to the WHATs. In this study, a three level rating scale {very weak relationship (1 or Θ ) , medium relationship (5 or O) and very strong relationship (9 or ▲ )} are used to indicate the degree of strengths between HOWs and WHATs. For example, there is very strong relationship between "Monitor all process in textile supply chain" and "Online automatic data capture system". The relationships between WHATs and HOWs are presented in Figure 4. After determining e-supply chain software design characteristics, correlation matrix of "HOWs" is analyzed. This matrix is to help the software design experts to determine which HOWs are correlated and the extent of these correlations. In the matrix, (+) indicates positive correlation, (-) indicates negative correlation. For example, there is positive correlation between "Online automatic data capture system" and "Using XML software for special information flow from different suppliers". The XML is effective tool to improve the functionality of the internet by providing flexible information structuring from their databases or computers. XML is a markup language used to design web pages. Unlike hypertext markup language (HTTP), XML is able to use tags that communicate specific meaning. XML allows for companies in supply chain to send data to and from different applications from companies database to internet. Another word, with using XML, special information can be published in internet automatically. Therefore, there are positive relations between online data capture systems and XML.

Evaluating different e-supply chain software is very important in HOQ. However, in spite of a lot of software about internet-based SCM systems and not much used in Denizli, I evaluated the relative design performance of the rival e-supply chain software (mySAP SCM and PeopleSoft Enterprise Supply Chain Management) from their web address (www.sap.com/solutions/business-suite/scm/index.epx and www.oracle.com/applications/supply-chain-management.html). The managers' wants from e-supply chain software are compared with mySAP SCM and PeopleSoft ESCM software by the 5 point scales (0-very poor, 100-very good). For example, in terms of designing for textile supply chain, automatic notification of emergencies in textile supply chain, and modeled for a different textile supply chain easily, mySAP SCM and PeopleSoft ESCM are very poor. Therefore, some of the managers' wants are not met from them. These wants will be very important requirement for new e-supply chain software design.

### 4.4. Managerial Implications and Recommendations to E-Supply Chain Software Designers

The QFD methodology is implemented in e-supply chain software development process and translated managers' or users' wants from e-supply chain software into e-supply chain software design requirements. According to QFD analysis, e-supply chain or the internet-based SCM software meets the following features; (1) having online automatic data capture system, (2) displaying manufacturing process, production schedules, their inventory levels, logistics information for supply chain partners etc., (3) integrating and synchronizing all supply chain activities, (4) containing only textile supply chain process, (5) enabling supply chain partners to work together, (6) having security system like password protected and 128-bit SSL certificate (7) having advance planning and scheduling systems of supply chain activities, (8) having high speed computers and servers of companies in textile supply chain, (9) containing good organized menu, toolbar and screen design and (10) being developed or customized for their special needs easily.



| Managers' wants from e-supply chain software (WHATs) \ E-supply chain software design requirments "HOWs" | Managers' Wants Weightings | Online automatic data capture system | Using XML software for special information flow | High speed computers and servers of companies | Simply customized for a different supply chain | Integrating and synchronizing all supply chain activities | Password protected and 128-bit SSL certificate | Advance planning and scheduling systems | Contain only textile supply chain process | Using across in supply chain partners | Good organized menu, toolbar and screen design | Rivals mySAP SCM (S) PeopleSoft SCM (P) 0 25 | 50 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitor all process in textile supply chain | 13,05 | ▲ | ▲ | Θ | | Θ | O | | O | O | Θ | | | | S/P |
| Design for just textile manufacturing processes | 10,77 | | | | | ▲ | | Θ | ▲ | O | | S/P | | | |
| Design for being used all supply chain activities in one software | 11,82 | | | | O | ▲ | O | ▲ | ▲ | O | | | S | P | |
| Automatic notification of emergencies in textile supply chain | 9,03 | ▲ | ▲ | O | | O | ▲ | O | Θ | O | | | S/P | | |
| Simple order processing and purchasing from suppliers' inventory | 5,20 | Θ | | | | | O | | ▲ | | ▲ | | | | S/P |
| Fast communication with all companies in textile supply chain | 7,46 | Θ | | ▲ | | | | | | | O | | | S/P | |
| Follow the order status in textile supply chain | 5,76 | ▲ | | | | ▲ | Θ | | Θ | ▲ | | | | | S/P |
| Reliable for every company in textile supply chain | 6,60 | | Θ | | | | ▲ | | O | O | | | | | S/P |
| Send certain information to some suppliers or companies automatically | 6,88 | ▲ | ▲ | Θ | | | | | Θ | Θ | | | S/P | | |
| Watched inventory levels of wholesalers, retailers and customers | 5,77 | ▲ | ▲ | | | | Θ | | | | | | | | S/P |
| Simple and easy interface of e-supply chain software | 6,32 | | | | | | | | | | ▲ | | | | S/P |
| Enable supply chain partners to work together | 4,67 | ▲ | ▲ | O | O | O | O | Θ | O | O | | | | S/P | |
| Modeled for a different textile supply chain easily | 6,65 | | | | ▲ | O | | | | ▲ | | | S | P | |
| Absolute Importance | | 419,1 | 361,2 | 155,6 | 142,3 | 370,0 | 325,9 | 167,0 | 393,4 | 398,3 | 154,0 | | | | |
| Relative Importance | | 14,52 | 12,51 | 5,39 | 4,93 | 12,82 | 11,29 | 5,78 | 13,63 | 13,80 | 5,34 | | | | |
| Rank | | 1 | 5 | 8 | 10 | 4 | 6 | 7 | 3 | 2 | 9 | | | | |
| Design Targets | | + | + | + | + | + | + | + | + | + | + | | | | |

Figure 4. House of Quality for developing e-supply chain software

## 5. Conclusion

As the economy becomes increasingly competitive and global, internet-based SCM will continue to take on a larger role for textile companies. If a textile company in supply chain has difficulty sharing information internally, it is difficult to then supply the necessary information to external supply chain members. Therefore, they need internet-based applications to sharing information about supply chain activities.

Suppliers, manufactures and customers should know how internet-based SCM and e-relationships are used to strengthen ties among supply chain members, how can internet be used to integrate suppliers' systems and which software is required for internet-based SCM. Although, there is a lot of e-supply chain software, they should be designed and developed separately or customized for a certain supply chain. For example, e-supply chain software ought to be developed for textile supply chain and companies. Instead of buying or using complicated systems and expensive SCM software, e-supply chain software developed by QFD will be very useful textile companies.

Consequently, the important design requirements to develop e-supply chain software were determined and QFD methodology translated users' wants to e-supply chain software design characteristics efficiently. The e-supply chain software designers should give to priority these features explained in managerial implications and recommendations section in order to develop more successful e-supply chain software.

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# DEVELOPING SUPPLY CHAIN STRATEGIES : A QUALITY FUNCTION DEPLOYMENT APPROACH

B.Esra Aslanertik[1]

## Abstract

*Companies realized that the effort to obtain products at the right cost, in the right quantity, with the right quality at the right time from the right source is crucial for their survival. These requirements force them to develop new supply chain strategies. To deal with this complexity, new methodologies should be adapted and integrated into supply chain decision making process. Evaluating and selecting right suppliers, providing logistics service which meets customer expectations can help to improve corporate competitiveness. Quality Function Deployment (QFD) is an effective tool to develop supplier evaluating criteria and to improve logistics performance. At the same time it enables companies to prioritize strategic dimensions of supply chain quality and deploy them to improve strategic decision making process. Specifically, this paper addresses the issue of how to integrate QFD into supply chain decision making process to effectively and efficiently improve customer satisfaction.*

Keywords: Supply Chain Management, Quality Function Deployment, Performance Measurement, Customer Satisfaction.

## 1. Introduction

Today's competition forces the companies to change their traditional focus from profitability to customer preferences. Customers become aware of the choices in a very broad perspective and they demand products/services with higher quality, faster delivery but of course with lower prices. In order to achieve competitive advantage, companies should understand and satisfy the needs of customers by adding value to the value chain but at the same time they have to reduce the cost of flexibility and complexity. Value creation for competition is based on three important concepts: customer requirements, cost, quality with continuous improvement

Within the globalization of the markets, Supply Chain Management (SCM) became a significant strategic tool in order to enhance competitiveness, to achieve customer satisfaction and increased profitability. Most of the companies realized that assessing supply chain performance is so important to perform an efficient and effective supply chain. SCM literature indicates that the emphasis is on performance measures dealing with suppliers, delivery performance, customer service, inventory and logistics costs. Also, Kuei, Madu, Lin, Chow (2002:890) states that:

*"Successful SCM depends on how well quality and technology are introduced and managed within the social and technical system of a supply chain".*

On these circumstances, companies try to become quality leadership companies and they began to implement certain quality management approaches. But at the same time, they recognize that sustainable growth not only demands quality leadership and customer satisfaction but also cost leadership, human resource effectiveness and effective business integration with the suppliers. These approaches force the companies to: (Quality Digest, 1998)

- Make quality the centre of increasing revenue growth and competitive leadership
- Achieve complete customer satisfaction by offering essentially perfect goods and services whose quality the customer determines
- Accelerate sales and earnings growth through quality failure reduction
- Innovate in product and service leadership and cycle time management
- Encourage employee participation in quality improvement
- Develop effective supplier partnerships
- Create seamless quality value network among customer, producer and supplier relationships
- Provide environmental and safety leadership.

The term "supply chain management" has a very broad perspective that it also covers issues like customer satisfaction, supplier selection, purchase management which means more than movement of materials or storage and inventory management. Various definitions have been made in the literature focusing on concepts like integration, optimization or the importance of IT. But, the importance of customer satisfaction as a strategic issue has emerged during the last decade. Within this, Mohanty and Desmukh (2005) defined SCM as a loop which starts with customer and ends with customer including the flow of all materials, finished goods, information and transactions. It requires looking at business as one continous, seamless process that absorbs functions such as forecasting, purchasing, manufacturing, distribution, sales and marketing into a continous business transaction. This definition is a very comprehensive definition. By focusing on customer it directly relates SCM to its ultimate goal of achieving competitive advantage and enhanced customer value. Since the customers become the center of success, without a

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satisfied customer, applying supply chain strategies will be unnecessary and costly (Gunasekaran, Patel, Tırtıroglu, 2001). A company that wants to gain competitive advantage through customer satisfaction should:

- Link all performance measurement metrics to customer satisfaction by integrating the customer preferences in all functions.
- Be able to quickly respond the changes in customer preferences.
- Understand its own capabilities relative to these preferences. (Love and Gunasekaran, 1999).

According to Morgan (1996), the ultimate aim of SCM is to attain high levels of customer satisfaction. This offers capabilities that enables the company and its supply chain partners to customize their products and services to meet individual customer needs. (Tracey, Tan, 2001).

Hence, two thing needs to be considered. First, understanding the customer. Second, understanding the own capabilities and performance. With these in mind, it is becoming harder for companies to remain self-sufficient within the challenging business environment. Effective SCM seeks close, long-term working relationships with the partners (both suppliers and customers), sharing information freely, working together to solve common problems during the design of new products/services, jointly planning for the future and at the same time making their success independent (Spekman, Kamauff, Muhr, 1998). In many of these relationships, suppliers are increasingly viewde as partnersand they are deeply involving in all kinds of areas of improvement. Thus, each part should be aware of the other part's needs in order to achieve high quality products and services to achieve competitive advantage through customer satisfaction. Therefore, the process of selection and involvement of suppliers is becoming more important. Research suggests that managing well supplier involvement and selection can lead to better supplier performance, improved manufacturing, product and process advancements resulting with enhanced customer satisfaction and firm performance (Shin et.al,2000).

This study, which is based on different aspects on SCM, contributes to the literature in the following ways:

- Based on the literature review, it discusses the importance of customer focus within the different levels of SCM.
- It emphasizes the use of QFD to enhance customer satisfaction and firm performance.
- Major contributions by researchers for handling the issues of SCM through QFD implementations are identifed and discussed.
- It uses the QFD approach as tool for strategy development and deployment within SCM by suggesting a broad framework.

## 2. Defining QFD

QFD was first introduced in 1972 by Akao at Mitsubishi Industries Kobe Shipyard. (Hauser, Clausing 1988). Akao defined QFD as a method for developing a design quality aimed at satisfying the customer and then translating the customer's demand into design targets and major quality assurance points to be used throughout the production phase. The needs and requirements of customers are called voices of customers. In short, QFD is often referred to as "listening to the voice of the customer". The very specific and unique needs of the customers are met by using the tool " House of Quality ". The process begins with an analysis of customer demands and preferences through a series of matrix diagram and it continues till all requirements have been fully described. Then customer requirements are converted to design requirements. The process results in a total view of the relative quality (voice of the customer) of products/services, the priorities and technical requirements also the difficulties. We can briefly describe the steps as follows: (Hwarng, Teo, 2001)

- Customer requirements (WHATs) are turned into product features
- Product features are translated into design requirements (HOWs)
- Design requirements are transferred to process requirements
- Process requirements are turned into processes or methods

Surveys, content analysis, interviews with customers and visits to the "gemba" are generally used in order to complete the process of gathering the "voice of the customer". According to Masaaki Imai, the author of 'Gemba Kaizen': (http://syque.com/improvement/Gemba.htm)

"Gemba in Japanese means the place where all activities are actually taking place; in other words, the place where value is added. In case of the manufacturing industry, gemba is the shop-floor; for the hotel industry, it is the place where the food is actually being cooked; and in case of the service industry; it is everywhere. Gemba is thus the most precious place for the management". All the information gathered is analyzed in the matrices of House of Quality. The traditional House of Quality is given in the figure 1.

Despite its apparent easiness, if information contained in the House of Quality is not sufficiently accurate, QFD can become a misleading tool. Its correct and effective use needs a careful design analysis and an accurate data collection (Vanegas and Labib, 2001).

In the dynamic competitive environment, an organization's vision, mission and strategies are the fundamental elements. Success will be of those who are able to take strategic decisions faster and better. QFD is a complex tool that can significantly help to achieve a customer oriented view for strategic decision making. QFD as a tool for strategic decision making offers improvements in the areas of;

- Customer Driven Strategies
- Strategies for risk management

- Product redesign decisions
- Innovation strategies
- Strategic cost management decisions
- Supply chain strategies
- All other related issues of business strategies and decision making

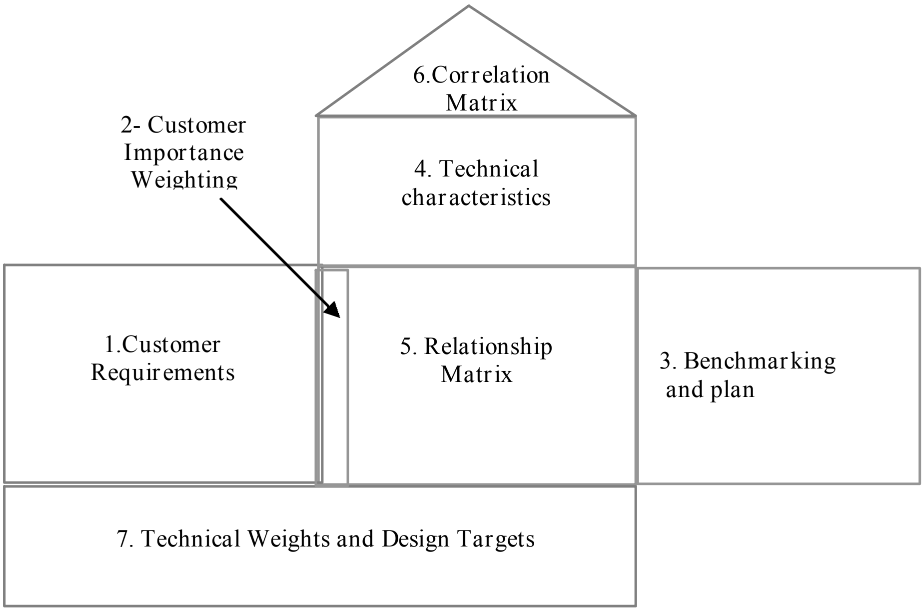


Figure 1: House of Quality

In addition to all these, QFD is a multi-disciplinary tool that combines different methods for thinking, learning, solving problems and taking effective actions. Integrating the different concepts and methods will help to analyze the business both from the aspect of technical and non-technical issues of customer satisfaction. Some specific methods related and/or integrated with QFD are; Concurrent Engineering, TRIZ, Theory of Constraints, and Analytical Hierarchy Process (AHP).

## 3. QFD and SCM

In today's market most of the companies have recognized the importance of quality within a broader supply chain view. Many researches have been made to emprically derive the importance of quality in order to achieve supply chain excellence. Supply chain quality management is a customer driven approach and strategies derived on this approach must be centered on these critical dimensions: (Ahire, Golhar, Waller, 1996; Flynn, Schroeder, Sakakibara, 1994)

1. customer focus and customer involvement
2. superior supplier quality and supplier involvement
3. human resource management
4. top management support
5. product design
6. process management

Within the concept of quality management, QFD is an effective tool to deal with the questions like what to do (requirements) and how to do (translated design requirements). It allows reducing the length of the product development cycle, while simultaneously improving product quality and delivering the product at a lower cost (Akao, 1990). Although QFD has been proved to be a successfull tool, the application of QFD within the issues of SCM is rarely found in the literature. These studies can be listed as follows:

- Using QFD for strategic deployment of supply chain strategies.
- Integration of QFD, AHP and Preemptive Goal Programming (PGP) for the supplier selection process.
- Optimizing SCM using a triangular fuzzy QFD algorithm.
- Using a fuzzy QFD approach for the strategic management of logistics service.

In their study of strategic deployment Kuei, Madu, Lin, Chow (2002) conducted interviews with the supply chain experts. Participants were asked to prioritize strategic dimensions of supply chain quality and technology and to brainstorm potential operating initiatives for better level of supply chain excellence. In the study, QFD was used to correlate critical perspectives of supply chain quality, technology management and the potential operating initiatives. The "what to do" portion was derived from the survey on supply chain quality and technology management, while "how to do" portion includes operating initiatives. Ratings of importance on strategic dimensions, and the evaluation of the correlation between strategic variables and operating initiatives were determined by the experts. In short, QFD was used to identify priorities on what to do and develop strategies to satisfy them. Table 1 shows the what to do and how to do sections.

Table 1 QFD Applications for Strategic Deployment of Supply Chain

| How / What | Rate Of Importance | Adopting the ERP System | Training TQ Leaders | Redesigning Fullfillment Process | Making Use of OR Models | Sharing the Best Practices |
|---|---|---|---|---|---|---|
| IT-Enabled Operations | 5 | S | S | S | S | S |
| Process Management | 4 | S | S | S | S | S |
| IT-Driven Integration | 3 | S | S | S | M | M |
| Supplier Selection | 3 | S | M | S | M | M |
| Training | 3 | S | S | S | S | S |

Rate of Importance
5 : most
1: least

Relationship
S: Strong
M: Medium
W: Weak

Further, a benchmarking process was used to compare with potential competitors from other supply chains.
This enabled the managers to decide where to focus their strategy and resource allocation efforts. Also, it was emphasized that, no sustainable development can be achieved without the involvement of the people who understand the internal quality and technology systems in the supply chain.

In another study, Onesime, Xiaofei and Dechen (2004) proposed to integrate QFD, AHP and PGP in order to deal with the complexities of the supplier selection process. During the supplier selection process various criteria should be considered and a criteria may have both quantitative and qualitative dimensions. A basic framework of the QFD derived by the authors contains the following sections:

1. A structured list of the requirements for suppliers, which contributes to satisfying customer requirements for the supplier selection process.
2. The supplier evaluating criteria which represent the evaluating criteria that should be considered to satisfy the requirements for suppliers.
3. A column vector called the relative importance weighting of the requirements to represent the relative degree of importance for each requirement by using the AHP technique.
4. A central relationship matrix to link the relationship between the requirements for supplier and the supplier evaluating criteria. This matrix shows the degree by which each evaluating criteria satisfies the corresponding requirement.
5. A row vector called the importance degree of the supplier criterion to identify the degree by which each criterion satisfies the all requirements Another row vector represents the normalized importance degree in order to prioritize the supplier criteria that will be used as the evaluating weight in the supplier selection process.
6. Considering supplier constraints such as capacity, quality and demand, a multi-objective preemptive goal programming is formulated to find the best suppliers. Also, it helps to place the optimum order quantities among the suppliers in a way that total value of purchasing becomes maximum and total cost of purchasing minimum.

The methodology given above is a quantitative tool that helps decision makers when they met a problem of selecting from various alternatives, that has multiple objectives and as a result, involves both quantitative and qualitative data (Onesime, Xiaofei and Dechen, 2004).

Gunasekaran, Rathesh, Arunachalam and Koh (2006), proposed a fuzzy multi-criteria decision making procedure in order to optimize SCM. This approach with the use of Monte Carlo simulation provides decision making with an optimal solution that is less imprecise and more realistic than other conventional QFD methods. Traditional QFD requires humans to translate their perceptions into numerical scales (Vanegas and Labib, 2001). However, two problems occur at this point. First, not every human has the same perception of a linguistic description. Second, the choice of scales can easily influence the outcome. But in the fuzzy QFD approach, fuzzy numbers are more appropriate than subjective numbers that are used in determining the importance of customer requirements or prioritized technical characteristics. Only a few responses derived from the customers, than they are simulated using a triangular fuzzy QFD algorithm, Monte Carlo simulation and a multi-objective model to optimize the total user preferences. This methodology enhances the decision making in a collaborative design environment and the use of fuzzy QFD brings a total user focus to the process. It seeks two objectives, namely minimizing total cost, maximizing customer value through user satiscation.

Another point of the approach is the importance of the strategic management of the logistics service. Bottani and Rizzi (2006) proposed an original approach for the management of customer service. The study addresses the issue of how to deploy the house of quality to effectively and efficiently improve logistics processes and thus customer satisfaction. Also, as in the previous study, fuzzy logic is also adapted to deal with the ill-defined nature of the qualitative linguistic judgements required in the proposed house of quality. The methodology was supported by a real case application regarding an Italian company operating in the mechanical industry. According to Bottani and Rizzi (2006), providing logistics service that meets customer expectations is a continous process that can be summarized through QFD thinking as follows:

- Understanding the customer's voice, that is requirements and expectations in terms of relevant logistics performances
- Assessing customer's service perception
- If a gap between perceptions and requirements occurs, identifying viable steps that can be implemented to improve customer satisfaction
- Identifying costs and benefits related to each step
- Implementing the most efficient actions for customer satisfaction by means of a cost/benefit analysis.

The approach proposed in this study is based on the translation of house of quality principles from product development to logistics service management. "Whats" and "hows" were determined as in table 2.

Table 2. Whats and Hows for Logistics Service Management

| WHATS (Service factors) | HOWS (Strategic actions) |
|---|---|
| Lead time | Just-In-Time philosophy |
| Regularity | Warehouse management optimisation |
| Reliability | Transport Management |
| Completeness | Information Technology |
| Flexibility | Demand forecasting methods |
| Correctness | Depending on the particular circumstance other strategic actions in the logistics field can be added. |
| Harmfulness | |
| Productivity | |

In addition, four fuzzy elements have been added to the traditional house of quality:

- The weighted importance of service factors
- The weighted importance of strategic actions
- The cost for the implementation of strategic actions
- The marginal benefit of strategic actions.

Specifically, this methodology can be a very beneficial tool to perform an effective and efficient logistics service management in order to achieve customer satisfaction. It allows the identification of service factors that are perceived to affect logistics performances from the customer's point of view, enabling the assessment of possible gaps between customer's and firm's perception of logistics services. Also, the weighted importance factors allow the firm to identify the key factors of intervention in order to improve the perceived service (Bottani, Rizzi, 2006:14).

Major contributions by various researchers on SCM and QFD integration has been summarized. In the next section, handling the issue of SCM and QFD synergy with regards to performance measurement will be given.

## 4. SCM Strategies, Performance Measurement and QFD

The supply chain offers many challenges through its broader view of various relationships. The fundamental relationships are between the strategy-supply chain-value adding process and the customer, and these relationships define every organisation (Morgan, 2004). To assess the problems faced within these relatioships, it is worthwhile to be able to answer the questions like where are we now, how we got here and where will be in the future. What seems clear is that everything begins with the strategy and ends with the performance evaluation but in heart of all these relies the most important concept "customer satisfaction".

The objective of this study is to introduce a framework for the SCM, QFD and performance measurement. The framework will help managers to perform integrated decision making. Firstly, the components of the framework will be explained step by step;

*1. Customer Requirements:* The fundamental issue of gaining competitive advantage is customer satisfaction. To satisfy the customers firstly we need to understand the needs and preferences of them. Different customers have different requirements so firms may need to focus on different aspects of supply chain. QFD technique investigates customer requirements in intensive detail and enables organizations to perform effective competitive strategies. Thus, strategy formulation should be linked with these requirements. The key is to identify both the quantitative and qualitative criteria considering the value adding process.

*2. Strategy Formulation:* The companies need to develop a general process for strategy formulation. The strategic planning process can be considered as primary decision making tool and needs to be value based. Also, it is important that the process is consequential and appropriate decisions are related to both short-term and long-term performance. Strategy formulation should be made considering the company's position and its competitiors. Within SCM, the goal of strategic planning is to achieve the most efficient and highly profitable supply chain that serves customers in a market (Varma, Wadhwa, Deshmukh, 2006). Supply chain strategy should be aligned with the customer requirements and the performance measurement system.

*3. Assessment of Supply Chain Capabilities:* Before implementing a supply chain strategy, it is necessary to assess the supply chain capabilities. These capabilities may focus on logistics, supplier relations, process capability, customer service, information sharing, organizational structure and e-business readiness (Lummus, Karen, Vokurka, 2000). Superior customer value lies in the firm's logistical capabilities that are associated with significant improvements in firm performance (Fawcett, Smith, 1997). Effectively selecting and evaluating suppliers and managing their involvement in the supply chain are thought to be capabilities that enable companies to achieve customer satisfaction (Tracey, Tan, 2001). QFD in this stage becomes an effective tool to increase the efficiencies of logistics services and supplier selection and involvement processes.

*4. Strategy Deployment and Implementation:* After the assessment of supply chain capabilities, in order to implement the strategy efficiently we need to prioritize the the quantitative and qualitative dimensions of the strategy by either using SWOT analysis and the interviews with supply chain experts, partners. Then, QFD can be applied to correlate these dimensions and the potential operating initiatives. Using QFD in this stage helps SCM managers in deciding where to focus their strategy and resource allocation efforts. The process of benchmarking within house of quality can be achieved by focusing on both competitive evaluation through supply chain based strategies and technical evaluations which we may call company-specific operating initiatives (Kuei, Madu, Lin, Chow, 2002)

*5. Performance Evaluation through a Performance Measurement System (PMS):* Most of the companies realized that in order to perform an efficient and effective supply chain, performance measures and metrics should be developed. These measures and metrics should be related to customer satisfaction (Gunasekaran, Patel, Tırtıroglu, 2001). As stated before, these metrics must be linked with the strategy. One of the more recently developed conceptual frameworks is the performance prism which suggests that a PMS should be organised around five distinct but linked perspectives of performance (Neely, Adams, Crowe, 2001):

(1) Stakeholder satisfaction: Who are the stakeholders and what do they want and need?

(2) Strategies: What are the strategies we require to ensure the wants and needs of our stakeholders?

(3) Processes: What are the processes we have to put in place in order to allow our strategies to be delivered? (4)

(4) Capabilities: The combination of people, practices, technology and infrastructure that together enable execution of the organisation's business processes (both now and in the future): what are the capabilities we require to operate our processes?

(5) Stakeholder contributions: What do we want and need from stakeholders to maintain and develop those capabilities?

The strength of this conceptual framework is that it first questions the company's existing strategy before the process of selecting measures is started. In this way, the framework ensures that the performance measures have a strong foundation. The performance prism also considers new stakeholders (such as employees, suppliers, alliance partners or intermediaries) who are usually neglected when forming performance measures. However, although the performance prism extends beyond "traditional" performance measurement, it offers little about how the performance measures are going to be realised (Tangen, 2004). At this point, QFD as a tool to determine the key characteristics of the performance can be used. It helps to measure the influence factors on overall performance metrics. QFD helps to evaluate the performance by performing the deployment of measurable indicators of performance metrics.

## 5. Conclusion

According to Lee and Billington (1992:66), "there were no performance measures for the complete supply chain. Many companies have this problem. Those that do have such metrics often do not monitor them regularly. Or their metrics are not directly related to customer satisfaction". Within this paper, based on the literature review, best researches of QFD-SCM integration are discussed. Then, a framework is offered which includes the performance evaluation and measurement into the QFD-SCM integration. It should be emphasized that a PMS should be derived from the company's strategic objectives. Furthermore, it is important to remember that strategies usually change over time and when a strategy changes, some performance measures must change too. There is therefore a need for flexibility in the PMS, providing a system that relates to the objectives of the company. By using only one technique it is impossible to cover all the dimensions of the performance measurement. Integration of QFD, SCM and PMS offers both an operational and a strategic view. Each technique describes one critical aspect of the overall performance and a synergy will occur from the simultaneous use of them. This study has broaden the concept of integrated decision making by introducing a framework that includes both the financial and non-financial information.

A future study can be a real case application of the framework to ensure the readiness of this framework within an efficient and effective SCM.

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# MARKET ORIENTATION OF PHARMACEUTICAL WHOLESALERS AS AGENTS OF THE PHARMACEUTICAL SUPPLY CHAIN

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## Abstract

*Since 90's market orientation has been a very popular concept among practitioners and, especially, researchers. Within its broad literature, several theories has been proposed. Although, some of these theories has been salient, they, mostly, overlooked market orientation in the services and business-to-business market contexts. Current study focuses on pharmaceutical industry as a representative case market with the aim to find out if (and how) the level of market orientation of pharmaceutical wholesalers influences the level of pharmacist's market orientation. The findings of a survey conducted with pharmacists located in İzmir, Hatay and Manisa revealed that value added throughout the supply chain influences the value that the end-user receives. Via exploiting market-oriented competitive rivalry among pharmaceutical wholesalers, pharmacists have been able to offer value added customer service.*

Keywords: Market Orientation, Demand-driven supply chain, Pharmaceutical Industry, Wholesalers

## 1. Introduction

After 1990, market orientation has been introduced to the marketing literature. Its origins can be tracked down to the marketing concept. Marketing is defined by American Marketing Association (AMA) as "an organizational function and a set of processes for creating, communicating, and delivering value to customers and for managing customer relationships in ways that benefit from the organization and its stakeholders" (AMA Marketing Dictionary, 2006). This and several other conceptualizations are accused as being theoretical and not capturing and guiding marketing in practice (e.g. Kohli and Jaworski, 1990; Henderson, 1998). Some marketing scholars proposed the concept of market orientation (e.g. Kohli and Jaworski, 1990; Narver and Slater, 1990) as an operational definition of the marketing concept and attempted to define its dimensions. These endeavors have attracted enthusiasm among marketing and management scholars and led to a broad literature. Until recently, however, business-to-business market contexts and supply chain configurations have been overlooked. Particularly, after 2000's supply chain approaches to the concept have been proposed. Considering supply chain holistically and based on a demand-drive supply chain perspective, the present study aims to find out if the level of market orientation of one chain member is influenced by the level of market orientation of other agents of the chain and how the value that the end-user receives is influenced by the value-added throughout the supply chain.

Pharmaceutical industry plays a central role in economies due to its importance for sustainable development and health. Because of its role and its dynamic market environment, pharmaceutical market and, specifically, pharmaceutical wholesalers as neglected agents of the supply chain has been chosen as the field where data has been collected and evaluated. The first part of the paper summarizes the theoretical framework of market orientation and the widely adopted approaches. Afterward, supply-chain approaches to market orientation are discussed. After an introduction of the pharmaceutical industry, the last part presents and discusses the findings of a survey.

## 2. Market Orientation: Theoretical Framework

Kohli and Jaworski (1990) propose that although the marketing concept is essentially a business philosophy or an ideal, its implementation by marketing practitioners might differ, and moreover, contrast, with its theory. Therefore, some leading authors (e.g. Kohli and Jaworski, 1990; Narver and Slater, 1990; Deshpandé, Farley and Webster, 1993) suggested a new concept, market orientation, which implies the implementation of the marketing concept which is seen as a prerequisite for the success of an organization. After 1990, some major perspectives to the concept have been developed within the growing body of related literature. Lafferty and Hult (1999), in their effort to synthesize major perspectives on market orientation, identified five different perspectives as the decision-making, the market intelligence, the culturally based behavioral, the strategic and the customer orientation perspectives. Among these, the perspectives developed by Narver and Slater (1990), Deshpandé, Farley and Webster (1993), Kohli and Jaworski (1990) are the ones which are most widely adopted among researchers.

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## 2. 1. Major Market Orientation Perspectives

According to Narver and Slater (1995), market orientation is the organizational culture which embraces behaviors essential for the creation of superior customer value next to caring for key stakeholders' interest and long-term superior organizational performance which is, at the very basic level, derived from the behavioral norms for organizational development and responsiveness to market information. They, further, propose (1990, 1994 and 1995) that this culture must be based on three behavioral components, i.e. on customer orientation, obviously, and further on competitor orientation and inter- functional coordination. Customer orientation is based on customer focus, i.e. focusing on customers so as to develop a deep understanding of customers' entire value chain and current and future, expressed and latent needs so as to delight customers (Narver, Slater and MacLachlan, 2004). Slater and Narver (1994) suggest that creating superior customer value also necessitates focusing on current and potential competitors' action, learning their short term weaknesses and strengths, long term capabilities and strategies and constantly performing better so as to gain above average returns. Creating superior customer value and continuous cross-functional learning about competitors capabilities and strategies, according to this perspective, also requires coordination of personnel and other company resources in order to facilitate a system in which any individual in any function can commit to the market-oriented organizational culture and contribute to the creation of customer value (Narver and Slater 1990).In their several studies, they found positive relationships between market orientation, organizational learning, organizational performance and profitability.

Supporting this culturally based organizational perspective, Deshpandé, Farley and Webster (1993) reminded, however, that market, in its conventional sense, is composed of the current and potential customers of the company and, hence proposed that, customer and market orientation are synonymous and differ from competitor orientation. They argued that an effective marketing strategy requires a balanced mix of customer and competitor analysis and competitor orientation can almost oppose customer orientation, especially, when company focus solely on its competitors (p.27). Jaworski and Kohli, further, argued (1993) that inter-functional coordination, consistent with customer orientation, should be part of its meaning and measurement. Based on these arguments, they defined customer orientation as a culture that puts the customers' interest first as well as the caring for the interests of other stakeholders in order to be profitable in the long term.

Another major perspective, market intelligence perspective, is the one developed by Kohli and Jaworski. They defined market orientation as "the organization-wide generation of market intelligence pertaining to current and future customer needs, dissemination of the intelligence across departments, and organization-wide responsiveness to it (Kohli and Jaworski, 1990: 6)". Putting forward that such a definition enables the managers to operationalize the marketing concept which, they assume, is philosophical in nature and difficult to implement. According to them (1990), market orientation is primarily based on market intelligence which includes not only current and future needs and preferences of customers but also monitoring competitors' actions together with its effect on customer preferences and analyzing of exogenous factors such as government regulation, technology and environmental forces that influence those needs. First element, market intelligence generation, encompasses environmental scanning activities, such as researching customer needs and preferences, the level of interaction between manufacturing department and customers, and collecting market information both formally and informally, at least, once in a year. Intelligence dissemination refers to effective market intelligence exchange, both horizontally and vertically, within the organization, whereas responsiveness requires that all departments respond to the market through market segmentation and targeting, designing, producing, distributing and promoting product development (Kohli, Jaworski and Kumar 1993).

## 2.2. Demand Chain Perspective of Market Orientation

Findings of several studies have demonstrated the effect of market orientation on business performance and profitability as well as effects of several environmental factors on market orientation. Comparatively a new body of knowledge (e.g. Langerak, 2001; Elg, 2003; Grunert et al., 2005; Mason, Doyle and Wong, 2006), however, asserted that current perspectives fall short to account for the services and business-to-business market contexts. The widely adopted perspectives outlined above mostly regard through a dyadic lens, i.e consider companies who primarily focus on their immediate customers.

Considering whole marketing channel holistically, Ozhan Dedeoglu (2006) in her working paper about the ways how managers utilize theoretical knowledge of market orientation, (parallel to the suggestions of Langerak (2001), Grunert et al. (2005) and Mason, Doyle and Wong (2006)) revealed that a channel conceptualization of the market orientation concept might be more relevant for the industrial market context. She suggested that being market oriented and creating superior customer value through such an orientation depends not only on relationships between customers and competitors, but also on other agents of supply chain, such as intermediaries and suppliers. A comparatively lower level of market orientation of suppliers, for instance, hinders manufacturer's attempts to develop market oriented capabilities and strategies. In a similar sense, in a market context where intermediaries constitute the immediate buyers of a company also buffer the company's abilities to develop market oriented behaviors. In order to create superior value for end-users the manufacturer has to delight its immediate customers, i.e. suppliers in the first case and intermediaries in the second. Value added throughout the supply chain influences the value that the end-user receives. Thus, the level of market orientation of one chain member may be influenced by the level of market orientation of other agents of the chain.

According to Langerak (2001), channel conceptualization of market orientation refers to the culture by which the manufacturer aims to create of superior customer value for customers on a continuous basis by encouraging downstream and upstream market-oriented behaviors. Utilizing both the market intelligence and culturally based behavioral perspectives, downstream market-oriented behaviors are defined as those that relate to the intelligence generation and dissemination activities that are necessary to understand what customers value and what competitors down the supply chain are capable to do and plan strategically. Upstream market-oriented behaviors are the intelligence generation and dissemination activities that focus on suppliers as upstream customers and upstream competitors. Both down and upstream market orientations also require inter-functional coordination.

Although the idea that companies need to look beyond its own operations into the value chain of suppliers, distributors, and costumers and partner with specific suppliers and distributors in order to be successful (Kotler and Keller, 2006) is the basic, and indeed, relatively a mature inspiration of supply chain management, supply chain perspective has been only currently employed by the market orientation literature. Going further from supply chain perspective, demand chain (or demand driven supply chain) perspective puts marketing at the center of the value delivery network design with target customers in mind and working backward, i.e. design supply chain backward from the point of customers (Kotler and Keller, 2006; Mason, Doyle and Wong, 2006).

Considering industrial market context through a demand chain perspective also necessitates taking interactions and power relations among channel members into account. Channel power is associated with a company's ability or potential to influence and/or alter other chain members' behavior (Mason, Doyle and Wong, 2006). It can be acquired through distinctive tangible and intangible assets such as high investment capital, brand equity, competencies and products which cannot be imitated easily, rare, and do not have substitutes. An unbalanced chain may hinder the whole chain and the comparatively less powerful companies' ability to develop market orientation (Ozhan Dedeoglu, 2006). The manufacturer could not put market oriented culture into the practice and develop superior customer value when, for instance, distributors "buffer" and do not bounce its activities back to the end-users. Grunert et al. (2005) further proposed that a short chain, as well as a balanced one, may further upstream market orientation. Other important dimensions of supply chain influence, as theorized by Mason, Doyle and Wong (2006), are relationship focus, channel leadership, channel communications and co-ordination technology.

## 3. Pharmaceutical Market and Pharmaceutical Wholesalers' Role as Agents of Supply Chain

Pharmaceutical market can be characterized with its distinctive demand structure; the derived demand. Consumers are not permitted to purchase, especially, the prescription drugs on their own accord. Physicians and other practitioners prescribe and demand drugs on behalf of consumers, but do not pay for them and feel the cost. Next to the derived demand structure, the relation of the product-related phenomenon is to health necessitates high levels of regulation throughout the value-delivery network. Even, becoming an actor within the pharmaceutical supply chain requires professional knowledge and authorization by governmental and professional institutions. Recent developments of the industry, especially at the side of the public insurance institutions, has transformed the supply chain and augmented the centrality of the role of independent pharmacies and wholesalers throughout the chain. Pharmaceutical wholesalers play a determining role in performance of the supply side of the market. They are important members of the pharmaceutical supply chain due to the necessities to store, handle, and transport drugs in an appropriate way so as to be sure that the drug is distributed in healthy and proper conditions. Despite the huge importance of pharmaceutical intermediaries (both wholesalers and pharmacists) in terms of outbound and reverse logistics and information management, their role has been neglected in governmental strategic development plans.

Global pharmaceutical market's growth for last three decades has witnessed a halt after 1993 because of governmental decision and regulations concerning the reduction of the drug expenses throughout the world with the aim reduce the expenses related to health (DPT 2001, Kanavos, Üstel and Costa-Font 2005). Some other changes, summarized in DPT Eigth five-year development plan (2001), are prescription restraints, encouragement of nonprescription drug use, restrictions on list of drugs which are approved to be paid back, an inclination toward the OTC (over the counter) drugs, increasing governmental pressures on drug prices, decreasing number of radical innovations and inventions despite augmented R&D expenditures, globalization of the industry, enlargement of generic drugs market. Additionally, the pharmaceutical industry in Turkey has also undergone through crises due to the frequent economic crises in Turkey. Companies acting in the industry experience, thus, several challenges. Some of the SME's has gone out of the business. Considering pharmaceutical wholesalers, one can notice a similar trend; the number of wholesalers has been in a rise after 1970's until 1997 (DPT 2001). After that year the number slipped down severely. Increasing level of competition and the changes mentioned above almost 60% of wholesales has gone bankrupt. This part of the market has also witnessed an increasing concentration; the first three wholesalers take 60% of the total market (DPT 2001). Next to privately owned wholesalers, there are pharmacists' cooperatives which carry out the wholesaling job. Most of the major wholesalers in Turkey have widely adopted late technological advances in warehousing, transportation, information and inventory management and utilize marketing techniques in order to outperform competitors.

## 4. Market Orientation of Pharmaceutical Wholesalers: Pharmacists' Evaluations

The aim of the study is to explore the intensity and outcomes of market orientated activities of pharmaceutical wholesalers as important members of the pharmaceutical supply chain. As suggested above, since the value added throughout the supply chain influences the end-user, the level of market orientation of one chain member may be influenced by the level of market orientation of other agents of the chain. Among other factors such as technological advancements, intensive rivalry among pharmaceutical wholesalers, in Turkey, necessitates pharmaceutical wholesalers to become more market oriented. In order to find out the market orientation level of pharmaceutical wholesalers, a face-to face questionnaire survey has been conducted with pharmacists. After conducting a pilot test with 10 pharmacists, the questionnaire was revised so that inapplicable questions and ambiguous wording could be avoided and clear instructions could be provided throughout the questionnaire. Data collection process, in general, has been very challenging for several reasons. Reaching pharmacists was not easy, even though data has been collected during the work hours, i.e. time when pharmacist have to be present at their stores. Even if they could be reached, most pharmacists were reluctant to become involved in the study. They claimed that they could not allocate time for the questionnaire. Another interesting observation was that they did not want to declare their income level. The reason can be attributed to the fact that during the time data was collected, there had been arguments in the public media about the tendency of pharmacists, doctors and accountants etc. to claim lower income to get rid of tax burden laid upon their income. Despite these impediments, a number of 102 utilizable forms could be collected (which, still, can be seen as a limitation of the study). Questionnaires were collected from city centers of İzmir, Hatay and Manisa. By choosing three different cities it was aimed to be able to compare the tendency and motives to become market oriented between cities which have different market contexts. First of all pharmaceutical market size and competitive rivalry is greater in İzmir owing to the larger population and concentration of health organizations in the district. Moreover, the number of active pharmaceutical wholesalers in Hatay is less than the others. Their working conditions are not as good as others' conditions in Manisa and İzmir; they try to reach out pharmacies in Hatay from Mersin or Adana where they located their company center and this means approximately one to three hours physical distance by car. Because of these, there are fewer wholesalers who want to serve this market. By allowing for these differences to be involved in the sample, the researchers aimed to comprehend the contextual differences in terms of competition structure and level.

The questionnaire included three sections; the first section aimed to define participant pharmacists' characteristics. Other sections include questions regarding main criteria that affect pharmacists' preferences of wholesaler choices and market orientation variables. The statements which aim to measure the evaluations of pharmacists regarding the level of market orientation of wholesalers are mainly inspired from Kohli and Jaworski (1990). Supply chain perspective has been employed throughout the study. Majority of the respondents are located in İzmir (36,3%) and Hatay (47,1%) with income level reported mostly less than 2500 YTL (35,8%). Most pharmacists prefer to work with two different wholesalers (34,4%) and with privately owned wholesalers (69,4%). Reason for working with more than supplier is assumed to increase rivalry among suppliers and, thus, receive higher quality service. Additional operating variables of the sample appear in Table 1.

Table 1. Descriptive and operating characteristics of the sample

| Variables | N | Valid Percent | Variables | N | Valid Percent |
|---|---|---|---|---|---|
| Location | | | Number of Daily Order (Mean=6,62 Std.Dev.=4,24) | | |
| İzmir | 37 | 36.3 | 1-2 | 11 | 11,3 |
| Hatay | 48 | 47.1 | 3-4 | 17 | 17,3 |
| Manisa | 17 | 16,7 | 5-6 | 37 | 37,8 |
| Total | 102 | 100 | 7-8 | 9 | 9,1 |
| Pharmaceutical Wholesaler Choice | | | 10-11 | 17 | 17,3 |
| Pharmaceutical Cooperative | 30 | 30,6 | 15-20 | 7 | 7,1 |
| Private Pharmaceutical Wholesaler | 68 | 69,4 | Missing | 4 | 0 |
| Missing | 4 | | Total | 102 | 100 |
| Total | 102 | 100 | | | |
| Income | | | Number of Pharmaceutical Wholesaler Being Worked With | | |
| 0- 2500 YTL | 29 | 35,8 | 1 | 13 | 13,0 |
| 2501 - 5000 YTL | 28 | 34,6 | 2 | 34 | 34,0 |
| 5001 - 7500 YTL | 14 | 17,3 | 3 | 34 | 34,0 |
| 7501 - 10000 YTL | 5 | 6,2 | 4 | 12 | 12,0 |
| higher than 10000 YTL | 5 | 6,2 | 5 | 7 | 7,0 |
| Not reported | 21 | | Missing | 2 | |
| Total | 102 | 100 | Total | 102 | 100 |

Main wholesaler preference criteria appeared to be, in the following order; quick delivery, carrying wide product assortment, providing financial credit, high quality service, and frequent delivery (Table 2). Due to the perishable nature of the products, the predisposition of public sector to pay back behind schedule, the level of investment needed to carry huge inventory and limited operating capital; pharmacists attempt to keep their inventory level low (Kanavos, Üstel and Costa-Font, 2005). They achieve that goal by exploiting rivalry among wholesalers and preferring the supplier who maintain sufficient stock for immediate delivery and carry wide product assortment. Pharmaceutical wholesalers are also expected to finance pharmacists by granting credits as well as sales promotion and trade allowances. Because of the governmental regulations on manufacturer, wholesaler and retailer prices, wholesalers cannot establish price strategies independently, instead they use discounts and similar pricing tools. Social bonds with customers and offering high technology service by means of online operating systems appeared to be the two least important criteria. Pharmacist, mostly, stated that they are bothered by frequent visits of wholesaler's sales personnel.

Table 2. Supplier Preference Criteria

| | Frequency | Valid percent |
|---|---|---|
| Quick delivery | 80 | 78.4 |
| Carrying wide product assortment | 78 | 76.5 |
| Providing financial credit | 69 | 67.6 |
| High quality service | 55 | 53.9 |
| Frequency of delivery in a day | 47 | 46.1 |
| Social bonds | 39 | 38.2 |
| Online operating systems | 26 | 25.5 |

In order to be able to determine which dimensions are of critical importance to pharmacists when evaluating pharmaceutical wholesalers, several one-sample t-tests has been conducted (Table 3). As indicated by the one sample t-test statistics, variables related to all of the three dimensions; the organization-wide generation of market intelligence pertaining to current and future customer needs, dissemination of the intelligence across departments, and organization-wide responsiveness to it, appeared to be important. The most important ones are related to wholesaler's efforts to manage post-purchase customer relationships, such as taking customer complaints into account and taking corrective action immediately when its customers are not satisfied. Wholesaler's responsiveness to demand and industrial and market related changes (in, for instance, competition, technology, regulations) emerged as another important dimension. Pharmacist's evaluations about their main supplier performance regarding the market orientation dimensions revealed that, on the whole, they are satisfied with their main supplier's performance (Table 3). On the other hand, pharmacists did not demonstrated any tendency in their evaluations of their main supplier's performance on some factors, such as wholesaler's promptness in discovering changes in pharmacies' product preferences, the time their supplier need to respond to market changes and their tendency to overlook market information when preparing business plan. It may be caused due to pharmacist's lack of knowledge about these factors.

Statistical results shown in Table 4 also demonstrate that although pharmacists attach more importance on some factors and although they are, somehow, satisfied with what they get, there are statistically significant differences between their expectations and perceptions about their main supplier's performance regarding most of the market orientation dimensions. For instance, they expect from their main suppliers more rapidity in discovering changes in their product preferences and detect fundamental shifts in the pharmaceutical industry. The significance statistics which are not flagged in Table 4 indicate those factors. On the other hand, more interesting was to find out that pharmacists do not expect wholesalers to plan for more sales calls, consultation service, market research activities, adoption of technological improvement for better customer service, generation of competitor intelligence and responding to competitors, and developing just one contact point for managing customer relationships. On these dimensions, it can be proposed that perceived performance of wholesalers match their expectations. On the other hand, however, they reported that they do not want to be visited very often by wholesaler's sales personnel who mostly use aggressive selling techniques. Moreover, researchers argue that pharmacists, in general, do not care of their supplier's competitor orientated culture-based behaviors. They do care, only if, they benefit from rivalry. In other words, they tend to be pragmatic in their evaluations.

Table 3. Pharmacists' Evaluations of their Main Supplier's Market Orientation Levels

| | Importance level | | | Wholesaler's Performance | | |
|---|---|---|---|---|---|---|
| | t | Sig. (2-tailed) | Mean | T | Sig. (2-tailed) | Mean |
| Wholesaler's sales personnel visit at least once a year so as to find out what products or services pharmacists will need in the future. | -9,859 | ,000 | 2,04 | -11,02 | ,000 | 1,81 |
| Wholesaler's rapidity in discovering changes in pharmacies' product preferences. | -10,007 | ,000 | 2,03 | -,716 | ,475* | 2,90 |
| Wholesaler's market research activities at least once a year so as to assess the quality of their services. | -8,198 | ,000 | 2,21 | -5,027 | ,000 | 2,36 |
| Wholesaler's rapidity to detect fundamental shifts (in, for instance, competition, technology, regulation) in pharmaceutical industry. | -16,495 | ,000 | 1,68 | -4,535 | ,000 | 2,33 |
| Wholesaler activities in periodically reviewing the likely effect of changes in our business environment on customers. | -8,157 | ,000 | 2,22 | -1,809 | ,073* | 2,76 |
| Time needed by the main wholesaler to respond to other wholesalers' pricing tactics. | -14,671 | ,000 | 1,75 | 1,697 | ,093* | 3,23 |
| Wholesaler's tendency to overlook changes in pharmacies' service needs. | -6,040 | ,000 | 2,29 | 2,161 | ,033* | 3,26 |
| Wholesaler's efforts to periodically review their service development activities to ensure that they respond to demand | -11,479 | ,000 | 1,94 | -5,187 | ,000 | 2,38 |
| Wholesaler's tendency to overlook market information when preparing business plan. | -11,956 | ,000 | 2,07 | -,518 | ,605* | 2,93 |
| Wholesalers' tendency to pay more attention to technological advances compared to market information. | -4,444 | ,000 | 2,45 | -2,756 | ,007 | 2,67 |
| Wholesaler's tendency to rely on company objectives rather than pharmacies' needs. | -10,123 | ,000 | 2,08 | -3,573 | ,001 | 2,54 |
| Wholesaler's tendency to watch out its competitors and respond. | -13,718 | ,000 | 1,93 | -13,34 | ,000 | 1,81 |
| Wholesaler's tendency to take customer complaints into account. | -26,669 | ,000 | 1,35 | -,173 | ,863* | 2,97 |
| Wholesaler's ability to respond to changes in its competitors' pricing tactics. | -14,736 | ,000 | 1,84 | -10,78 | ,000 | 2,01 |
| Wholesaler's efforts to take corrective action immediately when its customers are not satisfied. | -32,368 | ,000 | 1,31 | -10,73 | ,000 | 1,80 |
| Wholesaler's capacity to offer consultation to pharmacies. | -10,980 | ,000 | 1,90 | -9,663 | ,000 | 2,11 |
| Wholesaler's tendency to involve its customer in important customer-related decisions. | -8,300 | ,000 | 2,15 | 1,554 | ,123* | 3,18 |
| Managing customer relationships through only one contact point. | -9,256 | ,000 | 2,16 | -6,138 | ,000 | 2,26 |
| Joint responsibility of wholesaler's company departments toward customers. | -9,066 | ,000 | 2,09 | -4,855 | ,000 | 2,41 |

Notes: 1. Likert scale has been used. '1' was the highest, whereas '5' was the lowest degree.
2. Test value is 3.
* Not significant at confidence level 95%

In general, there are just a few differences between wholesaler's performance evaluations done by pharmacists that supply their products mainly from pharmaceutical cooperatives and pharmacists that supply their products mainly from privately owned wholesalers. Privately owned wholesalers' customers evaluate their suppliers market research activities (in order to assess the service quality) more favorably than the pharmacists that mostly prefer cooperatives (t=2,569 d.f.=96 p=0,012). On the other hand, compared to other pharmacists, pharmaceutical cooperatives' customers point at their supplier's tendency to rely on company objectives and policy rather than pharmacies' needs (t=4,506 d.f.=96 p=0,000). The only difference between customers of pharmaceutical cooperatives and customers of privately owned wholesalers is that the latter assign more value to wholesaler's ability to respond to changes in its competitors' pricing tactics (t=2,142 d.f.=96 p=0,035). As stated earlier, however, all respondents value supplier's market oriented behavior.

Table 4. Comparisons between Their Expectations and Perceptions about Their Main Supplier's Performance on Market Orientation Dimensions

| | Paired Differences | | t | df | Sig. |
|---|---|---|---|---|---|
| | Mean | Std. Dev. | | | (2-tailed) |
| Wholesaler's sales personnel visit at least once a year so as to find out what products or services pharmacists will need in the future. | ,23 | 1,193 | 1,908 | 101 | ,059* |
| Wholesaler's rapidity in discovering changes in pharmacies' product preferences. | -,87 | 1,669 | -5,28 | 101 | ,000 |
| Wholesaler's market research activities at least once a year so as to assess the quality of their services. | -,16 | 1,340 | -1,18 | 101 | ,240* |
| Wholesaler's rapidity to detect fundamental shifts (in, for instance, competition, technology, regulation) in pharmaceutical industry. | -,66 | 1,816 | -3,65 | 101 | ,000 |
| Wholesaler activities in periodically reviewing the likely effect of changes in our business environment on customers. | -,55 | 1,347 | -4,12 | 101 | ,000 |
| Time needed by the main wholesaler to respond to other wholesalers' pricing tactics. | -1,48 | 1,739 | -8,60 | 101 | ,000 |
| Wholesaler's tendency to overlook changes in pharmacies' service needs. | -,97 | 1,513 | -6,45 | 100 | ,000 |
| Wholesaler's efforts to periodically review their service development activities to ensure that they respond to demand | -,44 | 1,157 | -3,85 | 101 | ,000 |
| Wholesaler's tendency to overlook market information when preparing business plan. | -,86 | 1,548 | -5,63 | 101 | ,000 |
| Wholesalers' tendency to pay more attention to technological advances compared to market information. | -,22 | 1,419 | -1,54 | 101 | ,128* |
| Wholesaler's tendency to rely on company objectives rather than pharmacies' needs. | -,46 | 1,310 | -3,55 | 101 | ,001 |
| Wholesaler's tendency to watch out its competitors and respond. | ,12 | 1,154 | 1,03 | 101 | ,306* |
| Wholesaler's tendency to take customer complaints into account. | -1,62 | 1,893 | -8,63 | 101 | ,000 |
| Wholesaler's ability to respond to changes in its competitors' pricing tactics. | -,17 | 1,082 | -1,56 | 101 | ,123* |
| Wholesaler's efforts to take corrective action immediately when its customers are not satisfied. | -,49 | 1,167 | -4,25 | 101 | ,000 |
| Wholesaler's capacity to offer consultation to pharmacies. | -,21 | 1,330 | -1,56 | 101 | ,121* |
| Wholesaler's tendency to involve its customer in important customer-related decisions. | -1,03 | 1,375 | -7,56 | 101 | ,000 |
| Managing customer relationships through only one contact point. | -,11 | 1,528 | -,71 | 101 | ,478* |
| Joint responsibility of wholesaler's company departments toward customers. | -,33 | 1,272 | -2,60 | 99 | ,011 |

Notes: 1. Likert scale has been used. '1' was the highest, whereas '5' was the lowest degree.
2. Mean difference score refers to difference between the level of importance attached to the variable and the level of performance as perceived by pharmacists
* Not significant at confidence level 95%

As expected, compared to others, the pharmacists that place more frequent orders tend to place more value on wholesaler's sales personnel frequent visits so as to find out what products or services pharmacists will need in the future (Pearson r=0,211 n=98 p=0,037), wholesaler's rapidity in discovering changes in pharmacies' product preferences (Pearson r=0,209 n=98 p=0,039), wholesaler's efforts to periodically review their service development activities to ensure that they respond to demand (Pearson r=0,309 n=98 p=0,002) and to take corrective action immediately when its customers are not satisfied (Pearson r=0,219 n=98 p=0,031). What's more interesting, but not anticipated, finding is that there are almost no significant differences between evaluations of pharmacists who supply from one or two main suppliers and pharmacists who do business with several suppliers. The only significant difference emerged to be when they evaluate their main supplier's performance regarding its rapidity in discovering changes in pharmacies' product preferences (F=2,824 d.f.=4/95 p=0,029). Pharmacists who work with one or two main suppliers are more satisfied with their main supplier's performance, whereas pharmacists who work with several suppliers are not satisfied, as anticipated.

Some evaluations regarding the main supplier market oriented behavioral performance differ between pharmacists located in different cities (Table 5). As the figures in Table 5 portray, pharmacists in İzmir and Hatay are not so much satisfied with their supplier's market oriented activities compared to those in Manisa. In Hatay, there are two wholesalers currently operating in the market. Because of the lack of the competition, pharmacists argue, wholesalers do not behave market oriented and try to develop such a culture. As can be seen in Table 5, they reported a general lack of customer-oriented culture and behaviors. In Manisa, however, the opposite is true. They are pretty much satisfied with their main supplier's behaviors. This findings support suggestions of Jaworski and

Kohli (1993) and Slater and Narver (1994). They proposed that, in markets with low competitive intensity, companies may choose not to devote resources to develop market-oriented culture and behaviors. In İzmir, on the other hand, because of the intensive competitive rivalry among wholesalers and the vital and dynamic market environment, pharmacists expectations in terms of organization-wide responsiveness to their needs and wants are supposed to surface at a higher level, they are less satisfied with what they get.

Table 5. Comparisons of Evaluations of Pharmacists Located in Different Cities

| | | N | Mean | Std. Dev. |
|---|---|---|---|---|
| Wholesaler's sales personnel visit at least once a year so as to find out what products or services pharmacists will need in the future. | Hatay | 48 | 1,56 | ,897 |
| | İzmir | 37 | 2,27 | 1,146 |
| | Manisa | 17 | 1,53 | 1,179 |
| | Total | 102 | 1,81 | 1,088 |
| F=5,587 d.f. =2/99 p=0,005 | | | | |
| Wholesaler's rapidity in discovering changes in pharmacies' product preferences. | Hatay | 48 | 3,17 | 1,449 |
| | İzmir | 37 | 3,22 | 1,134 |
| | Manisa | 17 | 1,47 | ,624 |
| F=13,703 d.f. =2/99 p=0,000 | Total | 102 | 2,90 | 1,382 |
| Wholesaler's rapidity to detect fundamental shifts (in, for instance, competition, technology, regulation) in pharmaceutical industry. | Hatay | 48 | 2,27 | 1,526 |
| | İzmir | 37 | 2,73 | 1,575 |
| | Manisa | 17 | 1,65 | ,786 |
| F=3,323 d.f. =2/99 p=0,040 | Total | 102 | 2,33 | 1,485 |
| Time needed by the main wholesaler to respond to other wholesalers' pricing tactics. | Hatay | 48 | 3,13 | 1,299 |
| | İzmir | 37 | 3,95 | 1,053 |
| | Manisa | 17 | 1,94 | ,966 |
| F=17,621 d.f. =2/99 p=0,000 | Total | 102 | 3,23 | 1,342 |
| Wholesalers' tendency to pay more attention to technological advances compared to market information | Hatay | 48 | 2,77 | 1,242 |
| | İzmir | 37 | 2,84 | 1,214 |
| | Manisa | 17 | 2,00 | 1,000 |
| F=3,204 d.f. =2/99 p=0,045 | Total | 102 | 2,67 | 1,221 |
| Wholesaler's tendency to take customer complaints into account. | Hatay | 48 | 3,46 | 1,688 |
| | İzmir | 37 | 3,03 | 1,624 |
| | Manisa | 17 | 1,47 | 1,068 |
| | Total | 102 | 2,97 | 1,715 |
| F=9,972 d.f. =2/99 p=0,000 | | | | |
| Wholesaler's efforts to take corrective action immediately when its customers are not satisfied. | Hatay | 48 | 1,67 | 1,059 |
| | İzmir | 37 | 2,24 | 1,256 |
| | Manisa | 17 | 1,24 | ,562 |
| F=5,853 d.f. =2/99 p=0,004 | Total | 102 | 1,80 | 1,126 |

Note: 1. Likert scale has been used. '1' was the highest, whereas '5' was the lowest degree.

## 5. Conclusions

After 90's market orientation has been a very popular concept, which is theorized as being business philosophy or an ideal. It implies the implementation of the marketing concept which is seen as a prerequisite for the success of an organization especially in certain turbulent and competitive market contexts. Although several major approaches to the concept have been developed within the growing body of related literature, such as the market intelligence, the culturally based behavioral, the customer orientation perspectives, it is also suggested that these popular approaches failed to account for the services and business-to-business market contexts. For that purpose, a supply chain conceptualization can be proposed. According to this approach, creating superior customer value through market orientation depends not only on relationships between customers and competitors, but also on other agents of supply chain, such as intermediaries and suppliers. Value added throughout the supply chain influences the value that the end-user receives. Thus, the level of market orientation of one chain member may be influenced by the level of market orientation of other agents of the chain.

As well as being inspired from the dominant market orientation theories, researchers have adopted a demand-driven supply chain (demand chain) perspective. Demand driven supply chain (or demand chain) perspective, goes further from supply chain perspective and puts marketing at the center of the value delivery network design with target customers in mind.

Current study focuses on pharmaceutical industry as a representative case market with the aim to examine demand-driven supply chain (demand chain) approach to market orientation. Global pharmaceutical industry comprises turbulent market environment with regard to technological advancement, intensity of competition, globalization of the industry, enlargement of generic drugs market, prescription restraints, encouragement of nonprescription drug use, restrictions on list of drugs which are approved to be paid back, increasing governmental pressures on drug prices, decreasing number of radical innovations and inventions despite augmented R&D expenditures,.

A field study with pharmacists has been conducted. They were asked to evaluate the importance of market-oriented behaviors of pharmaceutical wholesalers as important agents of the supply chain and how their activities are influenced from their main supplier's market orientation. The findings support the demand-driven supply chain (demand chain) perspective in market orientation. Through exploiting market-oriented competitive rivalry among wholesalers, pharmacists have been able to offer wide variety of pharmaceuticals to the end-user quickly. They also maintain low levels of inventory because of wholesaler's frequent and immediate delivery. Pharmacists also benefit from wholesaler high quality service, financial credits, discounts and sales promotion activities. All of these enable pharmacists work efficiently and pursue profitability through value-added customer service.

The findings also revealed that all of the three market orientation dimensions; the organization-wide generation of market intelligence pertaining to current and future customer needs, dissemination of the intelligence across departments, and organization-wide responsiveness to it, are considered as important. It is discovered that organization-wide responsiveness is of critical importance. Pharmacist's evaluations about their main supplier performance regarding the market orientation dimensions revealed that, on the whole, they are satisfied with their main supplier's performance. Despite that, still, there are some differences between their expectations and perceptions about their main supplier's performance regarding most of the market orientation dimensions. For instance, they expect from their main suppliers more rapidity in discovering changes in their product preferences and detect fundamental shifts in the pharmaceutical industry.

On some dimensions, such as frequent sales calls, consultation service, market research activities, adoption of technological improvement for better customer service, generation of competitor intelligence and responding to competitors, it can be proposed that perceived performance of wholesalers match, and sometimes even exceed their expectations. This finding, however, has to be evaluated carefully, since, for instance, very often sales visits may not be desired by pharmacists. Moreover, researchers argue that pharmacists, in general, are not well-informed and sometimesmay not care of their supplier's competitor orientated culture-based behaviors. They do care, only if, they benefit from rivalry.

Privately owned wholesalers' market research activities (in order to assess the service quality) are appreciated, while pharmaceutical cooperatives' tendency to rely on company objectives and policy rather than pharmacies' needs is criticized. The pharmacists who choose to supply from privately owned assign more value to wholesaler's ability to respond to changes in its competitors' pricing tactics. What's more interesting, but not anticipated, finding is that there are almost no significant differences between evaluations of pharmacists who supply from one or two main suppliers and pharmacists who do business with several suppliers. Pharmacists in İzmir and Hatay are the less satisfied with their supplier's market-oriented activities compared to Manisa. In Hatay, there are two wholesalers currently operating in the market. Because of the lack of the competition, pharmacists argue, wholesalers do not behave market oriented and try to develop such a culture. This findings support suggestions of Jaworski and Kohli (1993) and Slater and Narver (1994) about possible tendency of companies, operating in markets with low competitive intensity, not to devote resources to market orientation.

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# MODELLING METHODS IN INTEGRATED ECONOMIC AND LOGISTICS AND SUPPLY CHAIN SYSTEMS: THE PRESENT STATE AND FUTURE DIRECTIONS

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## Abstract

*The objective of this paper is to discuss the existing sectoral and economy wide logistics and supply chain models (mathematical and computational methods), which can be used for the formulation of logistics and supply chain systems and policies. Mathematical models are important tools in a holistic representation of the important components of a logistics and supply chain system and in formulating logistics and supply chain policies to address the underlying issues and choices. Therefore, to examine the issues surrounding a logistics and supply chain system, an understanding the integrated mathematical models of the system can be very useful. These models include sectoral logistics and supply chain models and economy wide models such as general equilibrium models, input-output analysis, and optimal control models, among others. Since a critical discussion of the modelling and computational methods in integrated economic and logistics and supply chain systems is lacking in the existing literature, this paper makes an important contribution to the literature.*

Keywords: Logistics, Supply Chain Models, Mathematical Models, Optimal Control Models and Computational Methods.

## 1. Introduction

Mathematical models are an integral part of the representation of the important components of a system and in formulating policies to address the underlying issues and choices. Therefore, these models can be used to solve the issues relating to logistics and supply chain systems. The objective of this paper is to discuss the existing sector and economy wide models, which can then be used for the formulation of an efficient logistics and supply chain system. The paper is organised as follows. In Section A, there is a discussion of the standard models applied to different sectors. Section B discusses economy wide models in which the logistics and supply chain sector is included as a separate sector and finally the areas for future developments are discussed in Section 9.

## 2. Logistics and supply chain system modelling

Logistics and supply chain management can be defined as the process of and the principles for understanding, organising, planning, implementing, and controlling the flow of and supply of goods, services, personnel, raw materials, knowledge and information, from the primary suppliers to the final users in an efficient (economic time saving without disruption) way. Mathematical modelling helps these processes in providing or designing an efficient (or optimal) logistics and supply chain management system to achieve business objectives.

The different stages of an applied logistics and supply chain management study are as follows (following Taha, 1992):

- defining the modelling problem,
- developing the logistics and supply chain model,
- computing the logistics and supply chain model numerically by some suitable algorithms and computer programs,
- undertaking validation tests of the logistics and supply chain model,
- analysing the implications of the logistics and supply chain model results for actions.

## A. SECTORAL MODELS

## 3. Static models

At the enterprise or sectoral level, the most commonly developed static models are optimisation (both static and dynamic) models. An example of a logistics and supply chain system optimisation model is given below.

Symbols:

c's are the costs of logistics and supply chain operations at different nodes.

Y,X,Z are the vectors of logistics and supply chain variables.

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$$\underset{(Y,X,Z)}{\text{MIN}}\ C = c_1X + c_2Y + c_3Z \quad \text{objective function} \tag{1}$$

s.t.

$X = bY$ refers to primary logistics and supply chain flows and balance constraints,

$Z \geq \overline{D}$ are the demand constraints,

$X \leq \overline{X}$ are the capacity constraints, (2)

$Z = aX$ are the intermediate logistics and supply chain flows and balance constraints,

$Y \leq \overline{Y}$ are the resource constraints,

$Y,X,Z \geq 0$ is the non-negativity constraint.

A survey of these types of logistics and supply chain models can be seen in Bramel and Simchi – Levi (1997). Different algorithms can be adopted to solve these models depending on the structure of the model including the simplex methods. Some of the commercially available computer programs are: lp_solve (for Unix), MacOSXLinPro (for Macintosh), MATLAB (from MathWorks), LINDO API and LINGO CPLEX packages, MINTO and TOMLAB.

## 4. Dynamic optimization models

Dynamic economic modelling involves the problem of optimisation of a logistics and supply chain system over a period of time (Islam 2001, Craven and Islam 2005). The optimisation problem is evaluated in terms of an objective function defined as follows.

Symbols:

Where:

$Y(t)$ = a vector of control variables,

$X(t)$ = a vector of state variables,

$t$ = time $t_0, t_1, ..., t_T$.

$$\text{Max } J = \int_{t_0}^{t_T} I[X(t), Y(t), t]\, dt$$

(3)

The logistics and supply chain dynamic system, to be optimised, can be represented by the following state equations:

$$\dot{X} = \frac{dX}{dt} = f(X(t), Y(t), t) \tag{4}$$

The initial and terminal conditions on the state variables are given as follows:

$$X(t_0) = X_0 \text{ and } X(t_T) = X_T \tag{5}$$

The boundary conditions on the state variables are:

$$X(t) \in X^n \in R^n \tag{6}$$

The decision problem is to choose the optimum control trajectory from this feasible set if the feasible region or the boundary conditions of the control variables are specified.

$$Y(t) \in Y^n \in E^n \tag{7}$$

Different algorithms (gradient search etc.) and computer programs for computing continuous logistics and supply chain dynamic system models are surveyed in Craven and Islam (2005). Some the recent computer programs for computing these models are RIOTS, SCOM OCIM, and MISER.

## 5. Integrated logistics and supply chain models

A basic deterministic model for a single product with manufacturing plants and markets in various countries is provided by Cohen and Huchzermeier (1999). A modified version of the model can be presented as follows (Craven and Islam 2006):

Symbols:

$x_{ij}$ = material flows (i refers to manufacturing plants and j refers to marketing regions),

$y_j$ = decision to start or close a manufacturing facility,

$p_{ij}$ =price of currency (fixed),

$\varepsilon_i$ = tax rate relating to plant i,

$\theta$= tarrif rate,

$y_i$ = after tax profit rate,

$F_i$ = fixed cost of the plant,
$b_i$ = marginal cost of running the plant,
$p_i$ = price in local currency,
$t_{ij}$= is the distribution cost for plant I in region j,
$d_j$ = market demand.

The model maximizes the profit function subject to constraints as presented below:

$$MAX_{x,y} \sum_i (1-\varepsilon_i) \sum_i \{p_j q_j - p^1_j (1 - \theta_{ij}) b_j - p_j \mu_j - p^1_i t_{ij}\} \ X_{ij} - p^1_i F_i y_i \quad (8)$$

Subject to constraints:
$(\nu_{ij})\ x_{ij} \geq 0$, $(\nu_j)\ y_i = 0$ or 1,
$(\nu_i) \sum_i x_{ij} \leq \gamma_i$, $(\nu_j) \sum_i x_{ij} = d_{j.}$

This is a *mixed-integer linear program* and can be solved by the branch-and-bound algorithm. Cohen and Huchzermeier (1999) also provide a stochastic version of this model, in which different scenarios are specified, presented by s, with probabilities P(s). The exchange rates and demands ($d_{js}$) are considered as stochastic variables. A modified version of this model is given below:

$$MAX_{x,y} \sum_s P(s) \sum_I (1-\varepsilon_i) \sum_I \{ p_{js} q_j \, p^1_{is} (1 - \theta_{ij})\, b_j - p^1_{is} \mu_j - p^1_{is} t_{ij}\} - p^1_{is} F_i y_i \quad (9)$$

Subject to constraints: (10)
$(\nu_{ij})\ x_{ijs} \geq 0$, $(\nu_j)\ y_i = 0$ or 1,
$(\nu_i) \sum_i x_{ijs} \leq \gamma_i$, $(\nu_j) \sum_i x_{ijs} = d_{js,}$
$\sum_s P(s) = 1$.

In the computational approach a number of possible *scenarios* s, each with a probability P(s) and a value of the demand ds are attached.

De Kok, Janssen and van Wachem (2005) considered a whole supply chain over a period of time. These integer-programming models in this section can be solved and computed by using the algorithms and computer programs discussed above.

## B. ECONOMY WIDE MODELS

In the economy wide models for the logistics and supply systems, the interactions between this sector and the rest of the economy are specified and represented by mathematical models. Economy wide logistics and supply chain models can be classified on the basis of the methodology adopted in each type of models. These models can be classified as one of the following types: (1) input output models, (2) general equilibrium models, (3) Static and dynamic optimizaton models, and (4) hybrid models.

## 6. Input output models

In an input output model, the economy is divided in different sectors x $i = 1,☹ ,n$. The output of an industry is used as an input in another industry at the rate given by $a_{ij} = i, j = 1,☹ ,n$, the technological coefficients. The remaining output of an industry goes to the consumers for final consumption $f_i$. The input output structure of the economy can then be represented in a matrix form as

$$X = AX + F \quad (11)$$

where

$$X = \begin{bmatrix} x_1 \\ x_2 \\ M \\ x_n \end{bmatrix} \quad A = \begin{bmatrix} a_{11} & a_{21} & \Lambda & a_{1n} \\ a_{21} & a_{22} & \Lambda & a_{2n} \\ M & M & M & M \\ a_{n1} & a_{n2} & \Lambda & a_{nn} \end{bmatrix} \quad F = \begin{bmatrix} f_1 \\ f_2 \\ M \\ f_n \end{bmatrix}$$

or

$$(I - A)X = F \quad (12)$$

or

$$X = (I - A)^{-1} F \quad (13)$$

An input output model is generally used for forecasting purposes. The input output model can be used to predict output in the logistics and supply chain sector for a given final demand sector $F$.

## 7. Computable general equilibrium (CGE) economic models

These models are developed within the established tradition of general equilibrium analysis in economics. The modelling approach is based on the consideration of the simultaneous existence of equilibrium output and price in all sectors of an economy including the logistics and supply chain sectors. This is achieved when demand and supply are equal in all the interdependent markets. CGE models represent the relationships of demand and supply of primary inputs, intermediate products and final output in factor and commodity markets (Islam 2001).

A general presentation of a CGE model including the logistics and supply chain sector is as follows:

L = f(Px, Pk, Pl) - Input demand function (labour)
X = f(k, L) - Production function
X = AX + C - Input-output model (14)
K = f(Px, Pk, Pl) - Input demand function (capital)
C = f(Px, Pl) - Consumption function

Where

K,L = vectors of input demands in each sector of the economy (n x 1) and (n x 1);
C = a vector of sectoral consumption (n x 1);
X = a vector of output in different sectors (n x 1)
A = a matrix of the input-output coefficients (n x n);
Px = a vector of output prices (1 x n);
Pk, Pl = vectors of interest and wage rates (1 x n) and (1 x n).

The equations of the CGE model are estimated by econometric methods and it is presented in reduced form for obtaining solution of the model. The CGE model is represented by a set of simultaneous equations of demand and supply of inputs and outputs; inter-industry balances and aggregate macro-economic relationships.

Y = f(X) (15)

where :

Y = a vector of endogenous macro-economic variables
X = a vector of exogenous macro-economic variables

## 8. Economy wide optimisation models

It was stated in Part A that optimisation models are developed in order to identify an optimum logistics and supply chain system. The general structure of the optimisation models involving the logistics and supply chain system and the economy is the same as in the sectoral models. The optimisation criteria are contained in the objective function of the mathematical programming problem as:

C = f(X) (16)

where X = a vector of instruments/activities in the model (n x 1), as $X = (x_1, x_2, ..., x_n)'$.

The objectives of the optimisation problem incorporate some macroeconomic objectives as well as some sectoral objectives. Constraints in optimisation models are the structure of the logistics and supply chain system and macroeconomic relationship.

Subject to:

$H(X) \geq R$ (17)

where :

R = vector of given constraint parameters (m x 1).
H(X) = vectors of constraint functions (m x 1);

The solution methods to optimisation models are the same as they are in sectoral models discussed in Part A. Optimisation models involve macro-economic and logistics and supply chain relationships and they are specified by reformulating a CGE model in an optimisation form.

Numerical GE models can be used for formulating an optimum economic and logistics and supply chain policy can be classified into the following groups:

- Activity analysis general equilibrium models;
- Computable General Equilibrium (CGE) models; and
- Macro-econometric general equilibrium models.

From these groups, the activity analysis types of models are mostly useful for analysing the logistics and supply chain system.

### 8.1. Activity analysis models

An activity analysis GE model can be developed by specifying an input output model in an optimisation framework (Islam 2001). In an activity GE model, the objective function is usually specified to constitute either a problem of maximisation of the output in different sectors of the economy or the final demand, or a problem of minimisation of input costs such as:

Max W = InF (18)
{X,F}

s.t.

$kX \le K$

(19)

$(I - A)X - F \ge 0$

$eX \le L$

$dX \le R$

where: In = a vector of 1's (1 x n) and I = identity matrix,

A = a matrix of the input-output coefficients (n x n),

X = a vector of outputs in different sectors (n x 1),

e, k & d = vectors of employment, capital, and technical coefficients (1 x n),

L, K & R = vectors of available working age population, capital and resources (n x 1) respectively.

F = a vector of final demands (n x 1),

The results of this model provide an optimum allocation of resources in the economy and the logistics and supply chain sector in the form of an optimum output levels and structures. Tinput for these types of model can be used to prepare or plan the optimum allocation of resources or designing the logistics and supply chain system.

As discussed in Section 3, dynamic logistics and supply chain models involve the problem of optimisation of a logistics and supply chain system and its interrelationships with the economy over a period of time (Islam 2001). The solution methods for such models are discussed in Section 3.

## 9. Hybrid Models

The logistics and supply chain models are very large as they involve a huge amount of activities. Therefore, it is necessary to couple the logistics and supply chain model with other models of the economy or other sectors. In these hybrid models various types of models such as input output, macro-econometric or linear programming models are combined together.

Especial computer programs and algorithms are available to solve the hybrid model (Fox, Sengupta and Thorbecke, 1973 and Islam 2001). Output of a hybrid model can be used to formulate multi-level planning involving planning at the macro and the sectoral level.

## 10. Conclusion

This paper has presented a survey of the mathematical models and methods for logistics and supply chain systems analysing their interactions with the economy. The issues that are discussed include multi-echelon logistics, optimal performance and control of logistics, assemble-to-order system and the impacts of demand information, etc (Shantikumar, Yao and Zijm 2003). This paper has also discussed the approaches for computing logistics and supply chain systems. The popularity of these approaches to modelling logistics and supply chains in the academic and practising world has been increasing in real life situations. However, it is essential to combine the optimisation models with the existing ERP software packages; is an area that needs urgent development.

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# CORE COMPETENCIES IN HOSPITAL PHARMACY; IMPROVING THE PHARMACEUTICAL SUPPLY CHAIN, LOGISTICS AND DRUG DISPENSING

Asli Süder[1]

## Abstract

*Traditionally, hospital pharmacy activities have been oriented towards logistics and manufacturings. As in many countries, patient-oriented pharmaceutical assistance is playing an ever increasing role in hospitals. Recently, hospitals have a pharmacy hotline and pharmacies have regular activities in the wards. However, the number of full-time equivalent pharmacist positions is not yet sufficient in any hospital to cover all medical specialities. Today, the role of e-commerce in hospital pharmacy in the procurement of pharmaceuticals is very important. It will determine how this has improved the internal pharmaceutical supply chain. Whilst e-commerce is in its infancy in this area it is still considered to be an important facet of supply chain management.The role of clinical pharmacy in the health care system is changing rapidly. This change is almost universal among different countries and is related to developments in medical technology, health economics, informatics, socio-economic status, and professional relations. Transitions to new systems of clinical pharmacy are difficult to anticipate. Even with well defined targets, it remains uncertain what the future of clinical pharmacy will bring us. Computerised physician order entries have the potential to improve medication safety in hospitals. With the current systems, transcription and interpretation errors can be prevented and computerised medication control can be performed. However, these systems may be optimised by giving support to the physician with regard to drug choice.*

Keywords: Hospital Pharmacy, Pharmaceutical Supply Chain, Logistics, Drug Dispensing, Information Technology

## 1. Introduction

The traditional role of hospital pharmacists in drug analysis and drug compounding broadened to a patient-oriented approach during the sixties and seventies. The clinical pharmacy concept was adopted. This practice includes daily prepared total parenteral nutrition and chemotheraphy, sophisticated analgesic systems, individualized drug distribution and specific information. The hospital pharmacy provides aseptic procedures as well as specialized logistics. Clinical pharmacy practice concentrates on tailor-made pharmaceutical care. As home health care usually deals with therapeutic modalities, this approach offers great possibilities for highly skilled out-patient care. Financial and legal interferences and the traditional gap between in patient care and out-patient care must be removed. Home health care challenges the hospital pharmacists to place his knowledge and abilities at the disposal of this new type of patient care (Vree, 1990).

There has been a continuous debate about the objectives, roles and added value to patient care of clinical pharmacists. Hospital conditions reflect the rapidly changing role of pharmacists in the health care system. The concept of pharmaceutical care has developed from the practice of clinical pharmacy and while it has been influential in contributing new approaches to education, practice and research, the transitions to new systems of health care delivery are difficult to anticipate. Even with well defined professional targets, it remains uncertain what the future of clinical pharmacy will bring us. In today's circumstances forecasts and target-setting scenarios might have only limited value in deciding future policy.

Traditionally, hospital pharmacy activities have been oriented towards logistics and manufacturings. As in many countries, patient-oriented pharmaceutical assistance is playing an ever increasing role in hospitals. Recently, hospitals have a pharmacy hotline and pharmacies have regular activities in the wards. However, the number of full-time equivalent pharmacist positions is not yet sufficient in any hospital to cover all medical specialities. Today, the role of e-commerce in hospital pharmacy in the procurement of pharmaceuticals is very important. It will determine how this has improved the internal pharmaceutical supply chain. Whilst e-commerce is in its infancy in this area it is still considered to be an important facet of supply chain management.

One of the greatest changes in global management today is the trend towards outsourcing services that have traditionally been provided in-house. This movement has been particularly evident in logistics where the provision of transport, warehousing and inventory control is increasingly subcontracted to specialists or logistics partners. Outsourcing has become an integral part of every business and most users are satisfied with the performance of the third-party-logistics providers (3PLs). The functions performed by 3PL providers can encompass the entire logistics process or selected activities within that process. Other terms used to describe these service providers are: contract

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logistics, logistical utilities and integrated logistics service providers. In the pharmacy supply chain the current role of third party logistics providers (3PLs) is multi-faceted, from acting as a transportation and warehousing agent, to order processor and distributor. The aim of this study was to assess the role of 3PLs in the hospital pharmacy supply chain and determine to what extent such services should be used and for which supply chain activities. This paper proposes that there is a place for the use of a 3PL carrier within the pharmaceutical supply chain in hospital pharmacy as an innovative distribution model for the future. The results of this change will directly benefit the procurement function in hospital pharmacy, providing a structured distribution model which all support or supplement ongoing supplier performance.

Drug dispensing is a broad topic and arguably one of the most important competencies to master in hospital pharmacies. It truly is core. Right or wrong, it is the yardstick that most nurses and some physicians use to measure pharmacy effectiveness. Further, the most thorough and accurate vanconmycin consult can be rendered meaningless if the drug is not available to administer at the appropriate time, or worse, if the correct dose is dispensed and administered. One of the challenges in hospital pharmacy is that there is not one definitive way to dispense. A dispensing methodology is dependent upon a variety of factors that can include hospital logistics, patient census, department size, pharmacist to technician ratio, hours of operation, and the availability of hospital resources. When considering the best way to dispense, there is not one right answer. Centralized vs decentralized dispensing, as well as the choice to incorporate automation, are decisions that must be made based on available resources, the strategic plans of the department and hospital, and the needs of the department in terms of enchancing patient safety and efficiency. Assesment of the current drug dispensing process and the expected goals of a redesigned process must be carefully evaluated prior to moving forward with improvements. In any case, it is fundamentally important that every pharmacy director masters this core competency.

In modern health care, pharmacotherapy has become the most frequently applied method of medical treatment. Therefore, for many physicians prescribing medication orders is the most frequent task in daily practice. However, considerable variability may exist among different medical specialists; interns and general practitioners will prescribe drugs more often than, for example, surgeons. Prior to the actual prescribing of the medication order, the physician makes important evaluations and decisions. Is the diagnosed disease treatable by drugs; which drug is most efficacious; which side-effects can be expected and are they an additional risk for this patient (taking into account patient specific characteristics such as age, gender, co-morbidity, contraindications); which dose form is

most suitable; which dose-regimen should be prescribed, and is there a need for individualisation of dosage due to impaired organ function; how long should the treatment be continued and how can the effectiveness of drug treatment be monitored; is the therapy cost-effective.

## 2. Core Competencies in Hospital Pharmacy

Drug dispencing is a broad topic and arguably one of the most important competencies to master in hospital pharmacies. It truly is a core. Right or wrong, it is the yardstick that most nurses and some physicians use to measure pharmacy effectiveness. Further, the most thorough and accurate vancomycin consult can be rendered meaningless if the drug is not available to administer at the appropriate time, or worse, if the incorrect dose is dispensed and administered. In many ways medication dispensing within the realm of pharmacy practice is analogous to mastering a musical instrument-you need to be an expert in the fundamentals before you can be a maestro. Mastering dispensing fundamentals, however, is often less alluring than implementing new, high-level clinical programs and services.

### 2.1 The Best Way to Dispense

One of the challenges in hospital pharmacy is that there is not one definitive way to dispense. A dispensing methodology is dependent upon a variety of factors that can include hospital logistics, patient census, department size, pharmacist to technician ratio, hours of operation, and the availability of hospital resources. Evidence of this fact can be seen in recent surveys of pharmacy directors on dispensing activities (Pedersen, Schneider & Scheckelhoff, 2003). Generally 80% of hospitals employed a centralized dispensing methodology, whereas 20% had a decentralized system. Hospitals with greater than 400 beds tended to be decentralized more so than hospitals with fewer than 100 beds. Dispensing shortcomings were also identified, such as approximately 19% of intravenous admixture or solution doses were prepared by nursing personnel. Patient safety is a critical benchmark by which to measure the effectiveness of a particular dispensing methodology. Studies have shown that dispensing error rates can comprise 8% or more of adverse drug events, and this demonstrates an ongoing need for improvement of the dispensing process (Leape, Bates, Cullen, et al., 1995). Errors in medication selection and dispensing are the most common type of errors that the general public associates with pharmacies, and both lay and professional publications are full of examples where the incorrect medication has resulted in direct patient consequences (Manasse & Thompson, 2005). Therefore, it is important that every hospital pharmacy monitor errors associated with dispensing and work to improve overall error rates.

Published information on the advantages and disadvantages of different dispensing models is another helpful resource. The pharmacy literature is replete with information on various types of distribution methodologies and information on dispensing in various practice settings. *Hospital Pharmacy* has also published many useful bibliographies on subjects such as unit-dose dispensing, the role of pharmacy technicians, and automation in acute care pharmacies (Woods, 2003).

The role of the pharmacy technician in the dispensing process cannot be overlooked. A significant majority of hospitals use pharmacy technicians to prepare unit doses for pharmacists to check prior to delivery. Over the last several years, the role of the technician has continued to expand into areas that have improved departmental efficiencies and have enhanced the pharmacist's ability to provide patient care. For example, in some limited cases, technicians have been used to check unit doses prepared by other technicians. The ability to deploy technician resources is different for every hospital and should be carefully considered as part of the overall dispensing plan.

There are some important elements necessary for any effective dispensing system in a hospital. These include:

1.Use of unit-dose dispensing where drugs are delivered in a dosage from that does not require further manipulation before administraton to the patient.

2. A pharmacist check of all manually dispensed doses.

3. Commercially available products should be used whenever possible.

4. Accurate and timely delivery of the product to the nurse or patient must be enured.

5. Adherence to federal, state, and other regulatory reqirements is essenial.

6. The multidisciplinary impact of the dispensing system must be considered.

7. Dispensing technology, when used, must be validated and then implemented in a way that does not compromise patient safety or bypass important patient safeguards (Sanborn, 2006).

### 2.2 Dispensing Systems

Years ago, a centralized unit-dose dispensing system was unquestionably the safest and most effective way to deliver medications to patients. Floor stock was generally minimized in an effort to improve drug-use control. In some hospitals, decentralized pharmacists were deployed with locked dispensing carts, and these pharmacists could dispense first doses and/ or a 24-hour supply of medications to their assigned patients. With the advent of decentralized automation in the late 1980s and early 90s, floor-stock systems once again became popular, and these systems introduced electronic safeguards that improved the pharmacist's ability to control access to floor-based medications. Centralized dispensing automation has also gained wide acceptance, and now pharmacy directors must decide which type of system to hinge their dispensing philosophy upon.

There are advantages and disadvantages to each of the two systems, and in reality, there is not one perfect system that can meet the needs of every hospital. In fact, many hospitals have started using a hybrid approach (where both decentralized and centralized dispensing is used depending on the type of medication needed) to capitalize on the benefits of both methods. The use of fixed pharmacy dispensing satellites is also common, especially in areas with high-patient acuity such as in operating rooms, intensive care units, oncology units, and neonational intensive care nurseries.

When deciding between a centralized vs decentralized approach, care should be given to the types of patients being seved, the needs of hospital personnel caring for the patient, and whether the approach is complimentary to the short-and long-term goals of the hospital. For instance, if the hospital has a 3-year plan to implement computerized prescriber order entry (CPOE) and bedside medication scanning, consideration must be given to the dispensing approach that will best complement that new environment.

Hospital logistics and space availability can also play a pivotal role in the decision. If space is limited on the nursing unit, it may be impossible to implement a fixed satellite for decentralized dispensing. Many times, minor-to-moderate renovation is necessary to install decentralized automation. In contrast, limited pharmacy space, medication delivery challenges, and distant or off-site patient care areas may suggest the need for more decentralized model.

## 3. Clinical Pharmacy and Health Care

There has been a continuous debate about the objectives, roles and added value to patient care of clinical pharmacists. Hospital conditions reflect the rapidly changing role of pharmacists in the health care system. The concept of pharmaceutical care has developed from the practice of clinical pharmacy and while it has been influential in contributing new approaches to education, practice and research, the transitions to new systems of health care delivery are difficult to anticipate. Even with well defined professional targets, it remains uncertain what the future of clinical pharmacy will bring us. In today's circumstances forecasts and target-setting scenarios might have only limited value in deciding future policy. The scanning of possible clues for driving forces resulted in a long and extensive listing of a wide range of candidates, representing developments, forces and observations in clinical pharmacy and healthcare in general.

### 3.1 Increased Need to Demonstrate Added Value of Pharmaceutical Services

There is continuous pressure on the profession of clinical pharmacy to make its role visible and to demonstrate its added value to benefit both patient outcome and economic criteria. Justification of pharmacy services is more and more required by payers and hospital managers to counter the rationing of resources.

### 3.2 Patient Focus

Patients and other health care consumers, especially those concerned with particular types of disease (chronic diseases, AIDS), bring political pressure to bear with a view to increasingly maximizing the availability of relevant services. Society also continues to seek improved protection in terms of provider liability and safety of medical technology. Demographics add to these developments in terms of increasing the need for care of the chronically ill.

### 3.3 Changes in the Market Place and in Decision Making

Patterns of power in health care are shifting as the position of health care providers weakens. New players, including insurer-based pharmaceutical benefit schemes, managed care organizations, are taking over new powerful positions in the health care arena.

### 3.4 New Technology, Robotics and the Expansion of Information Technology (IT)

The successful synergy of basic sciences with technology has accelerated information technology, materials technology and biotechnology, which increases the likelihood of future breakthroughs in drug treatment. The management of these new treatments will require advanced pharmaceutical expertise and new skills. The growth of information technology facilitates risk monitoring, the automation of routine procedures and will provide increased opportunity for feedback of data to help the implementation and control of therapies and to provide strategic management information.

### 3.5 Shift to Disease Orientation

Traditionally, drug compounding, distribution services and quality assurance were key components of pharmacy practice. These product-oriented tasks are diminishing, with a shift to more clinical and disease-oriented tasks. This driving force is not specific to the profession of pharmacy; but reflects a more general paradigm shift in patient care, where disease management is becoming seen holistically, rather than a series of processes of detection, diagnosis, treatment and follow-up.

### 3.6 Changes in Training and Education

Pharmacy education has increasingly become more patient oientated, particularly in the past decade, preparing new pharmacy professionals for prominence in pharmacotherapy, delivery of clinical services, computerisation and formulary management. However, the innovators within the profession and the educational institutions generate role models who are influential but not necessarily accepted by all pharmacists. Demographically, today two out of three pharmacy graduates are females, and these changes have a major influence on the emerging role models and on professional attitudes (Leufkens).

## 4. Improving the Pharmaceutical Supply Chain

Today there is confusion about the definition of supply chain management that industry is moving towards "supplier relationship management" as opposed to the former supply chain management. This is a reflection of the movement from the sometimes presented linear supply chains to a more complex supply network characterised by lateral links, reverse loops, two-way exchanges, encompassing upstream and downstream activity. Services now account for the largest share of gross domestic product (GDP) in all but the least developed countries and are a major source of employment in both developed and developing countries. This growth of service economies world-wide and the vast amount of revenue they generate have undoubtedly contributed to the subsequent increase in scholarly and practitioner interest regarding services, service quality, failure and recovery. There has never been then a more opportune time to pursue the notion of excellence in service quality by whichever means possible, to enhance service delivery and outputs. Like supply chain management, there are many varied definitions and form of e-commerce. It has been used as a broad term to cover the use of the internet for advertising and presenting information about products and/or services and as a narrow term which recognises e-commerce to only include business transactions, involving ordering and payment on the internet. The move towards e-commerce brings an end to the paper trail indicative of purchasing departments and ensures secure transmission of nformation and funds. In hospital pharmacy it has been defined as "the electronic communication of messages such as orders and invoics between companies' computers in such a way that the messages can immediately be actioned by receiving company's systems without the for manual keying" (Convatec Ltd/ Bristol Myers Squibbs, 1999). Services, like industry in general, are contributing to the economy in a way that they have never done before and the level of technology by which they manage this is proggressing also. It is no longer the case that services stagnate in the background. As such, the level of technology being adopted within this environment is rising, with service delivery being a crucial part of everyday life. Hospitals therefore are developing and introducing sophisticated technology where possible, to enhance service outputs but also to improve the quality of working life amongst the more supportive functions such as procurement.

## 5. Lojistics Providers in the Hospital Pharmacy Supply Chain

In hospitals, logistics cover not just support services such as purchasing, stores and the pharmacy, but also healthcare services such as patient care units and operating rooms (Suder, 2005). One of the greatest changes in global management today is the trend towards outsourcing services that have traditionally been provided in-house (Christopher, 1998). This movement has been particularly evident in logistics where the provision of transport, warehousing and inventory control is increasingly subcontracted to specialists or logistics partners. Outsourcing has become an integral part of every business and most users are satisfied with the performance of the third-party logistics providers (3PLs) (Langley, 1997). The functions performed by 3PL providers can encompass the entire logistics process or selected activities within that process (Lieb, Millen, & Wassenhove, 1993). Other terms used to describe these service providers are: contract logistics, logistical utilities and integrated logistics service providers (Bowersox, & Closs, 1996).

The use of 3PLs for distribution activities is one of its more common services. This has been extended to develop what is known as "supply collection" or "milk round". The implications of this are that organizations can acquire the services of 3PLs to ensure efficient collection and delivery of products, orders etc. In the pharmacy supply chain the current role of third party logistics providers (3PLs) is multi-faceted, from acting as a transportation and warehousing agent, to order processor and distributor. It is important to understand the role of 3PLs in the hospital pharmacy supply chain and determine to what extent such services should be used and for which supply chain activities. There is a place for the use of a 3PL carrier within the pharmaceutical supply chain in hospital pharmacy as an innovative distribution model for the future. The results of this change will directly benefit the procurement function in hospital pharmacy, providing a structured distribution model which will support or supplement ongoing supplier performance. Generally hospitals sign a contract with a logistics company to manage its supply chain [8]. The logistics company's support team carried out ward-level demand capture for all stock and non-stock products, linen, fluids and sterile procedure packs. Orders were then passed to suppliers who delivered to the off-site support centre, where multi-product consignments were assembled for dispatch to each ward. In the first year, stocks of commonly used items were reduced. Reported benefits were cost savings, increased control and co-ordination of purchasing, improved service levels, full audit trails and space release. The time spent by trust staff on supply chain activities was reduced and the daily deliveries, which added to the congestion on site, were reduced to three consolidated deliveries. Companies that do not use 3PLs most frequently cited loss of control as their reason for not using them (Dapiran, Lieb, Millen & Sohal, 1996). The second most common factor cited was the concern that using third parties would lead to increased costs.

## 6. The Potential Role of Computerisation and Information Technology In Improving Prescribing in Hospital

In hospitals for physicians, prescribing of drugs is one of the most common actions in daily practice. In the continuum prescribing, dispensing, administration and use of drugs, failures may occur and can lead to patient harm. The use of computerised physician order entry systems is subject to much discussion regarding medication error reduction. This issues where such systems can contribute to improved care.

### 6.1 Drug Prescription

In modern health care, pharmacotherapy has become the most frequently applied method of medical treatment. Therefore, for many physicians prescribing medication orders is the most frequent task in daily practice. However, considerable variability may exist among different medical specialists; interns and general practitioners will prescribe drugs more often than, for example, surgeons. Prior to the actual prescribing of the medication order, the physician makes important evaluations and decisions. Is the diagnosed disease treatable by drugs; which drug is most efficatious; which side effects can be expected and are they an additional risk for this patient (taking into account patient specific characteristics such as age, gender, co-morbidity, contraindications); which dose form is most suitable; which dose-regimen should be prescribed, and is there a need for individualisation of dosage due to impaired organ function; how long should the treatment be continued and how can the effectiveness of drug treatment be monitored; is the therapy cost-effective. It is known that different physicians may come to highly variable choices in prescribing drugs in similar situations. Often the rationale and reasons for the choices made are unclear. Furthermore, the factors influencing individual physician's prescribing patterns are largely unknown. It is thought that prescribing patterns of individual physicians are explained by tradition, i.e., by what has been learned during medical training or by what was usual in hospitals where they previously worked. Consequently, it appears logical that in educating medical students much attention should be paid to pharmacotheraphy, and more specifically to the decision-making process of prescribing drugs. With respect to the latter, a stepwise approach is advocated and learned in order to structure and activate the decision making process (Ufkes , et al. 2000).

### 6.2 Drug Distribution

The medication order is in fact a request to the pharmacist to dispense the drug. It is the task of the pharmacist to check the appropriateness of the prescription for the individual patient. The correctness of dosage and application are checked and it is decided whether special precautions are necessary with respect to co-morbidity and other medications. Currently, the pharmacist increasingly fulfils the role of informing and instructing the patient or nurse on the correct usage of the drug. Sometimes, the pharmacists checks whether the prescription applies to guidelines and the drug formulary. In most hospitals, a restrictive policy is followed for non-formulary drugs, requiring authorisation by the pharmacist prior to dispensing. Drug distribution is completed with dispensing the right drug with the right instructions to the right patient. To accomplish this goal, several checks are made in the pharmacy before dispensing the drug.

### 6.3 Administration and Usage of Drugs

After dispensing the drug, care sould be taken to assure proper administration and use of the drug. For ambulatory patients this means that the drug should come with clear and unambigiuous instructions given by the physician and pharmacist. In hospitals drug administration is mostly done by nurses or physicians. In these cases the health care professionals should have adequate information on correct administration of the drugs.

### 6.4 Medication Safety in the Continuum

In the medication system, failures may occur that can lead to patient harm. Failures may occur in all parts of the system. The patient harm may occur in several forms and may vary from prescribing suboptimal pharmacotheraphy to prescribing a fatal overdose or administering the drug to the wrong patient. The use of computerised prescriber order entry systems is subject to much discussion regarding medication error reduction. This commentary analyses the issues where such systems can contribute to improved care (Guchelaar & Kalmeijer, 2003).

## 7. Hospital Diversification

Participation by hospital pharmacy departments in planning and development of diversified services is described. Diversification requires market planning. Seven basic marketing steps are identification of mission, goals, and objectives; identification of growth strategies (market penetration, market development, product development, and diversification); market analysis of external factors (size, growth, and logistics; reimbursement and financial considerations; competition; regulatory issues; legal issues); market analysis of internal factors (departmental organization and reporting lines, demographics of the institution, and costs and productivity associated with the new service); program development and design; implementation; and evaluation. Hospitals can diversify by expanding acute-care services though management contracts and mergers; developing new services to include long-term care, ambulatory-care, occupational-health, and wellness programs; starting other health-care ventures, such as consulting, continuing medical education, and continuing education for nurses; and expanding into non-health-care businesses. Vertical diversification is finding new markets for existing services; horizontal diversification is development; horizontal diversification is development of new services for new markets. To diversify, an institution may need to change its corporate structure; it may form a family of corporations that includes a universiy, nonprofit hospitals, holding companies, for-profit corporations, joint ventures, and service organizations. Through diversification, institutions and pharmacy departments can create alternative sources of funding and offer more comprehensive services to patients (Smith & Black, 1987).

## 8. Hospital Pharmacies In Turkey

Turkey is a developing country and has a population of 70 million. There are a lot of problems in Turkish health sector. Some of the major problems are in numbers of doctors, nurses, physicians, technicians, hospitals, polyclinics, and brand small health units and because of this reason these units are not enough to produce efficient healthcare. In addition to these problems government's financial support is not enough to give response the health problems of this crowded population. Also, these population is consists of mostly lower and middle-income groups. Higher income groups can get private healthcare, but numbers of these groups are highly small if we compare it to general population. Healthcare industry is under tremendous pressure to reduce costs while enhancing the quality and efficiency of care. Because of this pressure the industry is in transition. The challenges it faces include: Government regulation (local and national), Managed care, Competition (between private hospitals), Cost control, Aging population with high expectations of quality and service. Adoption of common automation goals for industry needs to reach critical mass. Effective healthcare consumer response strategies and product movement in the healthcare industry includes a broad spectrum of activity from manufacturer to patient. It includes managing programs for inventory, warehouse, distribution, and transportation. The specific tasks and activities that compose product movement within the manufacturer, distributor, and provider entities fall within this strategy. As the product gets closer to use for a patient or service, the amount of material moved per handling tends to decrease toward the unit of consumption. Thus, product movement differs as it moves from the manufacturer through the distributor or directly to the provider in supply chain. In Turkey, we can see three types of hospitals, university, government, and social insurance, military, and private hospitals. Ministry of Health decided to get control of Social Insurance hospitals. University hospitals and government hospitals and social insurance hospitals have a lot of problems. Numbers of patients are very high and in polyclinics each doctor has at least 70-80 patients. University hospitals' pharmacies do not have enough medicines they need for their patients. They do not have enough financial resources to buy all kinds of medicines that are necessary for their hospitals. Generally they have medicines for emergency cases. They do not have enough stock of medicines for great number of patients. In these situation patients relatives or friends have to get these medicines from pharmacies around the hospitals. Chamber of pharmacists try to control unfair competition between pharmacies. If your patient is in hospital, doctors write necessary medicines to their prescriptions. These pills can be obtained by prescriptions only. Chamber of pharmacists have an office in hospitals and they supply these medicines from near pharmacies, but each they buy from different 5 or 6 pharmacies. Social security institutions in healthcare follow and control their patients their from Internet. Pharmaceutical products, meanwhile, are divided under two main headings: pharmaceutical products and general products. In case of emergency hospitals try to get blood from Kizilay (Turkish Red Cross), Florence Nightingale and from Military units. Also, patient's relatives are used in case of emergency, but according to doctors it happens rarely but first-degree relatives bloods have some risks.

In most studies on possible changes in pharmacy practice, many barriers are encountered. Not only a money barrier, but also time and pharmacy staffing barriers. If one wants pharmacists and pharmacies to change from a distribution- to a patient-oriented practice model, one should have to know where those pharmacists come from, most certainly if one wants to guide this change and help pharmacists assume their new roles. It is obvious that studying the current situation is not very 'academic'. It is much more interesting to study the clinical, humanistic and economic outcomes of advanced practice models than assessing what pharmacists and their staff are currently doing. It would not make a nice intervention study, could not be conducted in a double-blind clinical trial environment, and the statistics are not exactly challenging either. In academia, only a limited number of elements of current are used as a reference within studies to accentuate the possible advantages of a new model. Pharmacist organizations are hesitant to have the occasionally flawed, practices of their members exposed to the public and politics; the pharmaceutical industry is not interested in studies where products are not involved; wholesalers concentrate on logistics. Currently, one of the health-care problems in many countries is the financing of medicines. Too often pharmacists are regarded as big money-makers, when actually the prices of the medicines are the real obstacle. The public does not exactly see the pharmacist as a 'professional', but as a grocer with an academic title. Nobody properly clarifies what pharmacists are doing. The universities do not seem to be concerned; they deliver 'academic' to society and their responsibility ends there. Their links with normal practice are very limited. Assessing the current activities of pharmacists must be done in order to depict a proper picture of the modern pharmacist in both hospital and community settings, to create a starting point for a possible change, but also to help pharmacists become more aware of their situation. University department of pharmacy practice should be especially involved in such analysis, to guarantee independence and to make valid instruments. Pharmacist organisations should fund such research, because in the end it will be of use to them in stimulating the implementation of newer practice models (Mil, 2003). In Turkey, pharmacy education is one of the popular professions and especially female students prefer this branch. Chamber of pharmacists try to make this profession more popular and honoroble. Ethics commitee tries to control unethical practices. They try to coordinate their members.

One of Turkish biggest pharmacetical producer companies organised a special pharmaceutical care unit for older people. Older people have many ailments and diseases, and the right priorities are not always obvious. Evidence-based multipharmacy may therefore represent an alternative to the 'as-few-as-possible' approach. Rational pharmacotheraphy should, however, not stand alone. Social and otherwise relevant gerontological offers may often be both cost-effective and improve the well-being and the quality of life of elderly people. To ensure that disabled older people have remedies for optimal sight and hearing, good transportation and possibilities to join social arrangements and physical activity may be superior to a number of pharmacological regimens. Medication for social and care problems is not acceptable. A dynamic and interactive cooperation with the home care system and out-patient hospital services is the key to pharmacologic as well as non-pharmacologic treatment. The coordination of logistics and professionals involved in geriatric medication is presumably best placed in the hands of a 'house-geriatrician (Vass & Hendriksen, 2005). Unfortunately it is very expensive, patients are only from higher-income groups.

## 9. Conclusion

Hospital conditions reflect the rapidly changing role of pharmacists in the health care system. In Turkey, pharmacies in university and in state hospitals have financial and personnel problems. The concept of pharmaceutical care has developed from the practice of clinical pharmacy and while it has been influential in contributing new approaches to education, practice and research, the transitions to new systems of health care delivery are difficult to anticipate. Even with well defined professional targets, it remains uncertain what the future of clinical pharmacy will bring us. In today's circumstances forecasts and target-setting scenarios might have only limited value in deciding future policy.

Traditionally, hospital pharmacy activities have been oriented towards logistics and manufacturings. As in many countries, patient-oriented pharmaceutical assistance is playing an ever increasing role in hospitals. Recently, hospitals have a pharmacy hotline and pharmacies have regular activities in the wards. However, the number of full-time equivalent pharmacist positions is not yet sufficient in any hospital to cover all medical specialities. Today, the role of e-commerce in hospital pharmacy in the procurement of pharmaceuticals is very important. It will determine how this has improved the internal pharmaceutical supply chain. Whilst e-commerce is in its infancy in this area it is still considered to be an important facet of supply chain management

The results have shown that the extension of 3PL services into pharmacy from a supplier point of view is feasible operationally in that it would fit-in with existing service provision without too much customisation. 3PLs, are currently being used within the supply chain to deliver products to hospital pharmacy. Their services would be used at the customer end of the supply chain, being responsible for picking up all pharmacy orders and delivering them in a consolidated delivery at a designated time. This is something that has not been done by 3PLs before although they are well versed in picking up stock from suppliers for onward distribution. The needs of pharmacy should be met by 'piggy-backing' on to their existing service, without much customisation. Considering that operationally there should not be many problems with this request, the main concerns will be cost and the level of service. How much will it cost for pharmacy to request this service and have a 3PL technically manage inbound logistics? These are the areas that need to be considered and discussed before entering into any contractual agreements with potential 3PLs.

From pharmacy perspective, based on the literature evident in this field, there are benefits to be realised from using 3PLs in this way, eg, the development of a structured distribution arrangement, which is externally managed, reliable, familiar to the pharmaceuticals and convenient for the pharmacy to fit-in around ongoing workload schedules. None of the above can be realised until a pilot is conducted which assures pharmacy that a standardised "milk-round" for pharmaceuticals can be established with the majority of its suppliers. As with some other hospital pharmacy initiative, such as ward order assembly, the success of this venture will rely on successful initial implementation and the co-operation of pharmaceutical suppliers.

Future developments within this area will be to appoach 3PLs currently used by pharmaceutical suppliers to discuss service profiles and costings. On the basis of a successful selection of a 3PL, the next step will be o initiate a pilot with the preferred carrier to assess performance and service delivery over a given period before agreeing to contractually consider this service provision. The pilot will ideally be conducted with a core number of suppliers initially and then rolled out further to ascertain if there are any capacity issues which may arise with the 3PL in handling the different types and bulk of pharmaceutical products.

At a larger stage, and depending upon the success of this venture, it may be opportune to discuss widening the remit of the remit 3PL service to other hospital pharmacies in the area, to gain value for money in service delivery and bulk discount. The use of regional and centralised strores for procurement and distribution of pharmaceuticals has not been investigated. The potential development of such stores to support the existing supply chain and centralise procurement efforts has been topical in the pharmaceutical supply chain for many years but has not been examined as thoroughly as it could. It does merit further analysis though and should be addressed in order to give a clearer picture of the potential use of 3PLs in this aera.

Drug dispensing is a broad topic and arguably one of the most important competencies to master in hospital pharmacies. It truly is core. Right or wrong, it is the yardstick that most nurses and some physicians use to measure pharmacy effectiveness. Further, the most thorough and accurate vanconmycin consult can be rendered meaningless if the drug is not available to administer at the appropriate time, or worse, if the correct dose is dispensed and administered. One of the challenges in hospital pharmacy is that there is not one definitive way to dispense. A dispensing methodology is dependent upon a variety of factors that can include hospital logistics, patient census, department size, pharmacist to technician ratio, hours of operation, and the availability of hospital resources. When considering the best way to dispense, there is not one right answer. Centralized vs decentralized dispensing, as well as the choice to incorporate automation, are decisions that must be made based on available resources, the strategic plans of the department and hospital, and the needs of the department in terms of enchancing patient safety and efficiency. Assesment of the current drug dispensing process and the expected goals of a redesigned process must be carefully evaluated prior to moving forward with improvements. In any case, it is fundamentally important that every pharmacy director masters this core competency.

In modern health care, pharmacotherapy has become the most frequently applied method of medical treatment. Therefore, for many physicians prescribing medication orders is the most frequent task in daily practice. However, considerable variability may exist among different medical specialists; interns and general practitioners will prescribe drugs more often than, for example, surgeons. Prior to the actual prescribing of the medication order, the physician makes important evaluations and decisions. Is the diagnosed disease treatable by drugs; which drug is most efficacious; which side-effects can be expected and are they an additional risk for this patient (taking into account patient specific characteristics such as age, gender, co-morbidity, contraindications); which dose form is most suitable; which dose-regimen should be prescribed, and is there a need for individualisation of dosage due to impaired organ function; how long should the treatment be continued and how can the effectiveness of drug treatment be monitored; is the therapy cost-effective.

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# COMPETITIVE SUPPLY CHAIN MANAGEMENT STRATEGIES IN LIQUID GOLD INDUSTRY: CASE STUDY

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## Abstract

*Liquid gold sector is a global industry in which a few number of suppliers play a significant role. They offer the various types of liquid gold to the tableware producers, tile producers, and wholesalers worldwide which ends in the necessity of effective international supply chain management. This paper analyzes the competitive supply chain management strategies implemented by a liquid gold producer as a case study. Also, effect of congruence between supply chain strategies and firm's strategy on the firm's performance is examined. The sample is chosen as Hereaus Tokmak Company, which is one of the major players in Europe and the sole producer in Turkey. Heraeus Tokmak is the leader of the sector in Turkish and Middle East markets. Thus, the competitive supply chain management strategies of Heraeus Tokmak have been examined in detail to identify the key success factors in this sector. This paper has many implications to the practitioners emphasizing the role of successful supply chain management as a competitive strategy, as well as to academicians examining these strategies in a special global sector, liquid gold.*

Keywords: Strategy, Supply chain management, Liquid gold industry, Case study

## 1. Introduction

Traditional concepts emphasized the optimization of the internal activities to improve the performance of the firms. However, in today's global world, no firm can achieve sustainable success without managing its external activities effectively. At this point, supply chain management appears as a broad concept including upstream and downstream linkages in the different processes and activities that produce value (Christopher, 2005). As consistent with this view, supply chain management is defined as "the integration of the key business processes among a network of interdependent suppliers, manufacturers, distribution centers, and retailers in order to improve the flow of goods, services, and information from original suppliers to final customers, within the objectives of reducing system-wide-costs while maintaining required service levels" (Cheng, & Grimm, 2006). Traditionally, logistics is seen as the essential part of the supply chain management. However, supply chain management does not only include the logistics issues, but also emphasizes the relationship management among the actors of the industry (Mangan & Christopher, 2005).

Supply chain management is considered as a way of improving the long-term performance of the companies. Creating and maintaining effective supply chains are considered as highly complex and challenging tasks, as a result of the continuing trends of expanding product variety, short product life-cycles, increased outsourcing, globalization, and continuous advances in information technology (Lee, 2002).

Popularity of supply chain management has been significantly increasing due to the rising uncertainty of the external environment (Mentzer et. al., 2001). Supply chain management is seen as an effective way of reducing the uncertainty by providing firms with fundamental advantages such as uninterrupted flow of supplies and services, minimum level of inventory cost, improvement of quality, working with competent suppliers, operating at lowest administrative costs, reducing the cost of inputs, creating productive relations with other functional areas within the organization, and improvement of organization's competitive advantage (Fearon & Johnson, 2001). Hence, building an effective supply chain is seen as a competitive weapon in this era.

There are many studies in the literature that have focused on supply chain management as a competitive strategy. Indeed, building and maintaining effective supply chains is considered as a firm strategy itself. Cheng and Grimm (2006) reported that 124 articles in the five most reputable management journals emphasized the relationship between supply chain management and the strategic management. Those studies investigate the business process management within the supply chain, boundaries of the firms, management of strategic networks, and the supply chain management as a source of competitive advantage.

A firm's activities produce value for the customers. Logistics and supply chain management are among those activities that aim to produce greater value than the competitors (Porter, 1985). Hence, the motive to build effective supply chains is to gain the competitive advantage (Mentzer, et. al., 2001). McGee et. al. (2005) defined competitive advantage as "delivering superior value to customers and in doing so earning an above average return for the

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company and its stakeholders". Firms gain the competitive advantage through creating an effective supply chain because it is one of the main sources of value creation. Mentzer et. al (2001) stated that implementation of supply chain management increases the customer value and satisfaction through reducing the cost of the materials, minimizing the lead time, increasing the availability of the supplier, addressing the specific needs of the customers, and offering specialized and innovative solutions to them. By merging manufacturing and marketing with distribution functions, supply chain management offers new ways of acquiring competitive advantage.

Porter said, "Competitive advantage is at the heart of a firm's performance in competitive markets." (Porter, 1985: xv). He stated the generic strategies to create and sustain competitive advantage in an industry. Porter introduced three generic strategies namely; cost leadership, differentiation, and focus (Porter, 1980). Figure-1 illustrates properness of Porter's generic strategies based on strategic targets and the strategic advantage of the firms. He offers three generic strategies depending on the firm position on the x and y axis. Axis-x represents the strategic targets, which illustrates the market characteristics in terms of size. Porter (1980) claims that if the market, in which the firm has been operating, is specific, firm shall target the particular segment only, and implement the "focus" strategy. However, if the market is large, a firm will face a choice of being "cost leader" or "differentiator". Axis-y shows the strategic advantage, which is about the product features in terms uniqueness. Uniqueness can be achieved in the market through many ways such as technology, branding, design, customer service, dealer network, etc (Porter, 1980). McGee et. al. (2005) evaluates these strategies as representatives of the type and range of strategic options that are available for the firms according to the industry conditions, especially product characteristics and market scope. Each of the generic strategies offers basically different routes for acquiring competitive advantage (Porter, 1985). Firms should decide on the appropriate one according to their strategic targets and product characteristics.

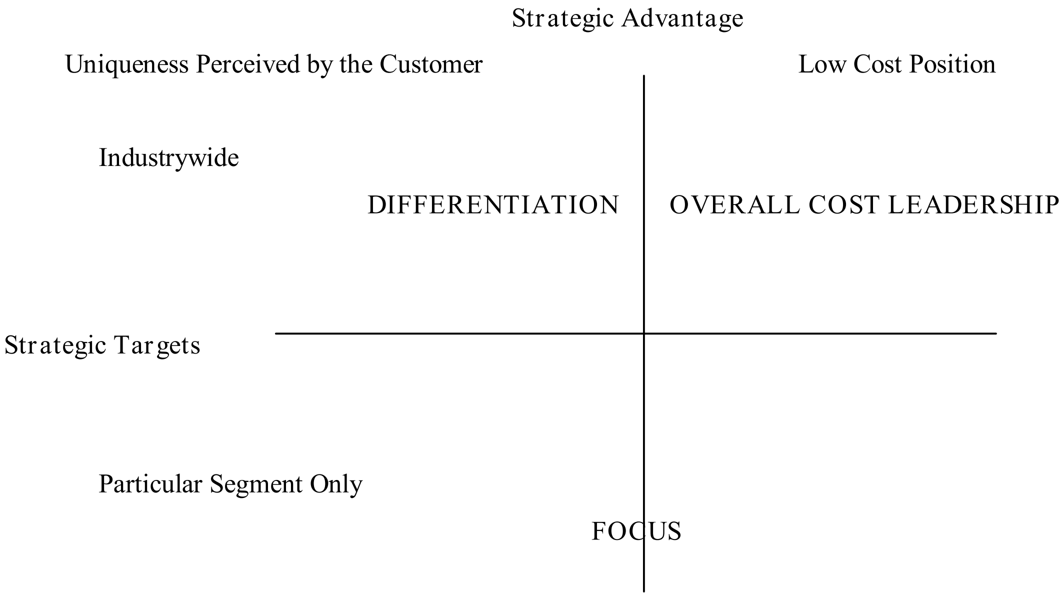


Figure 1. Three Generic Strategies
Source: Porter,1980

Cost leadership is defined as being the lowest-cost producer. In this strategy, firms should operate in a broad market scope, and even supply products and services to related industries (Porter, 1985). McGee et. al. (2005) stated that large markets and relatively stable environments are the preconditions for the success of this strategy. Cost leadership strategy is maintained by implementing continuous cost reduction. This strategy can be achieved through efficient operations, strict cost controls, and economies of scale based on the high production volume (Lassar & Kerr, 1996). A typical low-cost producer sells a standard or no frills products and services in the market (Porter, 1985).

Differentiation strategy involves offering the extra value to the customers by differentiating the products or services from the competitors. Firms, which implement this strategy, should determine one or more important attributes of the products and services according to the buyers' perspective. Then, they should provide extra value through meeting the buyers' needs, especially regarding those attributes. Offering the extra value to the buyers results in higher prices than the competitors. Therefore, a differentiator should search alternatives to reduce the cost in all areas, which do not affect differentiation of the product or service (Porter, 1985). Differentiation strategy can be acquired through the innovative technology and design, creating high value through advertising, prestige pricing, and market segmentation (Lassar & Kerr, 1996).

The third generic strategy, focus, is completely different from the other strategies because it requires a niche market (Porter, 1985). Meeting the special needs of this niche better than the competitor is the goal of the focus strategy. It also includes the choice of cost leadership and differentiation strategy at the second step (McGee et. al., 2005). A firm, which implements the focus strategy, should define itself as a cost leader or the differentiator of this niche according to the firm structure and the industry conditions. In cost focus, a firm searches for a cost advantage in its target segment, whereas in differentiation focus a firm seeks differentiation in its target segment. A focuser gets the advantage of sub optimization in its niche, and meets the customers' needs in this particular segment better than the competitors (Porter, 1985).

Generic strategies offer the useful framework for the scholars to examine the effect of strategy on manufacturer-distributor relationships (Lassar, & Kerr, 1996), broadly on the supply chains. Lassar & Kerr (1996) suggested that firms should maintain the congruence between strategy and external activities. For example, cost leaders should exert low coordination efforts among huge number of players in the supply chain. They should be careful of the cost of coordination efforts to maintain their cost leadership. Thus, minimizing the cost of such efforts is considered consistent with their strategy. However, differentiators' case is completely different. They should show highest coordination efforts through building stronger relationship in the supply chain to "differentiate" them from the competitors. They should build relationships with fewer players than cost leaders but more players than the focused players. The cost of the coordination efforts is exerted by the differentiators is highest. Finally, focused players should build strong relationship with fewest players in the niche. The cost of such efforts is not as high as the differentiators due the fewer number of players that they are in touch. Since strategic choice of the firms affects their overall activities, it should be consistent with the structure of the supply chain in which they take place. Otherwise, firms cannot sustain their advantage that they capture in the market (Gheng & Grimm, 2006).

It is obvious that supply chain management affects the firms' overall performance directly or indirectly (Wisner, 2003). The value created by the supply chain activities obviously supports the organizational strategy when they are matched accurately. Successful supply chain management decreases the inventory costs, makes firm more flexible against the external changes, and addresses the customers' expectations (Wisner, 2003). Hence, a proper match between strategy and supply chain management increases the firms' overall performance in a sustainable way (Stank et. al., 2005).

## 2. Objective

Due to the increasing importance of providing the congruence between supply chain management and firm strategy, scholars have attempted to concretize the conditions of this match according to the different perspectives such as agency theory, resource based theory, value chains, and Porter's generic strategies (Afuah, 2001; Dyer, 1997; Gulati, 1998 Lassar & Kerr, 1996; Leiblein, and Miller, 2003; Olavarrieta, and Ellinger, 1997; Peteraf, 1993). Consistent with those efforts, this study investigates the conditions of the proper match between strategy and supply chain activities in a special industry, namely the liquid gold industry. The aim of this study is to examine the existing supply chain network in the liquid gold industry and determine the role of major players in this network according to Porter's generic strategies. In addition, the competitive strategies of the major liquid gold producer in Turkey are analyzed as a case study. Congruence of the firm's strategy with its supply chain activities, and the effects of the congruence on the firm performance are examined. At the end of the study, matches and mismatches of the firm's strategy and supply chain activities are identified, and recommendations to build more effective supply chains in this industry are offered. The industry provides a unique sample with the very high value of gold as a raw material for the liquid gold producers and liquid gold as a raw material for the end product producers. Supply chain management strategies for such a valuable input/output proves to be an important contribution for the supply chain management literature.

This study aims to contribute to the literature by showing the effects of the match between strategy and firm performance in a special industry. Also, it intends to offer data for the practitioners, who have been playing in the liquid gold or a similar industry, to improve the firms' performance.

## 3. Methodology

This is an exploratory study where the case analysis method is used. Secondary data on liquid gold industry is collected and analyzed. In addition to that, primary data on liquid gold industry and data on the competitive strategies of the leading liquid gold producer in Turkey is collected through personal interviews. The case study is performed on Heraeus Tokmak Company, which is the only liquid gold producer in Turkey and the leading supplier of liquid gold in Turkey and the Middle East.

## 4. Case Study: Liquid Gold Industry and Heraeus Tokmak Company

### 4.1. Global Liquid Gold Industry

Liquid gold is a global industry, in which a few number of producers have been playing significant roles. The existence of liquid gold industry started in early 1920's in the world. The founder of the German Heraeus Company, dissolved the gold in acid mixtures and created the first liquid gold. Since then, liquid gold has been used widely in the decoration of ceramics, glass, porcelain and tiles. Currently, liquid gold producers offer the various types of liquid gold to the tableware producers, tile producers, and wholesalers worldwide which ends in the necessity of effective international supply chain management.

Liquid gold is the mixture of gold solution, metal oxides and aromatic oils. It is mainly used for decoration of glass and porcelain tableware as well as ceramic tiles. The major input of liquid gold is fine gold. Fine gold bars are dissolved in acidic environment and combined with organic sulfur compounds to form gold sulforesinat. This compound is then mixed with some metal oxides to regulate the firing range, adhesion on the substrate and color shade. The addition of the aromatic oils changes the odor and affects the application quality.

Liquid gold is applied by brush or spraying. The product is thinned by around 50% by special thinners. It is either sprayed with a gun machine or applied by brush. The glass or porcelain substrate is fired after the application in the kiln up to 600 or 800 0C respectively. After firing only the gold layer remains and gives a shiny yellow color to the substrate (Heraeus Tokmak, 2006).

Liquid gold usage started in the Middle Europe and improved in especially Germany, France, Italy. Hence the major producers in this industry are mainly European companies. The leader of the industry is German Heraeus Company. Other producers are German – American joint venture; Ferro, German – Turkish joint venture; Heraeus Tokmak, English Johnson Matthey, Italian Colorobbia, Italian Ceramvetro. These companies are not only producing liquid gold but also producing gold paste for printing, high tech products containing gold, different colors and auxiliary materials. Liquid gold producers can be divided into two groups according to the markets, in which they have been operating. Heraeus Tokmak and Ceramvetro have offered their products and services to particular regions, while others have been operating in the global arena. Heraeus Tokmak is active in Middle East and Turkish Republics, and Ceramvetro only in East Europe. The choice of being regional depends on the cost related issues. Heraeus, Ferro, Colorobbia and Johnson Matthey are large scaled companies, and they can reach all over the world with their sales team. Large scaled companies are more successful to reach the customers worldwide. However, regional companies benefit from the cost advantage that comes from employing limited number of people. Also the regional companies are more specialized on low number of products because a specific region needs limited variety of products (Heraeus Tokmak, 2006).

Liquid gold industry is mainly spread all over the world. However in the recent years developed countries started to lose the market due to high production costs. Wages and environmental regulations increase the cost of production when compared with the developing countries. For instance, in Germany the disposal of the chemical wastes costs serious amounts. In France, all chemical factories and production plants should build water filters and air cleaning systems. It is not allowed to only throw out the polluted air. The polluted air should be cleaned up before throwing to the atmosphere. All employees in European countries should be subjected to medical controls in every six months. All these precautions affect the production costs and sales prices. Also the changing life style, and consumption habits of people, shifted the market to mainly Asia and Middle East. In the past European women used to use a lot of gold decorated tableware. However nowadays people in Europe are working very hard and long time in a day. Women in Europe are searching for solutions to ease their lives. Gold decorated tableware is not suggested to be washed in dishwasher machines. As the women are looking for simple solutions in Europe, they use white porcelain or porcelain, which are decorated in glaze. In glaze decoration there is no gold but there are only specific color designs, which have long-lasting life against dishwasher machines. Additionally although the women in Middle East prefer more imposing tableware, European women prefer the simpler types (Heraeus Tokmak, 2006). According to the factors emphasized above, production volume of liquid gold has been decreasing in the world. Table-1 shows the total amount of liquid gold production and gold content.

Table-1: Global Liquid Gold Production and Gold Content

| YEARS | PRODUCED AMOUNT OF LIQUID GOLD (TONS) | GOLD CONTENT (TONS) |
|---|---|---|
| 2000 | 102 | 12 |
| 2001 | 86 | 9 |
| 2002 | 93 | 10 |
| 2003 | 91 | 10 |
| 2004 | 84 | 9 |
| 2005 | 81 | 9 |

Source: Teamwork, 2005

The liquid gold production process does not require high amount of investments nor labor force. Instead, production depends on strict formulations and chemical reactions. Hence, liquid gold producers have been strictly protecting their formulations and recipes. However, know-how is not considered enough to achieve sustainable success in this industry. Expectations of the customers are changing very fast. In recent years as the metal prices have been increasing due to the economical and political reasons, and customers have concerned the lower prices in tableware products, liquid gold producers have focused on R&D projects to reach the same quality with lower precious metal content. Competition in this industry depends on the ability of launching new products with high quality or acceptable quality with lower prices. Some of the companies have been choosing the low price strategy, and they aim to sell with lower profit margins but higher quantities. But some of them have been trying to differentiate their products by offering additional services to meet their customers' needs better than the competitors.

### 4.2. Liquid Gold Market in Turkey

Two kinds of liquid gold producers have been operating in the Turkish market. The first one is, Heraeus Tokmak A.S, which is the only liquid gold producer serving the glass and porcelain industry and sells to porcelain and glass decorators. Besides Heraeus Tokmak there are two agency companies, which are selling the products of Italian Colorobbia and English Lohnson Matthey companies in Turkey. Turkey is an attractive market for the liquid gold industry. Table-2 shows the total market size of Turkey between the years of 2000 and 2005.

Table-1: Turkish Liquid Gold Market

| YEARS | MARKET SIZE OF TURKEY (KG) |
|---|---|
| 2000 | 3000 |
| 2001 | 2800 |
| 2002 | 2200 |
| 2003 | 2600 |
| 2004 | 2700 |
| 2005 | 2500 |

Source: Heraeus Tokmak, 2006

The main customer of liquid gold industry is tableware industry, which consists of glass and porcelain industries. The aim of liquid gold usage in these industries is to increase the attractiveness of the products through decoration. Especially in oriental style gold and gold decoration takes important place. Customers of liquid gold industry can be classified in three groups; large companies, small workshops, and wholesalers. In the glass industry, the biggest manufacturer is Pasabahce Group. In porcelain, Gural Porselen, Kutahya Porselen and Porland Porselen are the leading porcelain manufacturers.

Liquid gold is sold to big scaled tableware manufacturers like Kutahya Porcelain, Gural Porcelain directly. But there are approximately 250 small decorators in the Turkish tableware industry, which are decorating glasses and porcelain. Liquid gold generally reaches them through the wholesalers. There are many wholesalers, foreign and domestic, taking place in the Turkish market. They buy large amount of gold at once from the producer, and sell them in Turkish and foreign markets. As the number of wholesalers is high and amount they buy is huge, they are considered as important players in the market. Although, wholesalers increase the sales price, working with them offers a significant cost advantage to the producers. Liquid gold producers can reach hundreds of clients with lower transaction and distribution costs through working with wholesalers.

As mentioned above, there are more than 250 glass and porcelain decorators and almost five large scaled companies, which have been using liquid gold as an important input, in Turkey. That makes the Turkish market very attractive for liquid gold producers. Also, reducing number of tableware producers in the European industry, and the increasing trend in the Turkish tableware industry increases the attractiveness of the Turkish market. Moreover, Turkish culture tends to be traditional, and most of the Turkish people prefer tableware with liquid gold decoration. Due to the cultural and regional similarity to Middle East, Turkish market appears as a gate to the Middle East market.

In business, Turkish and Middle East people give great importance to relations. Building strong relationships with the customers is the key factor to be successful in these markets. Therefore, frequent customer visits, offering tailored solutions to customers are important factors that bring sustainable success.

### 4.3. Heraeus Tokmak Company

Heraeus Tokmak Company was established in 1999. It is the joint venture of German Heraeus Company and Turkish Semik Kimya Company. The parent company, German Heraeus, is a global holding acting on precious metal industry. The activity field of Heraeus Holding consists of everything related to precious metals like Quartz glass production, refining technologies, precious metal trading, ceramic colors and liquid gold production, electronics and solder pastes. However, in the holding the major part is the liquid gold production. In 2005, Heraeus Holding has 9800 employees and more than 11 billion euros of revenue worldwide (Heraeus Annual Report, 2006). In liquid gold industry, Heraeus is seen as the technology leader of the industry with the new and high tech products and R&D activities. Since the company invests millions of euros each year for R&D activities, strength of the company depends on its innovation capabilities. The vision of the company is defined as to achieve above-average growth both organically and through acquisitions, to strengthen the international market positions and customer partnerships, to expand the innovation leadership on the basis of a broad product range, to manage risks and opportunities with a sense of balance and proportion and to continuously foster management and employee development. The other partner, Semik Kimya, was the first and only liquid gold producer in Turkey. It was founded in 1970. Semik Kimya grew especially in early 1980's and supplied high volume of gold to Turkey and Middle East. But in the meantime, company faced with some difficulties to meet the changing needs of the market. Semik Kimya had not made any investments for R&D activities. At the end of 1990's, the company could not offer new products to the market. The owner of the company started to search the possibilities to solve this problem and to enlarge the company. It was also the time; German Heraeus Company had been facing problems about the production costs in Germany because of the labor and environmental regulations costs. Due to the high costs, Heraeus' sales to Middle East countries were lower than their expectations.

Factors stated above from both sides met the two competitors; Heraeus and Semik Kimya, and in 1999 the joint venture, Heraeus Tokmak, was established. The company started its activities with 11 employees and got 3,5 million USD revenue at the end of 1999. After the establishment of this joint venture, Heraeus supported Heraeus Tokmak with its technology and produced some key products in Turkey, which were necessary to succeed in the Middle East. With the support of Heraeus, Heraeus Tokmak built modern research and development laboratories to present the new application methods to the customers. Combining the cost advantage of Heraeus Tokmak and technology of Heraeus, Heraeus Tokmak increased its market share in Turkey and Middle East significantly. Table-3 shows the sales volume of Heraus Tokmak in the Turkish market, and Table-4 shows the market shares of Heraeus Tokmak in domestic and international markets before and after the joint venture. In 2005, company was active with 17 employees, and realized a revenue of 7.23 million USD.

Table-3: Sales Volume of Hereaus Tokmak

| YEARS | SALES OF HERAEUS TOKMAK IN TURKEY (KG) |
|---|---|
| 2000 | 1800 |
| 2001 | 2000 |
| 2002 | 1850 |
| 2003 | 2200 |
| 2004 | 2350 |
| 2005 | 2250 |

Source: Heraeus Tokmak. 2006

Table-4: Market Shares of Heraeus Tokmak Before and After the Joint Venture

| Country | Market Share (%) In 1998 | Market Share (%) In 2005 | Changes (%) |
|---|---|---|---|
| IRAN | 12 | 36 | 24 |
| SYRIA | 80 | 86 | 6 |
| EGYPT | 42 | 55 | 13 |
| S.ARABIA | 5 | 22 | 17 |
| TUNUSIA | ---- | 7 | 7 |
| ALGERIA | ---- | 6 | 6 |
| MOROCCO | ---- | 6 | 6 |
| UZBEKISTAN | 50 | 65 | 15 |
| ARMENIA | 22 | 25 | 3 |
| AZEBAIJAN | 10 | 16 | 6 |
| JORDAN | 25 | 65 | 40 |
| U.A.E (DUBAI) | 20 | 55 | 35 |
| RUSSIA | ---- | 18 | 18 |
| TURKEY | 55 | 68 | 13 |

Source: Heraeus Tokmak. 2006

Heraeus Tokmak Company has three kinds of suppliers. The first and the most important one is the gold exchange market in Istanbul. Liquid gold produced by Heraeus Tokmak contains 70% fine gold, and 30% chemicals. Thus, gold is the most important supplied material of Heraeus Tokmak Company. Heraeus Tokmak purchases the gold via licensed gold exchange agencies. The agencies give moment prices of gold. After the payment they deliver the fine gold bars with private couriers to Heraeus Tokmak. As the gold prices fluctuate every moment, Heraeus Tokmak either sells its products with the momentarily gold price and immediately buys the same volume of gold from gold exchange, or hedges the gold in order to fix the gold price and protect itself against the fluctuations. The second supplier is the partner company, Heraeus. Heraeus supplies some chemicals and metal solutions to Heraeus Tokmak Company. The aim of buying some raw materials from Heraeus is the cost advantage. As Heraeus is purchasing resins and chemicals in larger quantities, Heraeus Tokmak can buy from Heraeus only with a small margin with a cost advantage. The last group of suppliers is the domestic companies, which supply some chemicals and packing materials.

Although there are several liquid gold and ceramic colors producers worldwide, Heraeus Tokmak has three main competitors in Turkey and Middle East. Those are English-Netherlands joint venture Johnson Matthey, German-American Ferro, and Halien Colorobbia. Heraeus Tokmak dominated the market in porcelain liquid gold, glass gold paste and intermediates like covercoat and media. Johnson Matthey is very strong with glass liquid gold, Ferro with porcelain gold paste. Direct printing gold paste for tiles is shared by Heraeus Tokmak and Colorobia. Quality wise, there are differences between companies' products and these differences reflect their market shares in different product groups. But when it comes to price competition, Heraeus Tokmak has a great advantage with lower production costs. Reducing the price level and sustaining the quality level provide great advantages for the companies to gain market share.

Heraeus Tokmak sells its products in two ways. The first way is directly to the customers or companies. The second way is to sell via wholesalers, which is preferred in Middle East and Uzbekistan. Figure-2 shows the supply chain network where Heraeus Tokmak takes place as the main producer. Flow of goods from its suppliers to sales channels in direct and indirect sales is illustrated.

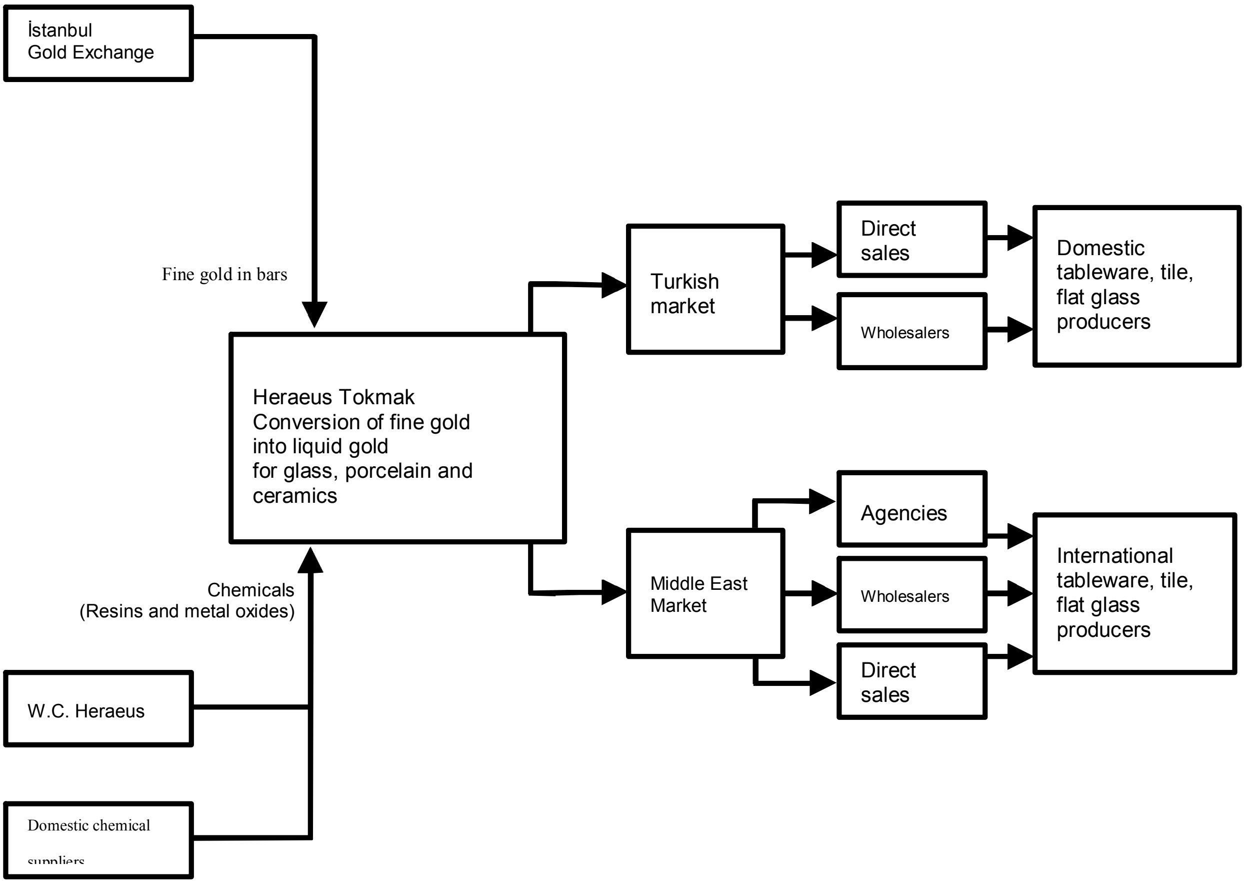


Figure 2. Supply Chain Network of Heraeus Tokmak in Liquid Gold Industry
Source: Heraeus Tokmak. 2006

In direct sales to companies the strength is, Heraeus Tokmak can follow up the market situation and competitors' actions directly. Heraeus Tokmak's sales people visit all countries and customers periodically. These frequent visits increase the quality of the relationship and helps Heraeus Tokmak to follow the competitor activities. In many Middle East countries Heraeus Tokmak sells its product with a label printed in the country's language, which is highly appreciated by the customers. In the packages there are always prospectus regarding the usage of the material and contact details in the need of any questions. The weakness is, all customers should be followed separately, Heraeus Tokmak has to obtain technical assistance to all customers. The financial positions and payments should be thought separately for all companies. That results in special service need for each customer, which increases the cost. To prevent its customers from the financial losses, Heraeus Tokmak prefers to make annual sales agreements with them. The customers define the approximate amount they wish to buy in a certain period and Heraeus Tokmak mentions the price and delivery terms. Also besides the product Heraeus Tokmak always assures its customers that, in case of any technical problem, the technical assistants of the company will visit the customer in a certain time period and solve the problem. If the problem cannot be solved or come out of the production, Heraeus Tokmak will accept all reclamation conditions. After certain time, this builds a very strong trust between the customers and

Heraeus Tokmak Company. The financial department follows all the accounts of customers periodically and every first working day of the month cross confirmation of the balances are taken from both parties.

Indirect sales or sales via resellers have a weakness of less information about the market and customers. On the other hand, Heraeus Tokmak deals with much less people in foreign markets. The resellers take the risk of payments. Heraeus Tokmak improves the technical knowledge of the resellers and they obtain technical assistance to their customers.

Heraeus Tokmak believed that competition based on prices bring nothing to producer companies after a certain level. For this reason Heraeus Tokmak tried to compete through improving its goods and services. For example, research and development team continuously searches for better alternatives to address the customers' needs. Besides, Heraeus Tokmak attempts to show a good institutional image. They started up technical seminars to inform the customers about the new product features and application methods. Purpose of those seminars is to understand the customers' problems in the liquid gold application and search for the alternatives to overcome those problems as a solution partner. To develop the relationship among the actors of the industry, Heraeus Tokmak periodically organizes industrial meetings. In these meetings, technical knowledge about the new products is introduced, and the current and future trends are discussed. The last meeting was held in June 2006, with the attendance of the main porcelain producers in Turkey. The coming standards about the heavy metal release like lead and cadmium on the decorated porcelain and their effects on porcelain industry were discussed in the conference. To strengthen its institutional image in the industry, Heraeus Tokmak also publishes an institutional magazine, Aurora. With Aurora, they can reach their customers in a fast way. Aurora is published quarterly. There new products, services and developments are mentioned to inform the customers periodically. With these changes, Heraeus Tokmak changed the image and turned from a gold producing company to a solution partner. In the past, former Semik Kimya was producing only liquid gold and there was no after sale service. But now, the sales people of Heraeus Tokmak are also acting to solve customers' problems and offer them alternatives for liquid gold usage. The sales people have at the same time great knowledge about the production and application. With frequent visits to customers, Heraeus Tokmak employees introduce new applications and explain different ways to produce new designs. Besides the visits of Heraeus Tokmak employees, either the customers visit Heraeus Tokmak or the parties meet in trade fairs. Heraeus Tokmak A.S has been attending trade fairs in Turkey independently and international fairs with Heraeus. By attending the fairs Heraeus Tokmak can reach the large customer portfolio in a very short time. This change made Heraeus Tokmak to be the first address for the customers as a solution partner.

## 5. Conclusion

To examine the effect of congruence between firm strategy and supply chain management strategies on a firm's success, liquid gold industry and the leading liquid gold producer in Turkey is analyzed as a case study. Liquid gold is a niche market where few players play significant roles. In this industry, Heraeus Tokmak Company has achieved sustainable success, which results above the industry average profitability, and being the market leader in Turkey and the Middle East. Heraeus Tokmak has been operating in a niche market. Accordingly, it implements the focus strategy. However, as Porter (1985; 16) claimed focus strategy has also choices of being differentiator or the cost leader in the niche market. Theoretically, if products and services that the company offers can be differentiated, and the features of the products are more important than the price, differentiation –focus strategy will be successful. When the investments for new product development and after-sale services are considered, it will be seen that Heraeus Tokmak implements the focus-differentiation strategy. We believe that the first reason of Heraeus Tokmak's success is to implement the appropriate strategy.

This paper also claims that sustainable success can be achieved if there exists congruence between firms' strategy and its external activities. In this paper, supply chain management is examined as a broad concept that includes all the external activities of a firm, which produces and markets a product of high value. Heraeus Tokmak has attempted to build strong supply chain network with the customers and distribution channels as a focus-differentiator. After-sales services, frequent customer visits, technical seminars in research and development laboratory, organizing industrial meetings, publishing an institutional magazine are the efforts to strengthen the relationships in the supply chain. In direct sales company builds close relationships with the customers themselves and works with long term agreements. Using the long-term sales agreements, Heraeus Tokmak can manage its inventories more effectively, and protect itself and its customers from the price fluctuations of gold through hedging the certain quantity. In indirect sales, relations with wholesalers and agencies are strong. Heraeus Tokmak makes collaborations with them to address the needs of tableware producers in foreign markets.

Heraeus Tokmak's relations with its suppliers do not seem as strong as its relations with customers. The main supplier, Istanbul Gold Exchange Market, is a formal institution. Also, the supplied material, fine gold has special features than the ordinary goods. Thus it is expected that Heraeus Tokmak's only activity about the fine gold purchasing is hedging. Heraeus Tokmak purchases some chemical inputs from the parent company, Heraeus, in order to benefit from the cost advantage. This is consistent with the focus-differentiator strategy due to the fact that differentiator should reduce the cost if it does not affect the quality or features of the product. Finally, Heraeus Tokmak purchases some chemicals from the domestic companies. However, they do not focus on the relations with them. They work with many domestic companies to purchase small amounts. Long-term agreement with fewer domestic chemical suppliers will provide many advantages such as cost reduction and increasing quality.

Heraeus Tokmak Company has achieved great success in liquid gold market through providing the congruent supply chain management strategies with the focus-differentiation strategy. Heraeus Tokmak takes place as solution partner as well as the leading supplier in the supply chain network. Hence, the competitive supply chain management strategies are main part of the firm's strategy. If strong relationships are developed with the suppliers, and long-term agreements are made, Heraeus Tokmak will strengthen the supply chain, and competitive supply chain strategies sustain the firm's leading position in the market.

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# A TRANSPORTATION OPTIMIZATION MODEL TO DETERMINE THE LOCATIONS OF DISTRIBUTION CENTERS

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## Abstract

*As the logistics costs of the companies can be minimized by the distribution centers, the customer service levels are increased. By using different transport alternatives, the companies will become more flexible. In our study, a transportation optimization model is established for a group of companies in Turkey, which uses soil as their raw material. The companies have twelve types of goods/raw materials. And they almost have dealers in each city of Turkey. The combinations of railway, highway and maritime lines are used to transport the goods and the raw materials. In our study, the transport alternatives and the locations of distribution centers are determined which minimize the total transportation cost. In our mixed integer model, the transport, handling, investment and dealer risk costs are taken into consideration*

*Keywords: transportation optimization, distribution center, transportation costs, mixed integer programming*

## 1. Introduction

Network design can be defined as the plan to gather and distribute the products in an economical way by keeping the customer service at the uppermost level. Network design models have been building by maximizing the total profit or minimizing the total cost. They are also used to determine the location and capacity of the supplier, plant, warehouse and distribution center among the suggested alternatives. The model decides also the proper delivery type and quantity for a specific product. In the design process, the below questions are answered.

- How many distribution centers should we have?
- Where the distribution centers should be placed?
- Which customers should the distribution centers serve?
- What should be the distribution frequency?
- Which transportation types should be used?

In this study, a network design model is composed to minimize all the transportation costs of five Turkish corporations that are using the soil as their raw material and belonging to the same commercial Group, by intending to decide the optimum transportation alternatives and appropriate distribution center locations. The model is formed and evaluated according to the corporations' next five year projections and strategies. Similarly, the distribution center alternatives are determined in the model by considering the possible five year demand projections of the Group's products. As the Group corporations' factories are deployed in several separate locations and raw material/product transports are driven parallel to each other, the model has a complex structure because of why the investment, transport and handling costs are considered. In the model, the inventory costs are neglected while deciding the distribution center alternatives. Also, the proper railway, maritime and highway transportation alternatives are determined.

## 2. Literature Survey

In the network design models, it is determined where the distribution centers' shall be located and which customers to serve from these distribution centers. While many non quantifiable factors can influence the network design decision, due to their complex nature, network design problems are usually posed as mixed-integer programming (MIP) models with binary variables for fixed charges related to site choices and fixed ordering costs, and continuous variables for the flows of goods. This line of research began to appear in the operations research literature with the paper of Baumol and Wolfe (1958) which described a heuristic for a nonlinear DC location model. Geoffrion and Graves (1974) proposed a multi-commodity supply chain design model to optimize product flows from plants to DCs and from DCs to the final customers.

Examining the previous twenty years' distribution strategies, it is seen that Geoffrion and Powers (1995) has brought a new dimension to the issue by their algoritmic perspective and approach. In the recent years, the inventory management theory has also integrated with network design models. Erlebacher and Meller (2000) has made up a model, which optimized the fixed operation and inventory costs together with the transportation costs. Teo and Shu (2004) has designed a two-phased network model under the deterministic retailers' demands, while Shen (2003) and

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Daskin (2002) has succeeded to form a one-phased model, containing inventory costs and showed that the problem can be effectively solved when the demands are deterministic or convenient to Poisson distributions. Shu et al. (2005) extended this model to arbitrary demand distributions. Freling et al. (2003) described a set-covering approach to a discrete-time multi-period single-sourcing model that can be viewed as an extension of the standard economic lot-sizing problem to the case of multiple facilities and multiple retailers. With a similar approach, Huang et al. (2005) applied a similar approach to a continuous-time framework where optimal replenishment times for supplying the DCs need to be found in the presence of production and inventory capacities and capacity expansion opportunities.

In this paper, the distribution centers' location decisions of a commercial Group, consisting of five different corporations', are made by considering the twelve separate product and raw material types and their ability to use both maritime, railway and highway alternatives.

## 3. Mathematical Model

The most common method of solving network design models is mixed integer programming. The basic two phases of the model are; the transfer model and the integer programming constraints. Integer programming constraints can determine as examples whether a distribution center is opened or not (0 or 1), each dealer buys from a single distribution center (0 or 1) etc. In the model; also constraints like customer response time, supplier-factory-dealer flow (the output can not be more than input), factory and warehouse capacities (tonne/pallet, etc.), responding customer demands, one dealer buying one product from a single location constraints can be used. Besides, inventory and inventory costs are considered only if product comes to distribution center. (not considered if product does not come to distribution center.) Distribution center costs are calculated as fixed costs and variable costs per pallet. In this study, first the decision variables of the model are determined:

- For $X_{ijkl}$,
  (i) : product / departure point of raw material (mine, factory or distribution center)
  (j) : product / arrival point of raw material (factory, distribution center or dealer)
  (k) : product / transport type of raw material (highway, railway and maritime line)
  (l) : product / raw material type
- $Y_m$ : $m \in M$, the decision of opening a distribution center or not (if $Y_m = 1$ open, $Y_m = 0$ not open)
- $C_{ijkl}$ : carrying cost of l product type from i departure point to j arrival point by transportation type k
- $h_j$ : handling cost in distribution centers per tonne if $j \in M$
- $f_m$ : $m \in M$, fixed investment costs of distribution centers
- $K_m$ : $m \in M$, minimum limit for the amount handled in the distribution centers
- $D_n$ : $n \in N$, dealer demand amount
- $T_p$: $p \in P$, factory capacity
- $S_k$: highway line capacity, $S_{tn}$: $t \in T$, $q \in Q$, railway line capacity
- $S_{gw}$: $g \in G$, $w \in W$, maritime line capacity
- $R_{vp}$: $v \in V$, $p \in P$ raw material carried from mine to factory
- Sets in the model: M: Distribution centers, P: Factories, V: Mines, N: Dealers,
  T: Factories located on the railways, G: Factories located on maritime lines,
  Q: Dealers located on the railways, W: Dealers located on maritime lines, L: Products and raw materials, U: Product, H: Raw material

The investment costs, distribution center handling costs and transportation costs are minimized in the objective function:

$$\min z = \sum_{i,j,k,l} \left[ (c_{ijkl} + h_j) X_{ijkl} \right] + \sum_{m \in M} f_m Y_m \tag{1}$$

There are nine constraint groups in the model:

1. Each dealer buys from a single distribution center:

$$\forall j \in N, \forall i \in M, \quad \text{for } i = m \quad \text{if} \sum_{k,l} X_{ijkl} > 0 \quad \text{then for } i \neq m \sum_{i,k,l} X_{ijkl} = 0 \tag{2}$$

2. Factory capacity constraint: $\forall i \in P$, $\sum_{j \in N,k,l} X_{ijkl} < T_p$ (3)

3. Dealers' demand constraint: $\forall l \in U$ (product), $\forall j \in N$, $\sum_{i \in (P \cup M),k} X_{ijkl} > D_n$ (4)

4. Load Flow constraint: the input and output product quantities are equal.

$$\forall l \in U, \forall m \in M, \sum_{i \in P,k} X_{ijkl,\, j=m} - \sum_{j \in N,k} X_{ijkl,\, i=m} = 0 \quad (5)$$

5. Do not send any products to a certain distribution center, when that center is not opened:

$$\forall j \in M, \text{ if } \sum_{i,k,l \in U} X_{ijkl} < K_m \text{ then } Y_m = 0, \text{ otherwise } Y_m = 1 \quad (6)$$

6. Highway capacity constraint: There is constraint only for one highway line which is used for transporting products from one of the factories.

$$\text{for i= factory, k= highway} \quad \sum_{j \in (N \cup M), l \in U} X_{ijkl} < S_k \quad (7)$$

7. Railway line capacity constraint: $\forall i \in T, \forall j \in Q, k = \text{railway} \sum_{l} X_{ijkl} < S_{tq}$ (8)

8. Maritime line capacity constraint: $\forall i \in G, \forall j \in W, k = \text{maritime} \sum_{l} X_{ijkl} < S_{gw}$ (9)

9. Return equilibrium constraint: The trucks carrying products from factories to the dealers, in whose cities there are mines, are carrying raw materials from mines to factories cheaper.

$L = U\ (Product) \cup H\ (Raw\ material)$

$\forall i \in V, \forall j \in P$, k = highway used for opposite directions (product and raw materials transport in opposite directions)

$$\sum_{l \in H} X_{i=v, j=p,k,l} < R_{vp} \ , \sum_{l \in U} X_{i=p, j=v,k,l} < R_{vp} \ , \sum_{l \in U} X_{i=p, j=v,k,l} - \sum_{l \in H} X_{i=v, j=p,k,l} = 0 \quad (10)$$

$X_{i,j,k,l} > 0$ , $Y_m = 0$ or 1

## 4. Application

In this model, five corporations' workloads and transportation costs are optimized and decision to open the distribution centers or not, are determined as considering the Group's five factories, four mines, and all the dealers located in eighty-one cities of Turkey. In the model, there are four raw material and eight product types and in order to forecast next five years' factory and dealer demands, the previous two years' demands are considered. The cities Ankara, Burdur, Malatya, Trabzon and Adana are assigned as distribution center alternatives. While assigning these cities as distribution center alternatives, their location to be on the way of railways are especially minded. The Group has ability to carry out combined logistics as both using railway, highway and maritime transport types. They use their eighty contractual trucks for the workload of South Marmara Region and subcontractors for other regions' highway transports. They also have their own wagons and own three ships that work on Marmara and Karadeniz. While carrying raw material from mines to factories by trucks, these trucks are carrying products on the return way to the close cities and this brings cost reduction advantage to the Group.

The optimization model is run on the GAMS programme for potential distribution center locations by using the avarege of the demands of the next five yeared projections. The costs of all the transport alternatives are calculated, written to model considering the transports to distribution centers and direct transports to dealers and factories. There are nine constraint types which makes totally 1.800 constraints and 650 variables in the model.

As a consequence of the model, the optimum transport alternatives and distribution center locations are determined which are Ankara, Burdur and Adana, inside from five alternative cities. The solution of the model shows that the Group will bear seventy million YTL logistic costs with four million tonne workload. The distribution centers provides two million cost reduction advantage to the Group and only opening a distribution center in Ankara brings one and half million cost advantage. Also, opening distribution centers provides ten percent increase in the usage of railway transport.

## 5. Conclusion

The solution of the model clearly displays that opening distribution centers brings a serious cost reduction. Opening distribution center together brings more usage of railway transport which means that the Group shall create its logistics strategies in this way. The advantages of opening distribution centers are indicated as below:

- Total logistic cost minimization
- Customer delivery time minimization
- The flexibility-planned transport
- Carrying with full truck and wagon (not partial loading)
- Controlled transport and waste minimization

For gaining a real advantage from distribution centers, these places shall not be used as warehouses or stocking points and only the order of the dealers shall be sent to these centers.

In this paper, mixed integer programming is used and demands are determined by the deterministic decision method. For the future studies, a new model will be designed, for this time including the inventory cost because of dealers stock on distribution centers and risk cost rising from dealer's possibility of canceling the orders.

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# COST SENSITIVITY ANALYSIS OF OPTIMAL SUPPLIER SYSTEM OF ASSEMBLY PLANTS OPERATING IN NETWORK LIKE STRUCTURE

Mónika Nagy[1], Ágota Bányai[2], and József Cselényi[3]

## Abstract

*In the paper we define the optimal supplier of a supplier-assembly logistics system operating in network like structure for case of components and production plants, and define the optimal number of component supply of different production plants for a given time period. As in our earlier detailed publications we suppose direct supply during the determination of objective function (simplified cost function) by different methods (reduced total counting, heuristic algorithm) for case of component demand of production plants in case of assembly system operating in network like structure. The paper details the effect of changing of specific costs (acquisition price, transportation, storage) on the cost components and on the total cost based on the elaborated model. The authors introduce the assembly system operating in network like structure and the cost components of simplified cost function in section 1. In the next section a numerical example is elaborated, in which the effect of different ratios of specific costs on cost function is described. At the end of the paper the evaluation and comparison of results of cost sensitivity analysis is completed and other optimization models are defined which provide an optimal operation.*

*Keywords: logistics, network, cost, supplier*

## 1. Introduction

The aim of our research is to solve a partial optimisation problem not known so far, during which the optimum supplier is to be selected for each component and for each production company and to determine the optimum number of transports of components into the production companies in a network-like operating supplier-assembly logistics system. There are several approaches to the matter of this paper, i.e. the optimisation of supplier logistics tasks, e.g. purchasing and production model for one product – Hill (1998). Several optimisation methods are known: linear programming – Pan (1989), game theory – Tallury (2002), neural networks – Siying (1997). Novelty of this paper appears in its network-like nature, in its methods of optimising as well as in its approach to the objective functions, especially to the cost functions. The specified system is considered as network-like operating, because analyses are carried out assuming several suppliers, several production companies and several customers. Optimisation is made with several parameters of objective functions and with several limitations. Among the objective functions, the cost function is of great importance, in whose context, it means new ways that realistic costs are used; our philosophy is based on displaying specific costs and natural characteristics when assuming these costs. (Granovetter 1965, Apple 1977, Camarinha-Matos 2004)

## 2. Objective functions and conditions of optimising the supplier system

In the operation of assembly networks, the optimisation of the supplier logistics system is a highly important task, where different objective functions and conditions must and can be taken into consideration. In the first step of the present optimisation, a cost function is chosen as objective function. Besides the method of total counting, the drafted multi-parameter optimisation task requires a heuristic method, which is to be solved in several steps, with a feedback after each step.

First, the present network-like logistics system, its objective functions, the influence of ordered quantity on the specific costs, the optimum selection of appointed suppliers and a simplified objective function and its parameters for optimising the number of yearly transports are blocked in.

*This system consists of the following units: production companies ($P_p$), in which component stores ($CS_p$), assembly plants ($AP_p$), finished goods stores ($FS_p$) (finished goods are transported from here to the customers ($CU_\delta$)) are indicated. Transports of component parts can take place into the above mentioned component stores: indirectly from the group of preferential suppliers ($S_i$), i.e. through distribution stores ($DS_j$), or by direct transports in case of bypassing the distribution stores. The preferential suppliers provide the so called brand featured component parts, which guarantee the quality connecting to a brand name for the customers. Suppliers within the right proximity to the assembly plants make up the group of local suppliers ($L_y$), from where only direct transports can take place into the production companies.*

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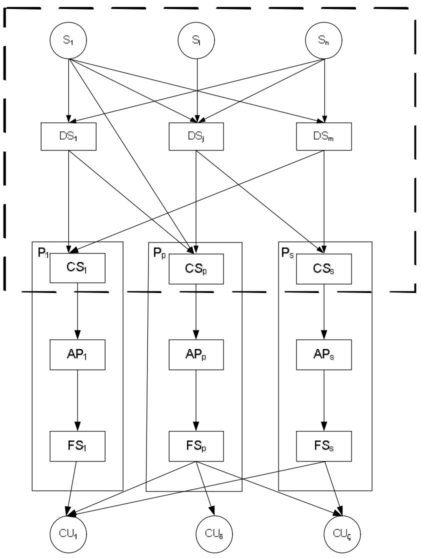


Figure 1. Network-like operating supplier-assembly logistics system

2.1 Simplified cost function

In the first step, a simplified formula of the cost function of the preferential suppliers is used as objective function, which of course, applies to direct transports only.

$$C_{gpi}^{S} = C_{gpi}^{SP} + C_{gpi}^{ST} + C_{gpi}^{CS} \rightarrow \min . \tag{1}$$

where $C_{gpi}^{S}$ is the total yearly cost of component *g* in the present partial system, which consists of the following cost components: $C_{gpi}^{SP}$ is the yearly total purchasing cost, $C_{gpi}^{ST}$ is the yearly total transport cost, $C_{gpi}^{CS}$ is the yearly total storage cost at the production company's component store. Formulas for calculating total costs and the cost function components of each total costs are described here in after. (Nagy, Bányai, & Cselényi, 2004, Nagy, Bányai, & Cselényi, 2005)

2.2. Cost function components

2.2.1. Purchasing cost

$$C_{gpi}^{SP} = s_{gpi}^{SP}(q_{gpi}^{S}) \cdot Q_{gpi}^{S} \tag{2}$$

Specific purchasing cost: $s_{gpi}^{sp} = s_{gpi}^{sp}(q_{gpi}^{S})$, where $q_{gpi}^{S}$ means the quantity of component *g* shipped at the same time by supplier *i* to production company *p*. Yearly total purchasing cost can be calculated according to the above mentioned, where $Q_{gpi}^{S}$ means the total quantity ordered yearly. Formula 2 assumes that every supply of any component part consists of the same quantity during the year and the component part consumption at the production company is uniform during the examined period of one year.

2.2.2. Transport cost

The following formula is to calculate the total yearly transport cost, assuming that component parts purchased at the same time will also be transported at the same time.

$$C_{gpi}^{ST} = n_{gpi}^{S}\left(\text{Entier}\frac{q_{gpi}^{S}}{c_{\phi g}} + \Phi\right) \cdot l_{ip}^{ST} \cdot s_{gpi}^{ST*} \tag{3}$$

where $n_{gpi}^{S}$ means the number of shipments in one year, i.e. how many shipments of component part *g* by supplier *i* to production company *p* takes place during the examined period. Parameter $c_{\varphi g}$ defines the capacity of the vehicle, i.e. what quantity of component *g* can be shipped by vehicle φ at the same time. Parameter $l_{ip}^{ST}$ indicates the transport distance between the suppliers and the production company. Parameter $s_{gpi}^{ST}$ is the specific transport cost referring to the average shipped quantity and parameter $s_{gpi}^{ST*}$ is the specific transport cost referring to one shipment.

If $\frac{q_{gpi}^{S}}{c_{\varphi g}} = \text{Integer}$, then $\Phi = 0$, else $\Phi = 1$, i.e. if the quantity to be shipped is integral multiple of the vehicle capacity, then obviously, the number of required transport vehicles is the quotient result of the above formula. Otherwise, an additional transport vehicle must be put in the shipping progress, even with empty tonnage.

2.2.3. Storage cost

The total storage cost can be calculated as follows, where $\vartheta = 1$ year means the examined period.

$$C_{gp}^{CS} = n_{gpi}^{S} \cdot q_{gpi}^{S} \cdot \frac{1}{2} \cdot \frac{\vartheta}{n_{gpi}^{S}} \cdot s_{gp}^{CS*} \quad (4)$$

Parameter $s_{gp}^{CS*}$ is the specific storage cost, which means the storage cost of one piece of component *g* at production company *p*. The cost calculation according to formula 4 assumes that shipped components are consumed uniformly.

2.3. Specific costs of functions of $q_{gpi}^{S}$

Specific purchasing cost: $s_{gpi}^{SP} = s_{gpi}^{SP}(q_{gpi}^{S})$, where $q_{gpi}^{S}$ means the quantity of component g transported at the same time from supplier i to production company p.

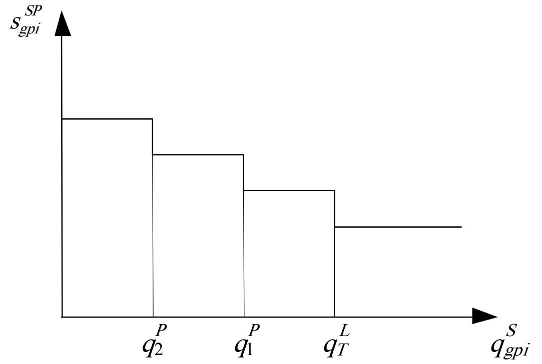


Figure 2. Change of specific purchasing cost as a function of ordered quantity

The figure above shows the step function of specific purchasing cost of component *g* ordered by production company *p* and supplied by supplier *i*. A similar specific cost function can be made for each component part from each supplier. This nature of the function arises from the assumption that higher ordered quantity is accompanied with lower specific purchasing costs. The total yearly purchasing cost can be calculated as follows, where $Q_{gpi}^{S}$ means the yearly ordered quantity:

$$s_{gpi}^{SP}(q_{gpi}^{S}) = \frac{C_{gpi}^{SP}}{Q_{gpi}^{S}} \quad (5)$$

Specific transport cost: $s_{gpi}^{ST} = s_{gpi}^{ST}(q_{gpi}^{S})$. The specific transport cost can be calculated as follows 5. Parameter $s_{gpi}^{ST}$ is the specific transport cost referring to the average quantity and parameter $s_{gpi}^{ST^*}$ is the specific transport cost referring to one piece.

Specific transport costs decrease hyperbolically as well as the maximum values of each range also decrease hyperbolically (ranges refer to the transport capacities).

$$s_{gpi}^{ST} = \frac{C_{gpi}^{ST}}{Q_{gpi}^{S}} = \frac{1}{q_{gpi}^{S}} \left( \text{Entier} \frac{q_{gpi}^{S}}{c_{\phi}} + \Phi \right) \cdot l_{ip}^{ST} \cdot s_{gpi}^{ST*} \quad 6)$$

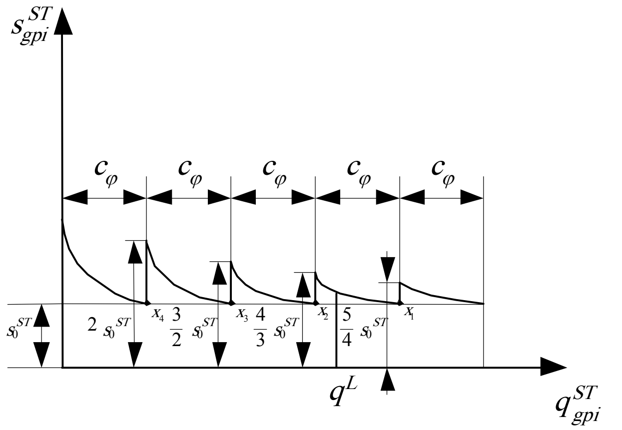

Figure 3. Change of specific transport cost as a function of ordered quantity

Specific storage cost: $s_{gp}^{CS} = s_{gp}^{Cs}(n_{gpi}^{S})$

$$s_{gp}^{CS} = \frac{C_{gp}^{CS}}{Q_{gpi}^{S}} = \frac{\vartheta}{2n_{gpi}^{S}} \cdot s_{gp}^{CS*} \qquad (7)$$

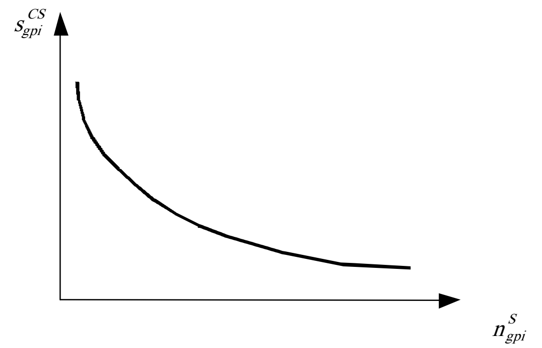

Figure 4. Specific storage cost as a function of yearly transport number

On the one part, the specific storage cost changes as a function of number of transports (hyperbolically); on the other part, it changes as a function of the transported quantity linearly.

A short evaluation of specific cost functions: the specific purchasing cost is constant above the $q_T^L$ limit quantity; the specific transport costs are the lowest at the X points; the specific cost of storage makes up a hyperbolic function as a function of yearly transport number.

The main principle of the heuristic algorithm arises from examining the specific costs: quantity transported at one time may be decreased until transport and purchasing costs do not increase. The specified simplified cost function can be calculated by two methods. One is the method of total counting, limited regarding the number of transports, which means that the cost function is calculated for numbers of transports discussed in the further parts of this paper (this time only for them) regarding each supplier, component part and production company. The other method is to go through a heuristic algorithm. The goal is to compare the results of these two methods within the confines of this paper. (Nagy, Bányai, & Cselényi, 2005, Nagy, Bányai, & Cselényi, 2006)

The aim of this paper is to examine how the change of specific costs in different proportions influences the cost function, as well as to evaluate and compare the results of the cost sensibility examination regarding the shown model.

## 3. Methods of optimisation

### 3.1. Limited total counting (I.)

On the grounds of the assumed base data, using formula 1, the optimum cost is calculated for different numbers of transports regarding component *g*, supplier *i* and production company *p* and the optimum supplier is determined. Because of the large extent of the example, calculations are made only with $n_{gpi}$ = 1, 2, 3, 12 and 48 yearly transports. (Therefore is limited the total counting.) In the first step, calculations are made regarding one production company, then regarding several companies (three companies within the confines of this paper). (Simchi-L, Chen, & Bramel, 2005)

3.2. Heuristic algorithm (II.)

When compiling the algorithm, specific purchasing, transport and storage costs have been taken as bases. The essential part of the algorithm examines the given specific cost functions (purchasing and transport costs), determines where the breakpoints are, it calculates step-by-step the costs at these breakpoints and then it calculates the total cost. All these calculations are made while the total costs decrease. At the resulted optimum point, it is also resulted that which component parts should be supplied by which suppliers how many times a year, i.e. the optimum supplier is selected for each component and for each production company and also the yearly transport number is determined regarding a given component and a given production company by this.

## 4. Data structure required for examining optimisation methods

To analyse the present system, several base data must be assumed so that the mentioned two methods can be used on this system. Base data in this example can be divided into constant and variable data.

### 4.1 Constant data of the examinations

g=4, examinations cover four types of component parts,

p=3, costs are calculated for three production companies (in the first example, examinations covered one production company)

$\varphi_i=1$, calculations concern one transport vehicle,

$C_{1g} = [700,700,800,1000]$ vehicle capacity matrix, which is defined as follows: transport vehicle no. 1 can carry the given quantity of the component part no. 1, i.e. the vehicle can carry 700 pcs of component part no. 1 at the same time. Similar definitions apply to the other components, too.

$$Q^S_{gpi} = \begin{bmatrix} 120 & 100 & 150 \\ 90 & 130 & 120 \\ 150 & 80 & 200 \\ 30 & 50 & 100 \end{bmatrix} [\text{kpcs/year}]$$

yearly ordered quantity, e.g. production company no. 2 orders yearly 100,000 pcs. of component part no. 1,

$s^{SP}_{gpi}$ specific purchasing cost can be read out of the graphs (see e.g. Figure 2.) as a function of the purchased and at the same time transported quantity.

$s^{ST*}_{gpi} = 0{,}8k_0 \; [\text{EUR / travel\_km}]$

specific transport cost for each supplier,

$$s^{CS*}_{gp} = \begin{bmatrix} 0.004 & 0.004 & 0.004 \\ 0.005 & 0.005 & 0.005 \\ 0.005 & 0.005 & 0.005 \\ 0.005 & 0.005 & 0.005 \end{bmatrix} k_0 \; [\text{EURO /(pcs * day)}]$$

specific storage cost.

### 4.2. Variable data of the examinations

During the examinations

i=7, optimum supplier is selected out of 7 suppliers,

in the examinations, all cases of yearly transport numbers $n_{11i}$ = 1, 2, 3, 12 and 48 are to be considered,

distance matrix, its elements mean the transport distances from each supplier in km (transposed matrix is shown here):

$$L^{ST^T}_{ip} = \begin{bmatrix} 40 & 50 & 70 & 75 & 80 & 100 & 125 \\ 50 & 60 & 80 & 60 & 85 & 60 & 110 \\ 120 & 90 & 70 & 95 & 100 & 90 & 70 \end{bmatrix} \text{km}$$

## 5. Cost sensibility examination

The principle of our cost sensibility examination is that only one cost factor changes in case of each variant, i.e. analysing the purchasing, transport or storage costs mean separate cases. We have changed the specific cost factors only, but capacity of transport vehicle or break-points of specific purchasing and transport functions have not changed, which would have distorted the influence of the specific functions on the total costs.

We use the multiplicator $\varphi$ at each specific costs with values of $\varphi$ =0.25, 0.5, 0.75, 1.25 and 1.5.

*Specific cost characteristics:*

$\varphi_P \rightarrow$ *multiplicator of specific purchasing costs*

$\varphi_T \rightarrow$ *multiplicator of specific transport costs*

$\varphi_S \rightarrow$ *multiplicator of specific storage costs*

*E.g.:* $s^{SP'}_{gpi}(q^{S}_{gpi}) = \varphi_P * s^{SP}_{gpi}$

Our analysis has been projected to the results of both total counting and heuristic algorithm in this paper. Our calculations has been done for 3 production plants, 7 suppliers, 4 types of component parts and for yearly transport numbers (1, 2, 3, 12, 48) given earlier, i.e. changing each specific cost separately, we have examined, how they influence the optimum resulted our analyses so far. Since optimum solution includes the amount of the total costs, the optimum yearly transport number and of course, the respective optimum supplier, therefore all of these must have been reconsidered.

Figure 5 shows the influence of changes of specific costs on the total costs in case of production plant 1 and examined component part 4.

Interpreting data in the chart, you can see, how the optimum total costs regarding the given production plant changes with the changes of proportions of specific costs. In the cells of the chart, optimum supplier, optimum yearly transport number and of course, total costs also change for component parts 2, 3 and 4. In this example of component part 4 and production plant 1, we encounter an interesting situation, since we obtain the same optimum costs in cases of two different yearly transport numbers.

Similar chart has been resulted for the other two production plants, but because of extension limits of this paper, they are not presented here.

| | | | component 1 | | component 2 | | component 3 | | component 4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| $\varphi_P$ | $\varphi_T$ | $\varphi_S$ | $C^{SP}_{gpi}$ | $\eta$ | $C^{SP}_{gpi}$ | $\eta$ | $C^{SP}_{gpi}$ | $\eta$ | $C^{SP}_{gpi}$ | $\eta$ |
| 1 | 1 | 1 | 160336 | | 124471 | | 92550 | | 146045 | |
| 0,25 | 1 | 1 | 70336 | 0,439 | 36721 | 0,295 | 36300 | 0,392 | 44795 | 0,307 |
| 0,5 | 1 | 1 | 100336 | 0,626 | 65971 | 0,530 | 55050 | 1,517 | 78545 | 0,538 |
| 0,75 | 1 | 1 | 130336 | 0,813 | 95221 | 0,765 | 73800 | 1,341 | 112295 | 0,769 |
| 1,25 | 1 | 1 | 190336 | 1,187 | 153721 | 1,235 | 111141 | 1,506 | 179795 | 1,231 |
| 1,5 | 1 | 1 | 220336 | 1,374 | 182971 | 1,470 | 128016 | 1,152 | 213545 | 1,462 |
| 1 | 0,25 | 1 | 151984 | 0,948 | 120121 | 0,965 | 82746 | 0,646 | 144605 | 0,990 |
| 1 | 0,5 | 1 | 154768 | 0,965 | 121591 | 0,977 | 86586 | 1,046 | 145085 | 0,993 |
| 1 | 0,75 | 1 | 157552 | 0,983 | 123031 | 0,988 | 90426 | 1,044 | 145565 | 0,997 |
| 1 | 1,25 | 1 | 163120 | 1,017 | 125911 | 1,012 | 94086 | 1,040 | 146525 | 1,003 |
| 1 | 1,5 | 1 | 165904 | 1,035 | 127351 | 1,023 | 95622 | 1,016 | 147005 | 1,007 |
| 1 | 1 | 0,25 | 138436 | 0,863 | 115544 | 0,928 | 62454 | 0,653 | 170670 | 1,169 |
| 1 | 1 | 0,5 | 145736 | 0,909 | 122388 | 0,983 | 73861 | 1,183 | 204420 | 1,400 |
| 1 | 1 | 0,75 | 153036 | 0,954 | 124043 | 0,997 | 82567 | 1,118 | 238170 | 1,631 |
| 1 | 1 | 1,25 | 167636 | 1,046 | 124899 | 1,003 | 95402 | 1,155 | 305670 | 2,093 |
| 1 | 1 | 1,5 | 174936 | 1,091 | 125326 | 1,007 | 98253 | 1,030 | 339420 | 2,324 |

*Figure 5. Influences of changes of specific costs on the total costs in case of production plant 1 and examined component part 4*

The following graph illustrates the costs referring to component part 1 in the chart in Figure 5, i.e. influences of different specific multiplicators are presented correlated to the optimum cost. It is conspicuous, that specific purchasing cost has a very dominant influence compared to the two other specific factors for the given component part, since if e.g. specific purchasing cost is decreased to its quarter, a decrease of total costs of 56.1 percent can be found, whilst considering either specific transport cost or specific storage cost in the same situation, we obtain decreases of only 5,2 percent and 13,7 percent, respectively.

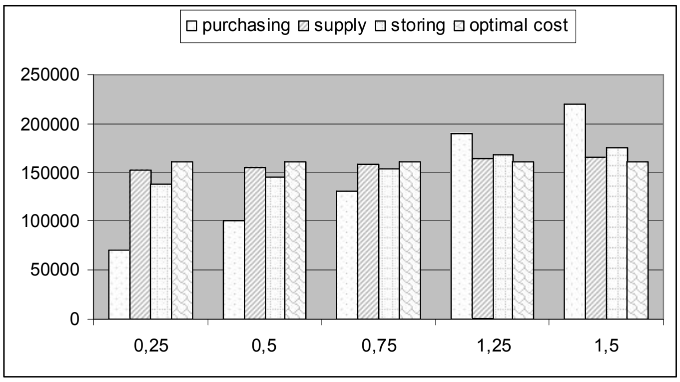


*Figure 6. Influences of changes of specific costs on the optimum total costs in case of total counting*

Influence of changes of specific cost functions on optimum results of heuristic algorithm is shown in Figure 7. Similarity is apparent in cases of the two methods. Great influence of specific purchasing cost on the optimum total costs shows up in both cases.

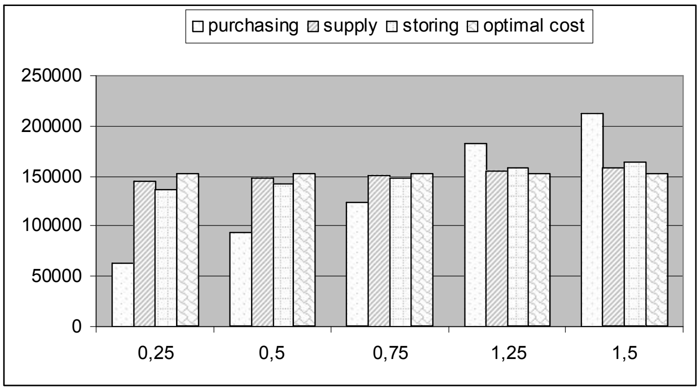


Figure 7. Influences of changes of specific costs on the optimum total costs in case of heuristic algorithm

Of course, this numeric example is only a backup of this examination, by which we aimed to introduce the influence of change of each specific cost on the optimum total costs, optimum supplier and optimum yearly transport number. It can be seen that changing the dominant parameter can result great cost increase or decrease and that the cost function applied in this model is quite insensible to the changes (of different proportion and of different extent) of certain parameters.

## 6. Conclusion

A network-like functioning assembly system and the formulas and elements of the simplified cost function has been reviewed. Influence of changes of specific costs in different proportions on the cost function and evaluation of their results have been introduced. Our future plans include the consideration of capacity limits per supplier and per distribution store in case of indirect transports, as well as introduction, analysis and sensibility examination of a new optimisation parameter (ordering time).


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# CONSUMER WELFARE IN SUPPLY CHAIN MANAGEMENT AND THE ROLE OF REGIONAL COOPERATION

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## Abstract

*As a result of trade policies the environment within which trade takes place differs across border both in scope and content as well as in administration. These include tariff and non-tariff barriers, differences in custom administration and documentation and as well transport network. This document presents some new requirements that facilitate the passage of goods across the borders and thus the SCM efficiency and consumers, welfare. We highlight the role of regional cooperation in facilitating Supply Chain Management (SCM).*

*Global facilitation will provide a multilateral platform for more efficient environment for international trade and transportation of products across the borders. Regional groupings should also complement this effort through provision of road network, reduction or elimination of impediments that prevents easy passage of goods within the region, maintenance of order along the border and conflict resolution in the region. These barriers hamper efficient SCM, add to the transaction costs and consequently and finally reduce welfare of consumers.*

Keywords: Consumer Welfare, Supply Chain Management, Regional Cooperation

## 1. Introduction

Profit or net revenue maximization is the major driving objective of the most business organisations. To achieve this aim business organisations use different strategies to reach the final users of their products at the required time, quantity and affordable prices. Besides, maximization of welfare of consumers can also be seen as another objective which also helps achieving profit maximization. Today, to maximize profit customers satisfaction is essential; therefore meeting their demand within shortest possible time is a must. This is one of the greatest challenges facing most business organizations. Some business organisations do neglect this objective and rather focus on net revenue maximization.

Current market conditions and globalization have changed the outlook of business environment and the ways most organisations conduct their business. Especially market conditions are affected by demanding and sophisticated customers and shorter product life cycles [1]. These changes caused organisations to adopt more competitive strategies to pursue net revenue maximization and/or cost minimization and as well satisfying consumer demands. Prominent among these strategies is the global Supply Chain Management (SCM) based on enhanced integration of suppliers and customers as well as increased coordination across multiple value-adding processes with the firm [2, 3]. These strategies require firms to maintain core competency on a global scale for fundamental processes such as order fulfilment, supply management and new product development [4, 5]. The global Supply Chain Management strategy also requires that the flow of information, cash and materials to be managed on an international basis [6, 7]. As result the global Supply Chain Management activities involve both operational and financial decisions [8]. Its successful implementation can lead more effective risk management and the leveraging of the firm-specific and location-specific advantages to yield lower costs and higher returns and ensure consumers welfare. Adoption of Supply Chain Management strategic solution tries to meet competitive requirements of the market and to meet the customer's orders on time.

Information Technology has facilitated the flow of information between business organisations, and as well as customers and has overcome time barriers and geography [9, 10]. Despite this and the growth of regional initiatives with objective of reducing restrictive trade barriers, much of these trade barriers are still in place in many countries. Some countries have regulatory rules other than trade barriers and there is lack of good road networks connecting the regions that hinder flow of goods and services across the borders. SCM initiatives that intend to operate across functional boundaries must take into account these factors as it can increase the cost of operation. A significant challenge faced by any executive team to maximize business value is to determine the optimal balance of the key financial metrics and institute the appropriate structure to enable the achievement of that balance. Supply chain initiatives are very sensitive to this balance as they usually span the domain of multiple departments. Therefore improving consumers' welfare within the context of Supply Chain Management these factors need be accounted for.

Thus, the objective of this paper is of two folds. First is to examine the problems facing the Supply Chain Management across borders in meeting the consumer demands. Second, what role can the regional cooperation play

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in Supply Chain Management? The regional cooperation can be critical factor in addressing the problems facing global Supply Chain Management and hence ensuring consumers' welfare.

The paper is organised as follows. The next section briefly highlights what Supply Chain Management is. In this, it tries to define and examine various forms of supply chain models and problems facing the Supply Chain Management. Section three takes a glance on the role of effective Supply Chain Management in the developing countries in relation to economies of scale and value. Section four describes the roles of the regional and multilateral trade liberalisation in facilitating the SCM in developing nations. The fifth section gives the summary and conclusion.

## 2. Understanding Supply Chain Management

Supply Chain Management is born from the design details of a system that is developed by Toyota Company. With this system, Toyota aims coordinate and manage their own suppliers [5]. Afterwards, Change in the market conditions causes other manufacturing systems to apply similar principles of Toyota. Finally, these principles become a new managerial approach which is denominated as Supply Chain Management.

Today, Supply Chain Management becomes the oversight of materials, information, and finances as they move in a process from supplier to manufacturer to wholesaler to retailer and finally to consumer. In this line SCM is seen as effort involved in producing and delivery a final product from the supplier's supplier to customer's customer [11]. Thus SCM involves coordinating and integrating these flows both within an organisation and entities that interact with the organization.

With this respect, SCM means the management of customer driven inter-organisational relationship or it can be viewed as a series of interconnected management activities which occur between suppliers and customers [12]. Thus, it is presented as holistic management concept. It is said that the ultimate goal of any effective Supply Chain Management system is to reduce transaction costs to a tolerable level and inventory with the assumption that products are available when needed. It involves concepts about integrated business planning that have been espoused by logistics experts, strategists and operation research practitioners as far back as the 1950's [13]. This concept is made easy by advances in Information Technology. However many organisations or companies are still learning about it and how to implement this new analytical tool of planning.

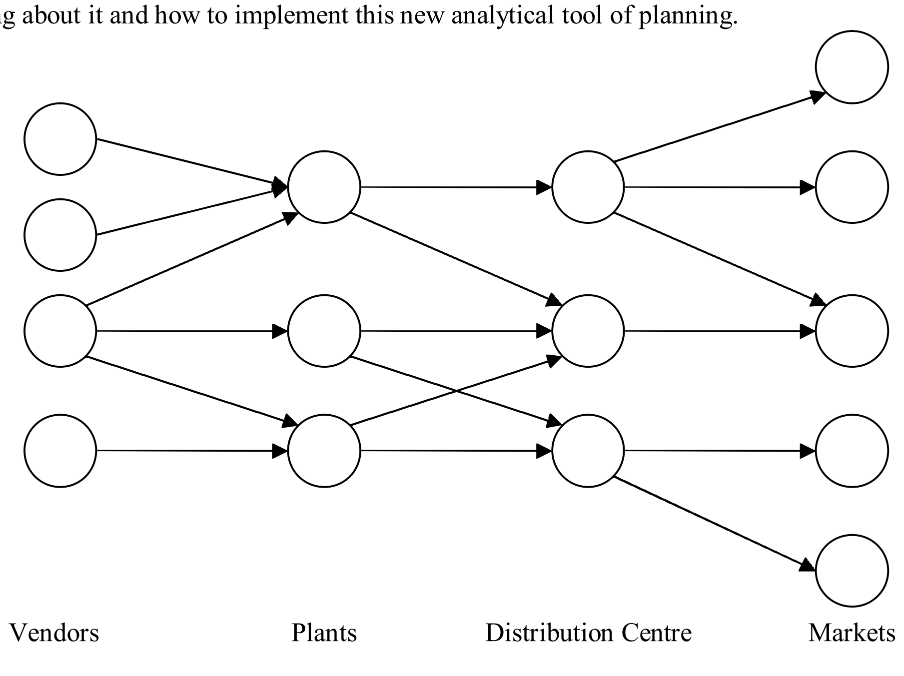


Figure 5: Supply Chain Network [13].

Supply chain of a company comprises geographically dispersed facilities where raw materials, intermediate goods or finished products are acquired, introduced, transformed, stored or sold and transportation links that connect facilities along which products flow. The facilities may be operated by the company or by the vendor, customers, third-party providers or other firms with which the company has business arrangements. The goal of most organisations is to add value to its products as they pass through the chain or maximize net revenue or income and transport them to geographically dispersed markets in the correct quantities, with correct specification at the correct time and at the competitive costs [13, 14]. A typical supply chain that depicts the above scenario is a representation of a network showing vendors, plants, distribution centres and markets (final consumers). This is shown in Figure 1. The supply chain is connected by links that represent both information and material flow which is permitted by company managing its supply chain.

This shows four levels of facilities. Products flow downstream from the vendors to plants and upstream from the plants to distribution centres, and distribution centres to markets. The various points in the supply chain are linked by transportation. Along these lines, especially across the border are intervening factors that include the trade restrictive policies and custom administration and documentation procedures and logistics infrastructures in the destination country. These factors shift the price or the cost of the products upward, capable of restricting supply at right quantity, at the right time and correct specification and limiting the effect of SCM on economic development. Some time, as a result, the supply chain is broken down.

The supply chain can be vertical or horizontal and it is not limited to physical product markets but also it extends to financial markets as well. It can involve Small and Medium Scale Enterprises (SMEs) that collaborate together in order to increase their respective impact on the final and intermediate markets and potential income [14]. This concept sees manufacturing as a process that is more or less dependent on a strict co-ordination and co-operation among a large number of trade partners. The first attempt of this sort of Supply Chain Management, in which some SMEs collaborate to increase their potential in a large market, is to search for a common interest either in production activities or in marketing efforts. These types of co-operations give rise to clustering (i.e. groups of small firms operating in a common territorial environment). The idea is that number of small firms should be able to grow together, as they share common abilities and opportunities offered by the same town or territory as well as common administrative rules and reference persons [14]. The second idea behind these types of co-operations is that a common place could be used for creating a trade mark, related to territory, facilitating a large circulation at least all over the country and possibly internationally. The sole condition necessary for cluster assembly is to have a common "political committee" with the aim of promoting contacts of the SMEs with local authorities, as dedicated legislative measures and funds for development.

Further supply chain may spring up among the agglomerations of firms that focus on a specific manufacturing sector in regions where gradual but relevant growth of a single enterprise is occurring. In this situation the creation of some SMEs is supported by the opportunity of offering side or ancillary production to the larger enterprise, which plays the role of leader of a group [14]. This leads to connection between the main enterprise which is the client of either raw materials or services supplied by the SMEs. This gives to the large number of supply chains operating in the most developed regions. The same idea is driving the allocations of new industry networks in developing countries. According to Villa et al. [14] the main idea, which motivates the generation of a new supply chain, is to assure that a production line could have its necessary supplies just in time and with the required precision and quality. Small ancillary firms are forced to assure this condition and are required to allocate either their plant or at least sufficient store close the leading enterprise. In this the necessary condition for Supply Chain Management is to have strong management centre, exercised by the leading enterprise and a hierarchical organisation able to assure that all SMEs.

Another form of supply chain has emerged which is called as demand and supply networks (DESNET). It is structured organisation of SMEs [14]. In practice, it emerges from the agreement among a set of SMEs. It is based on multi-agent concept and it is a virtual enterprise. This means that it is a temporary networks of several small firms which are agreed on co-operating in a common given value chain for a limited time horizon. The common example of a DESNET is a set of different enterprises able to produce different parts which are used in a common family of final product and to apply co-ordinated complementary production programmes for a common industrial goal. A typical DESENT is presented in Figure 2.

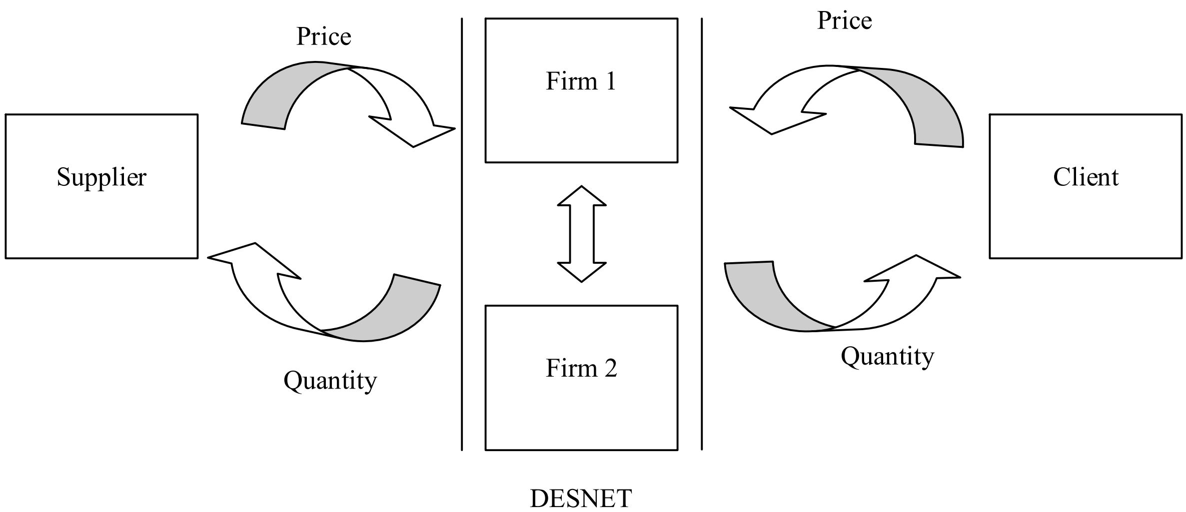


Figure 6: DESNET Supply Chain Model

The DESNET has characteristics of negotiation opportunity and open commercial system with which any two member SMEs interact by exchanging resources. Since each buyer will purchase resources to apply to his manufacturing operations the principal functions of any component firm are purchasing, transforming and selling. The supply chain model is in Figure 2 a simplified form and it consists of four enterprises belonging to three different stages and two market places that define the interactions among agents. One market is concerned with negotiation between a supplier firm and the internal stage, the other market is concerned with negotiation between the internal stage and the final client. The operations and decisions at each stage are described according to the following steps:

First step: The client firm C asks for a volume y of the final products to the internal working stage and it is offered a price p.

Second step: The two SMEs (F1 and F2) belonging to internal working stage as for a volume m of raw materials to the supplier firm S and is offered a price q.

Third step: Within the internal working stage the SME F1 searches for agreement with SME F2 for defining the two volumes y1 and y2 to be delivered to the client C.

In this model there is also a co-operation among the internal working stage firms. This co-operation leads to satisfying the client's required quantity and meeting the delivery time. Thus all the firms are maximizing their net revenues. This presupposes that the major objective of the Supply Chain Management is to minimize the total supply and distribution costs to meet fixed and given demand. Therefore, SCM intends to minimize costs such as raw material and acquisition cost, inbound transportation costs, facility investment costs, direct and indirect manufacturing costs, direct and indirect distribution centre costs, inventory holding costs, inter-facility transportation costs and outbound transportation costs. The across border costs that firms will intend to minimize will among other things costs associated with customs administration and documentation, trade barriers, inadequate road network and exchange rate.

## 3. Supply Chain Management, Development

Having discussed what Supply Chain Management means and different models of Supply Chain Management we briefly take a look at the role of Supply Chain Management in development. From the preceding section it can be observed that Supply Chain Management can play a vital role in economic development of a region or country. Reviewed analytical frameworks of supply chain spell out implicitly the critical impact of Supply Chain Management in development process and these are categorized into two - economies of scale and value.

In this section the discussion starts with the premise that such endogenous factors (exports, domestic investments etc) are necessary, but insufficient on their own, to generate regional growth in an era in which competition is increasingly global. There is no doubt that, for development to take place a region must benefit from economies of scale and scope derived from what Storper [15] terms the "holy trinity" of technology - organization- territory. In Figure 1, the term "regional assets" is used to describe necessary precondition for regional development. In general, these assets can produce two types of economies. First, economies of scale can be achieved in certain regions through highly localised concentrations of specific knowledge, skills and expertise. This concentration of technological advantages embodied in social actors located in specific regions creates economies of scale in particular technologies that can be exploited through the agglomeration of firms that in turn provide employment and generate economic outputs within similar high tech industries [16]. Second, economies of scope can exist if these regions are able to reap the intangible benefits of learning and the co-operative atmosphere embedded in these agglomerations. This is famously known as the spill-over effects. A variety of different high value-added activities may be located or developed in these regions because the tendencies towards learning and cooperation facilitate a broad spectrum of production and entrepreneurial activities. Silicon Valley is perhaps the archetypal case in this regard [17-19].

It is argued that economies of scale and scope embedded within specific regions are only advantageous to those regions and bring about regional development insofar as these region-specific economies can complement the strategic needs of trans-local actors situated within global production networks or supply chains. As shown in Figure 1, when such a complementary effect exists between regions and global production networks, a coupling process will take place through which the relational advantages of regions interact with the strategic needs of these global production networks. Regional development thus depends on such a coupling process that evolves over time in relation to the rapidly changing strategic needs of global production networks and the rather slow transformations in regional economies of scale and scope.

Before analysing such a coupling process, it is important to unpack the strategic needs of global production networks. Global production networks can be defined as the globally organized nexus of interconnected functions and operations through which goods and services are produced and distributed. Such networks not only integrate firms (and parts of firms) into structures which blur traditional organizational boundaries through the development of diverse forms of equity and non-equity relationships, but also integrate regional and national economies in ways that have enormous implications for their developmental outcomes. At the same time, the precise nature and articulation of firm-centred production networks are deeply influenced by the concrete socio-political contexts within which they are embedded. The process is especially complex because while the latter are essentially territorially specific (primarily, though not exclusively, at the level of the nation-state or the region), the production networks themselves are not. Global production networks "cut through" national and regional boundaries in highly differentiated ways, influenced in part by regulatory and non-regulatory barriers and local socio-cultural conditions, to create structures that are "discontinuously territorial" [20, 21].

Spanning national boundaries and market areas, the strategic needs of focal firms –defined as dominant firms spearheading the global organization of production networks through their corporate and market power– in global production networks do not always and necessarily intersect with regional advantages. Global integration of activities within these production networks, for example, may not be beneficial to some regions because of the likelihood of greater external control of the regional economy. Indeed, many focal firms in global production networks may pursue different organizational configurations to reap economies of scale and scope in these networks. In general, economies of scale in global production networks can be achieved through globally integrated R&D, sourcing, production, and marketing activities that take place only in specific locations. The smaller the number of firms will engage in each of these functions, the greater the economies of scale will be in a particular global production network. This is because each of these firms can specialise in a designated function, e.g. R&D or assembly operations. Economies of scope in global production networks; on the other hand, exist through differentiation in the functional activities of firms in the network such that a variety of firms may be used for R&D, sourcing, production, and marketing activities. These different firms often offer learning and knowledge possibilities that are not available if the function is performed by a single firm, as in the practice of global sourcing or R&D. As Nohria and Ghoshal [22] argue, many leading global corporations are increasingly tapping into differentiated advantages among different subsidiaries and supplier networks [23, 24]. Different attributes of subsidiaries and suppliers within a global production network can be explained in terms of selected attributes of the external network within which it is embedded. Internal differentiation within a global production network can also be seen as requisite to a network's success with overall network performance being positively correlated with a high degree of internal differentiation.

How then is this complex organization of global production networks related to regional development? In Figure 1, this relationship can work through the creation, enhancement, and capture of value. "Value" term is used to refer to various forms of economic rent that can be realised through market as well as non-market transactions and exchanges [25]. Alongside value creation through the labour process, for instance, value can take the form of technological rents by way of access to particular product or process technologies, or may be manifest as relational rents, based on inter-organisational links improving know how transfer and collective learning. The fact that a region is "plugged" into global production networks does not guarantee its positive developmental outcome because actors in this region may not be able to capture much of the value created in the region [26]. From the regional development perspective, the creation and retention of value within the region is imperative. The presence of a regional advantage may only ensure such value is created in the region, but not necessarily the retention of this value within the region. For example, a region may have an advantage in the quantity of labour, but much of the value created in the utilisation of this abundant pool of labour may be transferred out of the region through the repatriation of profits (realised value) and eventually the relocation of the production networks to other regions.

At the other end of the value-creation spectrum, nevertheless, a region with substantial "relational assets" (e.g. co-operative learning) may be successful in creating value in team-based projects that require face-to-face interaction in spatially proximate clusters. However, such a value creation process may run out of steam when these highly localised conventions and norms in learning are so binding and constraining that they hinder the development of alternative mode of learning, say, through decentralised and distanced networks facilitated by greater mobility of actors and a series of other technologies of contact and translation [27-29]. Hence, regional assets can become an advantage for regional development only if they fit the strategic needs of global production networks. The process of "fitting" regional assets with strategic needs of global production networks thus requires the presence of appropriate institutional structures that simultaneously promote regional advantages and enhance the region's articulation into global production networks (see Figure 1). Again, it is crucial to stress that the notion of 'regional' institutions includes not only regionally-specific institutions, but also local arms of national/supranational bodies (e.g. a trade union in the cooperating countries, a national tax authority), and extra-local institutions that affect activities within the region without necessarily having a presence (e.g. regional trade blocs and multilateral trading systems). These regional institutions are important because they can provide the "glue" that ties global capital and unleashes regional potential.

Three dimensions of such institutional structures are crucial to regional development. The first dimension involves the creation of value through the efforts of regional institutions in attracting the location of value-added activities. Although it is often unclear whether such a process involves too much "tying" the region to the value activities of particular focal firms or global production networks, the efficacy of this relational coupling between the region and the focal firm hinges on the region's capacity to enhance and capture value from the process [30]. However, in the absence of such a coupling process, the question of regional development remains a moot point since no value will be created, let alone enhanced and captured. More importantly, the second and third dimensions refer to the capacity of regional institutions in value enhancement and value capture.

Value enhancement essentially involves technology transfer and industrial upgrading. The influence of regional institutions via government agencies, trade unions, employer associations and so on can be significant. On the one hand, regional institutions may promote specific "regional assets" (e.g. co-operative industrial relations) that are conductive to high value-added production activities because these activities incur high costs of fixed investment (i.e. sunk costs) and are difficult to be relocated within a short period of time. There is thus a mutually beneficial interaction between regional institutions and regional assets (see Figure 1). On the other hand, regional institutions can also promote the value enhancement activities of focal firms in global production networks. This occurs when regional institutions are prepared to invest in developing the infrastructure and human resources required for value enhancement (e.g. highly stable power supply and skilled engineers for wafer fabrication). Over time, more value enhancement activities within global production networks may occur in these regions when focal firms are induced to bring in their core technologies and expertise. The development of sophisticated local supplier networks, for example, is important in enhancing the value activities of focal firms through "reversed" transfer of local knowledge and experience [31]. In short, not all regional assets are complementary to the enhancement of value by focal firms in global production networks. The key issue is the appropriateness and complementarity of these assets, not their mere presence.

The third dimension of regional institutions in promoting regional development rests with their capacity to ensure value capture. It is one thing for value to be created and enhanced in some regions, but it may be quite another for it to be captured for the benefit of these regions. The issues of power and control are critical in the analysis of value capture. The role of regional institutions in negotiating these issues of power and control by local firms in global production networks is linked to their development policies, ownership patterns, and corporate governance. Clearly, focal firms in global production networks have enormous corporate power through their ability to collect and process information on a global basis. This information asymmetry may ensure very high bargaining power among some focal firms' vis-à-vis host regional institutions [32, 33]. But equally, regional institutions may mobilise their region-specific assets to bargain with these focal firms. The bargaining power of these regional institutions is particularly high if their region-specific assets are highly complementary to the strategic needs of focal firms. For example, focal firms that are under severe cost pressures are likely to allow for more value to be captured in regions that offer significantly cheaper factors of production. Conversely, a region can achieve greater value capture if the reinvestment of retained earnings in localised subsidiaries is critical to a particular function of the global production network (e.g. new process technology). As such, the capacity of regions to capture value is a dynamic outcome of the complex bargaining process between regional institutions and focal firms in global production networks. The presence of region-specific assets is only relevant in this process if these assets are complementary to the strategic needs of trans-local actors embedded in global production networks.

## 4. Trade Policies and The Role of Regional Cooperation

The preceding section has outlined the importance and problems facing the global Supply Chain Management in developing countries. In this section we examine the role of regional initiatives in Supply Chain Management and ensuring consumers' welfare. From the preceding section it is clear that Supply Chain Management is adversely affected by excessive burdensome of trade procedures. These constitute fixed costs and result in reduced returns and disincentives to service the markets. For example, if the country of one of the co-operating firms has quantitative restriction on goods involved in supply chain, then the required quantity will not be shipped. The Supply Chain Management has hampered by this quantitative restriction placed on the goods. This makes goods to be scarce and increases the prices of the products and reduces the net income of the co-operating firms. Besides, the consumers' opportunity to choose from the variety of goods is limited. For example the European Union (EU) common agricultural policy has inhibited Supply Chain Management in agricultural products and prevents EU consumers from the opportunity of choosing from variety of products created by Supply Chain Management. Other trade policies such as tariff and non-tariff barriers, as well as phytosanitary regulations have similar impacts on the Supply Chain Management; the firms' net income will be affected as the costs along the supply chain curve increases.

Let us take a hypothetical model of Supply Chain Management which can be of any variant, for example. Our involving firms in different regions can be represented in Figure 3.

Here the customs administration denotes all forms of restrictive trade policies and unnecessary inspections in the regions. These trade policies that restrict effective supply management include export tariff, quotas and import tariffs. Firms in region 1 are designated suppliers and firms in region 2 are clients or co-operating firms of firms in region 1.

Let us assume that order originates from the firms (clients) in region 2 and they specify the quantity and offer the price they are likely to purchase the goods. The co-operating firms (suppliers) in region 1 accept the price offered by the firms in region 2. If the firms supply this quantity at specified price the actual price they receive will be less customs administration costs (export tariff, inspection etc). On the other hand, the price at which the firms in region 2 sell will be increased by customs administration costs. In both cases the net income of the co-operating firms are reduced by amount equivalent to customs administration costs, assuming all other factors affecting the supply and demand for the goods remain unchanged.

Thus the role of regional initiatives is to help create an enabling environment for trade transactions. This trade facilitation measures would benefit developing countries not only in creating and or expanding opportunities but also in increasing the number of potential multinational enterprises. In this regard developing countries need to establish a favourable domestic environment for international trade transactions by collectively reducing trade barriers, harmonising customs procedures within their region and adopting international instruments and best commercial practices. Border-crossing points are critically important as they are key locations where discrepancies between buyers and sellers in domestic environment are exacerbated. Regional trading arrangements are critical in this respect to address the difficult challenges arising from globalisation, many which often are beyond the capacity of individual developing countries to handle.

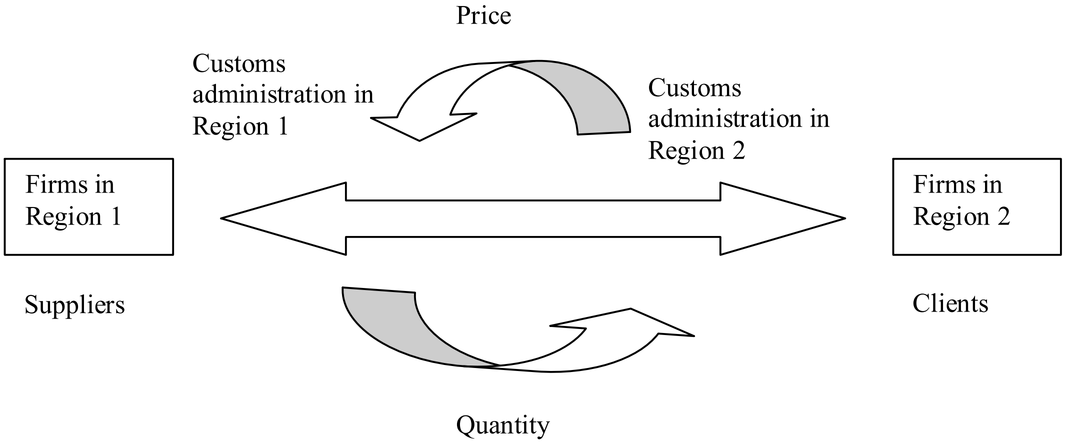


Figure 7: Representative model of Cross border SCM

Through the regional trade blocks the developing countries could strengthen their capacity to link with regional markets and logistics networks. In some countries the state road network is deplorable. The inefficiencies and delays occur at the interchange points at border crossings and along the national transport network. These delays result from inadequate infrastructure, inappropriate cargo handling equipment and transport fleets, cumbersome trade procedures, inappropriate management procedures and lack of know-how. Removing or minimizing the problems will reduce the costs and delays and thus improve the Supply Chain Management in developing countries. In such cases, applications of Information Technology such as Management Information Systems and Geographic Information Systems (GIS) can be utilized. Moreover, satellite based tracking systems like European Global Navigation Satellite System (GNSS), Global Positioning Systems and Russian Global Navigation Satellite System (GLONASS) can be beneficial in tracking goods not only at borders but also in all of the countries [34, 35].

Regional trade arrangements should aid the individual countries within its domain to streamline its national procedures, rules and regulations using international instruments, standards and recommendations. This could lead to improvement in existing facilities without large investments. For example allowing goods to be cleared by customs twenty-four hours a day facilitates the global Supply Chain Management as it doubles the capacity of national transport fleet. With this respect, the port logistics, infrastructure quality and efficiency, customs efficiency and the regulatory environment require improvement [36, 37]. Institutional reforms that aimed at increasing private sector participation and competition are necessary to increase the SCM infrastructure.

The use of Information and Communication Technology (ICT) speeds up the exchange of information and allows for more efficient customs operations including risk management techniques. It also provides management with advanced information for planning; gives shippers greater choice and improves the quality of service. The use of ICT especially integrated applications of MIS, GIS and GNSS/GPS/GLONASS are necessary to introduce multimodal transport and Supply Chain Management.

With respect to E-Commerce and ICT the regional trade arrangements need to review the way limited access is constrained by lack of infrastructure, especially internet connections and the relatively high user charges for telephones. Uniform or relatively uniform charge telephone in the region might be necessary to support the global Supply Chain Management as high charges on phone calls increase the cost of coordination.

## 5. Summary and Conclusion

This paper examines the role of regional initiatives in facilitating global Supply Chain Management and consumers' welfare. With this respect, the problems facing the global Supply Chain Management in general and in developing countries in particular are highlighted. These problems include trade barriers, custom procedures, poor transport infrastructures and insufficient use of information and communication technology and lack of inter regional networks. These problems can increase transaction costs of Supply Chain Management, reduce the opportunity to consumers to benefit from variety of goods at competitive prices and cause delays in delivery of goods. The effective Supply Chain Management depends among other things on quality of transport networks and communication infrastructure and the institutional frameworks in individual countries and trade polices to allow access to the hinterland. If Supply Chain Management can open new markets in developing countries, efficient institutional frameworks and less stringent trade policies are necessary to connect the domestic and international producers with these markets.

Since the use of Supply Chain Management networks in international trade requires a favourable legal environment, it is suggested that to establish similar structure of the United Nations Commission on International Trade Laws on Electronic Commerce and Electronic Signatures to be set up for global Supply Chain Management. This will provide guidelines for national governments in creating an enabling and secure legal environment for Supply Chain Management in general. Multilateral efforts are required in this regard and should be coordinated to help developing countries take advantage of Supply Chain Management to ensure consumers welfare.

International cooperation in transport and trade facilitation is required to increase efficiency. Policy programmes should be developed with the objective of providing developing countries with sustainable capacity to plan and implement trade and transport facilitation initiatives. The creation of local trade and transport facilitation platforms is part of comprehensive institution-building programme that would form the basis for the promotion of partnerships in Supply Chain Management in border trading communities. The partnership platform is a vehicle to facilitate the implementation of recommendations and guidelines, provides policy advice disseminate information relating to transport and trade facilitation issues.

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# SALES FORECASTING AND DEMAND PLANNING PROCESSES: RESULTS OF A SURVEY IN ITALY

Alessandro Creazza[1], Fabrizio Dallari[2], Carlo Noè[3]

## Abstract

*Although every business function needs accurate sales forecasts, very little attention has been devoted to examining how the sales forecasting and demand planning (SF&DP) process should be managed. Having the goal of highlighting the critical issues in the management of the SF&DP process along with the best practices found in world-class organizations, this paper reports the results of a research performed on over 25 companies in Italy. Results show which functions are mainly involved the SF&DP process and how different managerial approaches can influence the effectiveness of the forecast performance. The cross industry analysis, carried out in the Beverage, Grocery and Pharmaceutical industries, can help supply chain managers to better understand their own "as-is" status and how the same issue has been approached and solved in a different business environment.*

Keywords*:* Sales forecasting; Demand planning; Supply Chain Management; Benchmarking.

## 1. Introduction

The present paper analyzes both Sales Forecasting and Demand Planning (SF&DP) process, as they are strictly linked and their boundaries are often not clearly drawn. Namely, we can define *sales forecasting* as the process to estimate the future sales volume over a specified period of time (forecasting horizon), starting from a time series of past sales data. Strongly based on statistics, this process yields, through a computerized system, the baseline of the forecast for a given "time bucket" (e.g. week). This baseline is the projection of the demand into the future not considering the effects of external inputs, such as promotional activities or other causal effects. *Demand planning* is the process that combines the statistical forecast with all internal and external market and customer information coming from the business functions involved in the process (either qualitative or quantitative). In this case the human impact is higher than in the previous one and it is accomplished during one or more forecast meetings. Starting from the baseline, the players of the demand planning evaluate how much of the external inputs is included in the base forecast and, at the same time, they take in the information or input of their own competence. The objective of Demand planning is therefore to achieve a consensus forecast plan.

Sales Forecasting and Demand Planning (SF&DP) process is a critical consideration for all the players in the supply chain and is a central activity for many executives who manage their companies' supply chain activities as well as those specialists responsible for developing and monitoring sales to forecast, schedule, and budget. For Sales, the forecast will be used as a way to increase customer-service levels; for Marketing, to measure the effectiveness of trade and advertising programs; for Finance, to project and track returns to financial plans; and for the Supply Chain, to drive efficiently production scheduling, inventory deployment, and capacity planning (Marien, 1999).

Indeed, forecasting future demand is essential for a company's tactical, operational, and strategic planning needs, but it is an extremely complex process, especially in recent years, when mass customizations and short product life cycles have replaced steady demand situations and factory push models.

Although every business function needs accurate sales forecasts, very little attention has been devoted to examine how the sales forecasting and demand planning process should be managed. Since early '90s, literature on sales forecasting has largely concentrated on the techniques or on the systems used, rather than on the forecasting managerial philosophy which considers the organizational, procedural, motivational and personnel aspects of the forecasting process and its integration into other business functions (Drury, 1990).

The interest on SF&DP process began in the '90s, particularly with the researches carried out by Mentzer and Moon (2005), covering more than 400 US-based companies which has been interviewed on their forecasting process, being made of 3 interdependent elements:

- Models and techniques*: which can be divided in open model time-series techniques (e.g. Box Jenkins), fixed model time-series techniques (e.g. exponential smoothing), regression analysis and qualitative techniques (e.g. Delphi method);*

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- IT systems and applications*: which include computer and electronic communications used to develop, analyze and distribute cross-functionally forecast data;*
- Managerial approaches*: that is how the sales forecasting and demand planning process is organized, managed and controlled, along with who has the ownership of each sub-phase.*

Although both models and IT systems are the basis for the SF&DP process, the third element (i.e. the organization) is the crucial one: Mentzer and Schroeter (1994) assert that improvement in this area has a greater impact on the formal forecasting accuracy than improvements in the other ones.

The "managerial approaches" dimension includes the identification of the individuals involved in the SF& DP process and their corresponding roles and responsibilities, along with deciding which business function will have the ownership of the SF&DP process (i.e. Sales, Marketing, Logistics, Production), how many planners are needed and what kind of reward policy to apply with respect to accuracy measures.

Yet, despite the importance of sales forecasting, a lack of communication within the company's functional areas and across trading partners in the same supply chain often leads to separate and disjointed forecasts, instead of a "consensus forecast". Following this process, the forecasts for the next planning horizon are achieved through discussions among the participants at the forecast meeting and should represent the input for the supply planning process, in which the forecasts are deployed in the most proper way (i.e. at SKU – Stock Keeping Unit – level and on a weekly basis).

In order to highlight the critical aspects and the best practices in the SF&DP process, and to give a reference model for each analyzed industry, an extensive survey has been carried out, as described in the following section. The third section of this paper presents the cross-industry results of the research, which gave enough issues to draw a roadmap for SF&DP process continuous improvement.

## 2. Research methodology and phases

The entire research was carried out over two years, involving more than 100 companies from different industries and consisted of two separate phases. In the first phase, from April 2004 to March 2005, the research focused on the forecasting process following the methodological framework proposed by Mentzer (2003), in which the collected information was analyzed in order to assess the current ("as-is") status of a company forecasting practice, using a 1 to 4 scale. An overall performance grid was developed for each company, with respect to four dimensions of analysis: functional integration, forecasting approach, IT systems and applications, performance measurement. In order to collect both qualitative and quantitative results, two different surveys were conducted in this first phase: 20 in-depth interviews and over 60 telephone interviews. The former were the basis for a benchmarking analysis to compare different forecasting processes. The latter resulted in a large data set of multiple answers for each of the four dimensions (Dallari et al., 2005).

In the second phase, from April 2005 to March 2006, about 25 leading companies operating in Italy across different industries were deeply analyzed in conjunction with Ailog (the Italian association for Logistics and Supply Chain Management). The previous investigation model was replaced with a new questionnaire, in order to deeply assess the organization, the governance and the "modus operandi" of a company's overall SF&DP process. So far, the objective was to analyze the link between business plans, operation planning and sales forecasts both horizontally and vertically within the organization and among the supply chain partners. In accordance with Ailog needs, the focus of the research was on three given industries: Beverage (waters, soft drinks, spirits and beer), Grocery non-food (beauty & health care, home cleaning products) and Pharmaceuticals. Therefore in this second phase of the research, we meant to investigate the drivers that make the SF&DP process different or equal across industries and, on the other hand, to summarize general figures allowing a rough cut benchmarking across companies.

As shown in figure 1, results of this second phase were studied separately for the three industries and were discussed during several industry-specific focus groups with supply chain managers of each company. A focus group is a data collection method that utilizes the face-to-face interaction among the participants (known as "group dynamics") to explore an issue, and importantly, to allow the participants in the session to discuss the topic among themselves, which normally will result in a much more in-depth exploration of the topic (Kreuger and Casey, 2000). So far, through the focus groups it was possible to achieve a better level of knowledge for each industry investigated, bringing together comments and remarks by the demand planners.

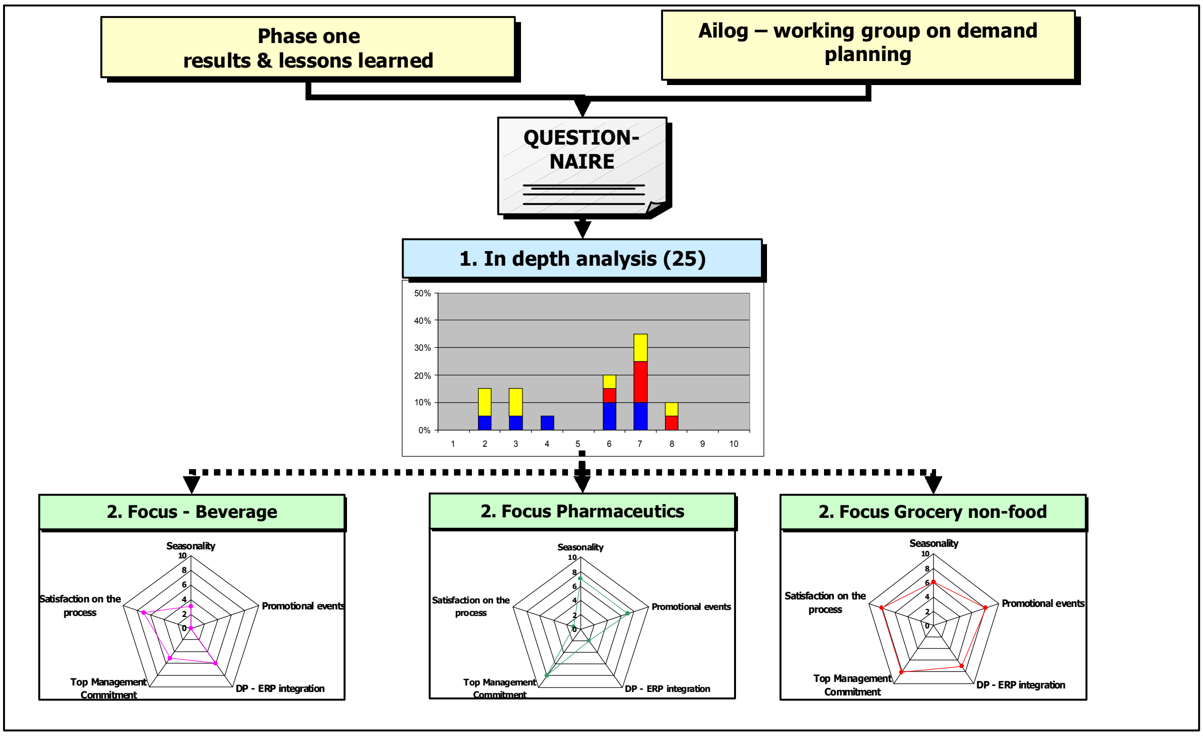


Figure 1. Framework of the research second phase

Since the goal was not to identify the best practices for each of the four dimensions, as in the first phase, the investigation protocol adapted from Mentzer for the first phase was refocused for the new objective, considering two main issues: primarily, that the second phase of the research should have dealt more with the organizational and managerial aspects rather than embracing all the four dimensions of the first phase; secondly, that such analysis should have been customized for each industry taken into account. Undoubtedly, the new questionnaire should also consider all the typical features of an Italy based company, in terms of size, organization and management approach.

To accomplish the above-mentioned requirements, second phase questionnaire was made of three sections, in order to understand:

- Section A - Company and industry features. *In order to better recognize the demand patterns, it is necessary to understand the environment in which the company competes. This includes the dimensions and complexity in terms of income, physical distribution networks, number of employees, product mix, and number of customers and distribution channels. In this section the impact of some factors (e.g. seasonality, promotional events, competitors' actions, and introduction of new product) is evaluated.*
- Section B - Organization of the demand planning process. *To evaluate the roles and responsibilities of the involved functions, in this section the focus was on the process architecture, in order to understand how the functional areas communicate and collaborate. The focus is on positioning the forecasting team within the organization, identifying the functions and those responsible for the process, which data and information are shared and how activities are coordinated.*
- Section C - Forecasting models, IT systems and performance measurement. *This section considers once again some factors analyzed in the first phase of the research, and focuses on the forecasting models adopted to generate the forecasts and the relative detail level. Additionally, it investigates the approach used to conduct the process (bottom up or top down) and the computerized systems used. This section also analyzes the performance measurement method (forecast accuracy) and the technique employed to evaluate the impacts of either good or poor accuracy on other important issues, such as stock-out events and inventory keeping costs.*

The questionnaire was the basis of the direct interviews and it was meant to guide the audit team through the entire data collection process. The audit team, composed by both academic researchers and professionals from Ailog (i.e. forecasters, demand planners, supply chain managers), interviewed 25 leading companies, mainly based in Northern Italy. In order to better understand the management and the ownership of the SF&DP process, a few days were spent on site. Sometimes the audit team participated also in the forecast meeting, in order to meet all the people involved in demand planning and to understand how the definitive forecast was generated.

## 3. Cross-industry results

The answers were analyzed and organized into groups, following the afore-mentioned three sections. As far as demand patterns are concerned (section A), supply chain and demand planning managers were asked to assess from

1 to 10 the incidence on sales of seasonality, promotional activities, new products launches and competitors' action (see figure 2).

Seasonality is very relevant only for the beverage industry, where about 80% of the companies results in a score of 7 out of 10, mainly due to the impact of climatic conditions on sales through the year. Almost all the companies of the panel declared to be affected by some form of seasonal cycles in sales time series, even if very low, especially as a consequence of incentives at fixed interval for sales people. In Grocery non-food, which encompasses a great variety of products, the seasonality depends on product category: the demand of personal care products, in fact, presents a higher seasonality (from 6 to 8 out of 10) than the one referring to home care products (from 2 to 3 out of 10).

Promotional activities, in which manufacturers and retailers agree on terms and conditions for a particular supply in a promotional period (in terms of reduction of the selling price, estimate of the volume to be supplied and the sell-in period) are very high only for Grocery non-food industry: 60% of the companies assign a score from 8 to 10. Conversely, in the pharmaceutical companies there is no apparent impact of promotions on sales, since these are prohibited by law (except for over-the-counter drugs), while there is high correlation with unexpected epidemic events or regulatory policies.

Similarly, pharmaceutical industry presents also very low score as far as new products launches are concerned. Generally few or very few in number, but still considered very important in demand planning, since no historical data are available, new products affects moderately only the Grocery non-food industry (on average 5 points out of 10), where the pace of innovation and the number of variants per products is quite high.

Finally, competitors' actions are not usually brought into account in the SF&DP process, although there is nowadays an impressive amount of external information and analysis on sell-out data, consumer purchase behavior and market shares provided by notable international market research organizations (i.e. IRI, Nielsen, GfK). Only a few leading multinational organizations in the Grocery non-food industry include competitors' policies in their SF&DP process.

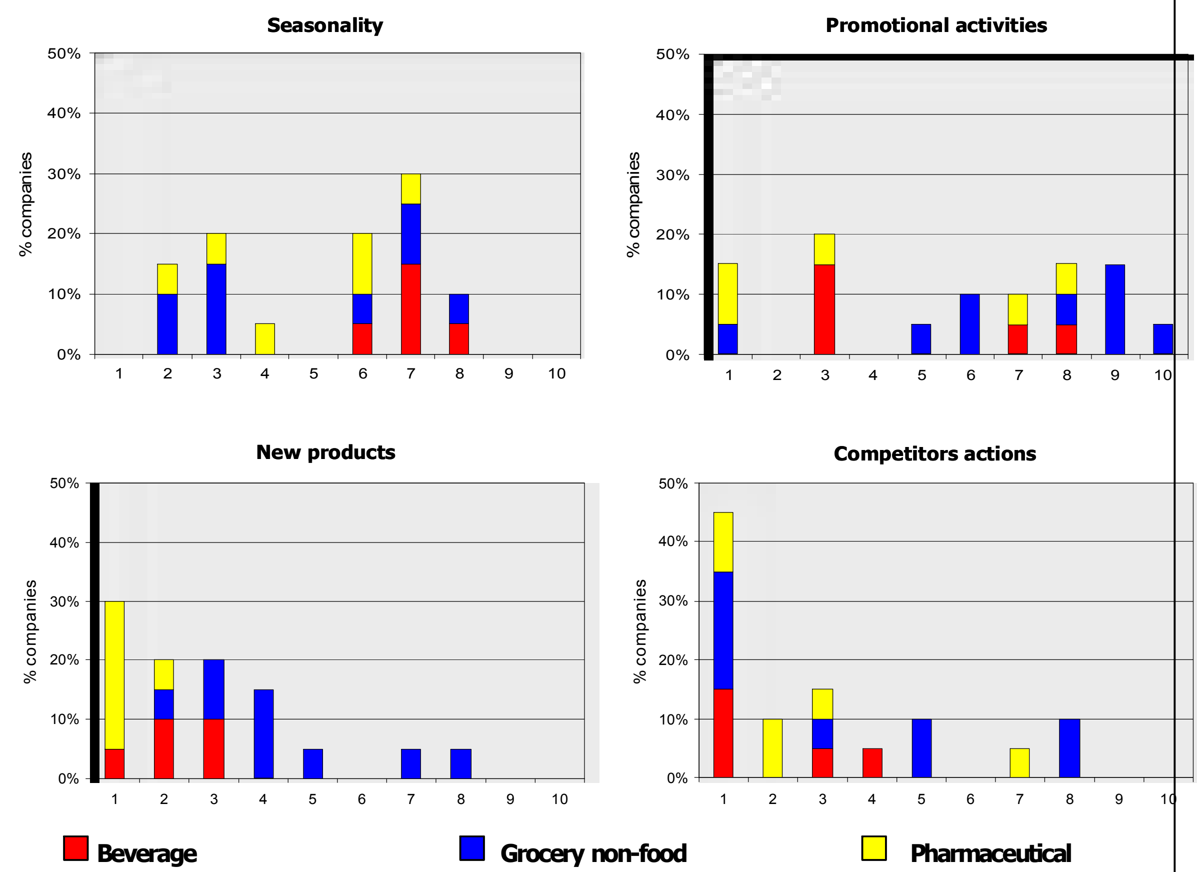

Figure 2. Section A results (incidence on sales: 1= lowest; 10 = highest)

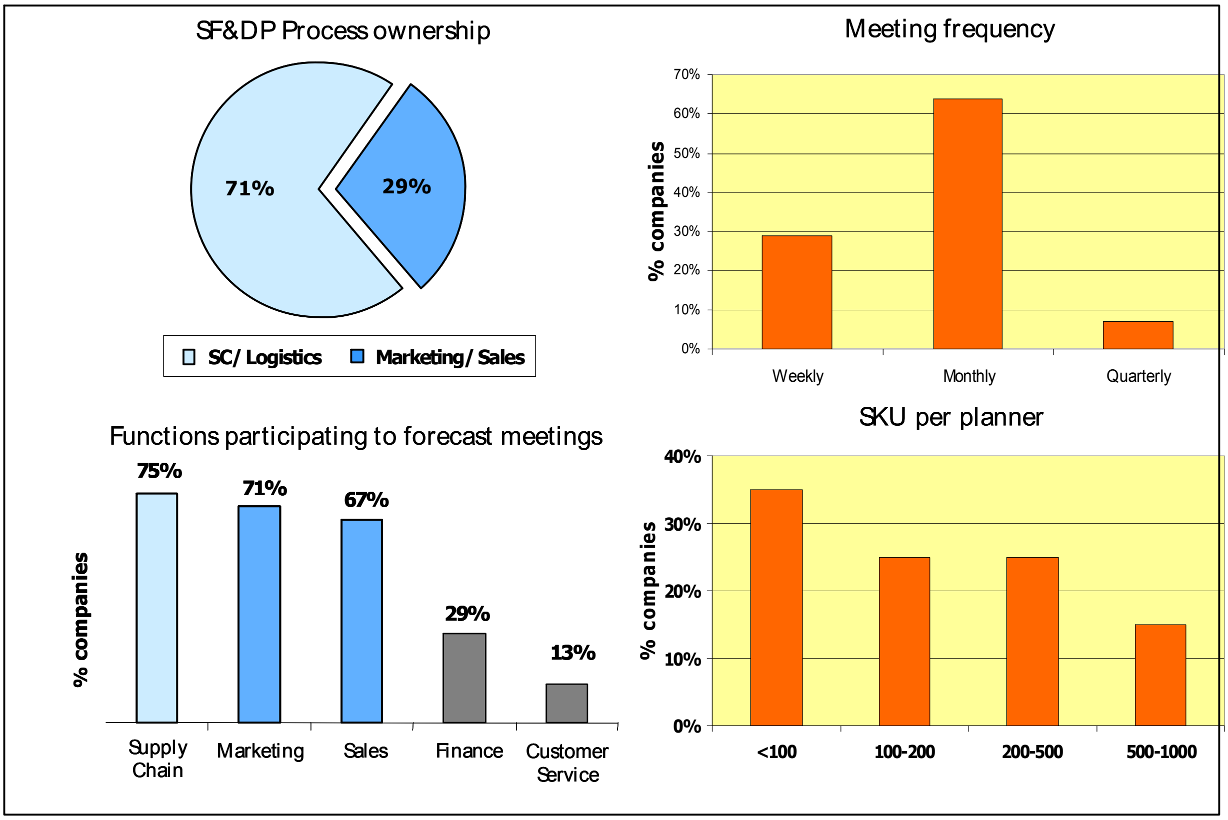


Figure 3. Section B results (% of respondents)

In order to find out new explanatory variables for the organization of the SF&DP process (section B), the audit protocol started with the identification of the Demand Planning owner, which in 71% of cases was in the logistics or supply chain department, while in the other 29% was the marketing and sales area (see fig.3). The 88% of the interviewed companies across all industries declared that Demand Planning is generated by a forecast meeting in which several functions participate: supply chain and logistics (in 75% of the companies), marketing (71%), sales (67%), finance (29%) and customer service (13%). This forecast meeting is generally held on a monthly basis (64%), sometimes on a weekly basis (29%) especially in the Beverage industry, while only a small number of companies (7%) have forecast meetings quarterly.

Considering the number of products (or SKU) managed per single planner as a proxy of the individual forecasting effort (to be correlated with both accuracy and IT resources), we found out it ranges from a minimum of 25 to a maximum of 800.

The final section of the second phase of the research (section C) was useful to compare the general results with those derived from the first phase, even if from a different point of view.

As shown on figure 4, almost all the interviewed companies make use of qualitative techniques, while regression models are used only by some companies in the Beverage industry, to include the causal effect of temperature on sales. Time series techniques are used by those companies employing a forecasting tool in order to extrapolate the baseline.

Demand plans are generally made at SKU level, aggregated per channel or sales area, and on a monthly basis. More than 60% of the companies adopt a forecasting tool (DP tool or a standalone application), 14% use spreadsheets (e.g. Excel) for forecasting purposes, and the remaining 23% generate forecasts without any software.

Only a few companies can correlate their forecast accuracy with the impacts generated by the latter on logistics processes' efficiency (for example the increase of costs due to safety stock) and effectiveness (customer service level). Even if a comparison between investigated companies forecast accuracy levels is not possible, because of the different used indicators, the lowest forecast accuracy levels have been recorded in the grocery non-food industry, mainly due to an increasing incidence of promotional events on the baseline, because of the high number of different products considered.

Though companies indicate that the fundamental contribution to the improvement of forecast accuracy comes from collaborative relationships between suppliers and retailers, more than 50% of them have not started yet any collaborative action, sharing no information and no objectives with their customers. Indeed, average collaboration level down and up-stream in supply chains is very low for every interviewed company (2.2 points out of 10), due to the very fragmented Italian distribution market.

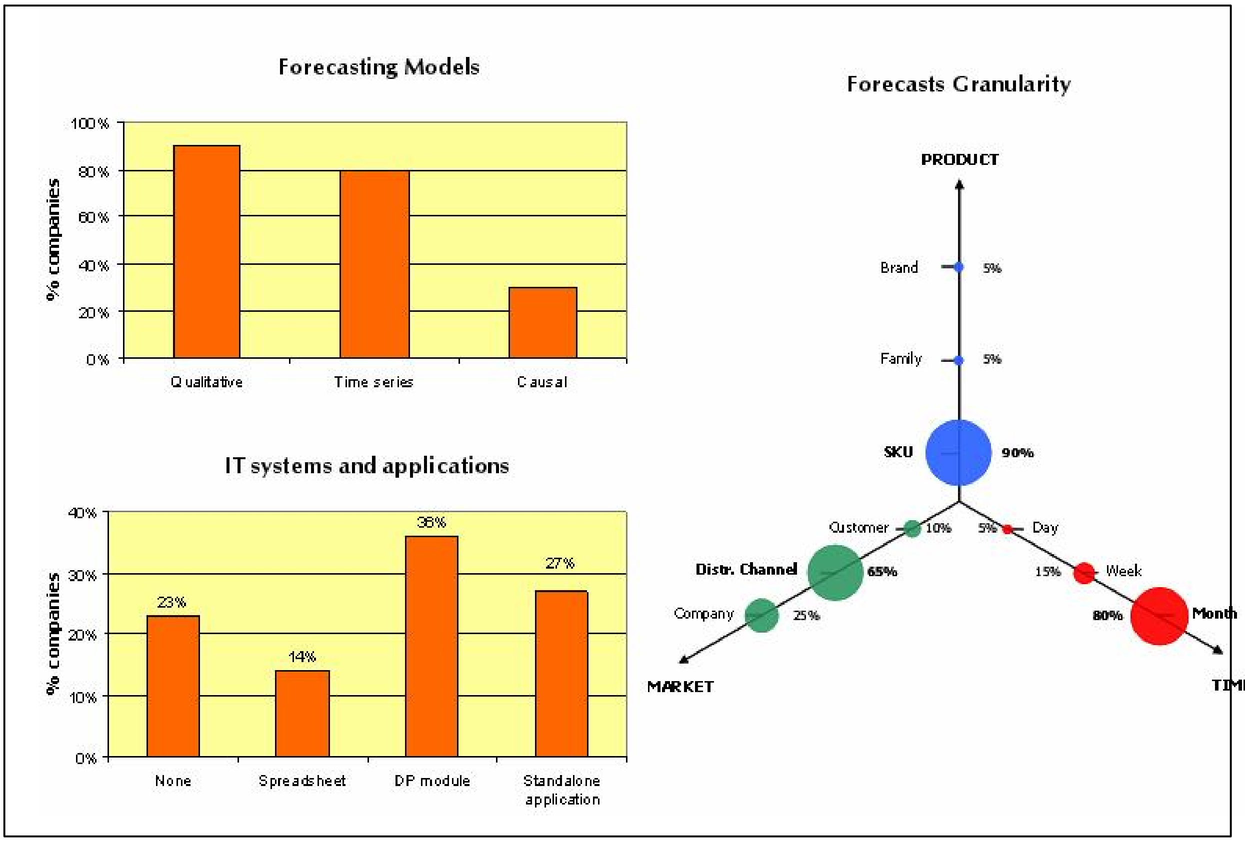


Figure 4. Section C results (% of respondents)

## 4. Final remarks and recommendations

The three industries investigated (Beverage, Grocery non-food and Pharmaceutical) by means of specific focus groups, while having different supply chain models, share common issues and symptoms such as increasing promotional activities, mistrust of statistical forecast and lack of performance measurement, evaluation and rewards.

Drawing a balance of the research, first it is necessary to highlight some critical points that prove to be generalized. Overall results show an existing misunderstanding of what is forecasting and faded distinction between Sales Forecasting and Demand Planning goals and their respective boundaries. For this reason, it is difficult to define the proper roles and responsibilities of each participating player, also because the terms of reference are not designed from a SF&DP process perspective.

The so called 3C ("communication, collaboration & coordination") influencing how the SF&DP process should be organized, managed and controlled are far from being completely accomplished. Real "consensus forecasting" is still more an appealing idiom than a common practice among departments involved in the SF&DP process, while very few collaboration projects in the extended supply chain (i.e. CPFR, VMI concepts ) could be mentioned. In several companies the forecasting process is compromised, because of to the traditional disagreement between Sales and Logistics functions, due to different goals and points of view.

With regard to the supply chain collaboration topic, it is necessary to highlight that the actual reason behind the creation of so many problems in the achieving effective collaboration is the high fragmentation of Italian distribution market, rather than the willingness of the companies.

Second, the research put into evidence that forecasting activity does not always derive from initial statistical data and information. Even when time series analysis seems to be adequate and well carried out, the data introduced are often not free of external distortion factors and still not reliable. In this way, forecast accuracy can be severely compromised at the beginning of the process. Time series techniques should be a common practice in leading companies, but our survey shows that not all of them rely thoroughly on statistical tools.

The majority of interviewed companies declare that they have more than one IT system or application installed for the SF&DP process. The consequence of having functions that use different tools are process duplication, more difficult communications and waste of resources. Besides, there are some examples of failed system implementations, due to a weak commitment of the real users, or cases of worrying under-use for lack of adequate statistical and IT skills.

Finally, concerning performance measurement, it is difficult to benchmark the various survey results: every single company has its own forecasting accuracy measure, making every comparison impossible. A small number of companies can correlate in a quantitative way the impact of forecasting accuracy on the global performance of an enterprise (such as customer service level, stock-out costs, etc.). They may also carry out analysis in order to identify the effects of a poor forecasting accuracy on global supply chain performance indicators.

All critical issues emerged from the survey should encourage companies to look for continual improvement of their forecasting process. Therefore, it is useful to summarize some insight and general recommendations, to let companies improve their SF&DP process both in terms of forecast accuracy, as far as overall supply chain performance (i.e. the higher production and distribution efficiency, the higher customer service level).

As a first step, it should be made important to mark out the interactions between sales forecasting and demand planning processes, to understand their respective boundaries and to identify their correlations. As a matter of fact, confusing the two processes can lead to activities overlapping, contributing to waste of resources and sub-optimization of company performance. Furthermore, it is really relevant to look for progressive growing integration, both on the inner organizational sphere, and the entire supply chain, moving towards a deeper functional integration, triggering the 3Cs "virtuous cycle" (Communication, Collaboration, Coordination). Performance rewards for all the personnel involved in the SF&DP process should be introduced in order to increase individual motivation. Also top management's commitment should be increased to ensure enough engagement and to improve resource allocation (financial resources, materials and employees).

Then, it is necessary to find out the most reliable time series, by filtering exceptions and other casual events on original data, which can help IT systems to better extrapolate baseline demand. Moreover, a better use of IT systems should be encouraged through continuous software update and personnel training program. By directly involving demand planners in system implementation and upgrading, it is possible to increase the confidence towards the DP tool, so to stimulate its proper use.

Finally, it is worthwhile to remember that the advantages and the implications created by forecasting processes on company performance should be measurable and measured. Evaluating the opportunity of a decision that could lead to increased forecast accuracy, requires the knowledge of an analytical relation with overall supply chain performance and costs.

To compare the results the present research with other businesses and environments, the study is supposed to be continued, by investigating the SF&DP planning process in more industries, namely CPG dry and food, Automotive and Fashion.

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# A COMPREHENSIVE LITERATURE SURVEY ON DEMAND-DRIVEN SUPPLY CHAIN COLLABORATION

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## Abstract

*One of the main challenges of today's environment is to have an efficient supply chain strategy. Demand-driven supply chain management under various market, logistics and production uncertainties is a critical issue for companies. An efficient supply chain can be improved by developing structural and formal procedures to enhance a customer orient approach. Supply chain integration has been emerged as a subject of significant debate and discussion in this new era. Recently, a need has been identified for a more integrated approach to system design. Effective design of supply chains assists in production and delivery of a variety of products at low cost, high quality, and short lead times. A good collaboration between the customer and the supplier to balance the customer demand through whole supply chain depends on reliable information flows. Demand-driven strategies require integrating demand information into the supply chain process. The aim of this study is to provide a focused review of literature in integrated supply chain design and to define a research agenda for the future in this area. The review presented focuses on model based methodologies that can provide quantitative support to design and operation of supply chains.*


Keywords: Supply chain, Demand-driven, Literature

## Introduction

The *supply chain* encompasses all organizations and activities associated with the flow and transformation of goods from the raw materials stage, through to the end user, as well as the associated information flows. Material and information flows both up and down the supply chain. *Supply chain management* (SCM) is the integration and management of supply chain organizations and activities through cooperative organizational relationships, effective business processes, and high levels of information sharing to create high-performing value systems that provide a sustainable competitive advantage to member organizations (Handfield & Nichols, 2002). Organizations continuously investigate to provide their products and services to customer faster, cheaper, and better than the competition. Managers have come to realize working on a cooperative basis with the best organizations in their supply chains.

The supply chain includes managing information systems, sourcing and procurement, production scheduling, order processing, inventory management, warehousing, customer service, and after-market disposition of packaging and materials with its upstream supplier network and its downstream distribution channel (Figure 1). Establishing integrated supply chains that provide end customers and supply chain member organizations with the materials required, in the proper quantities, in the desired form, with the appropriate documentation, at the desired location, at the right time, and at the lowest possible cost lies at the heart of SCM. (Handfield & Nichols, 2002). In supply chain management, relationship management is supposed to be the most critical activity concerning its fragility and tendency to breakdown. A poor relationship at any link in the supply chain can have dramatic results that can affect the entire supply chain. Hence, organizations must understand their processes, as well as of their suppliers' quality and delivery performance in order to find better ways to serve their customers. A relationship based on mutual benefits and trust must exist to implement an integrated SCM effectively. To have a reliable working relationship, communication links with customers and suppliers must be established, maintained, and used regularly.

This paper discusses the demand-driven supply chain collaboration and its conceptual view in literature to help the academicians who are interested in integrated supply chain concept. The purpose of the study is to assess how well the existing proposals and models in literature support the integrated supply chain design problem, in light of ongoing and emerging issues in the global environment. In the next section, demand-driven strategies is described; in section 3, collaborative supply chain concept is summarized; in section 4, mathematical models in supply chain are explained; in section 5 literature is reviewed; and finally conclusions and future research are presented in section 6.

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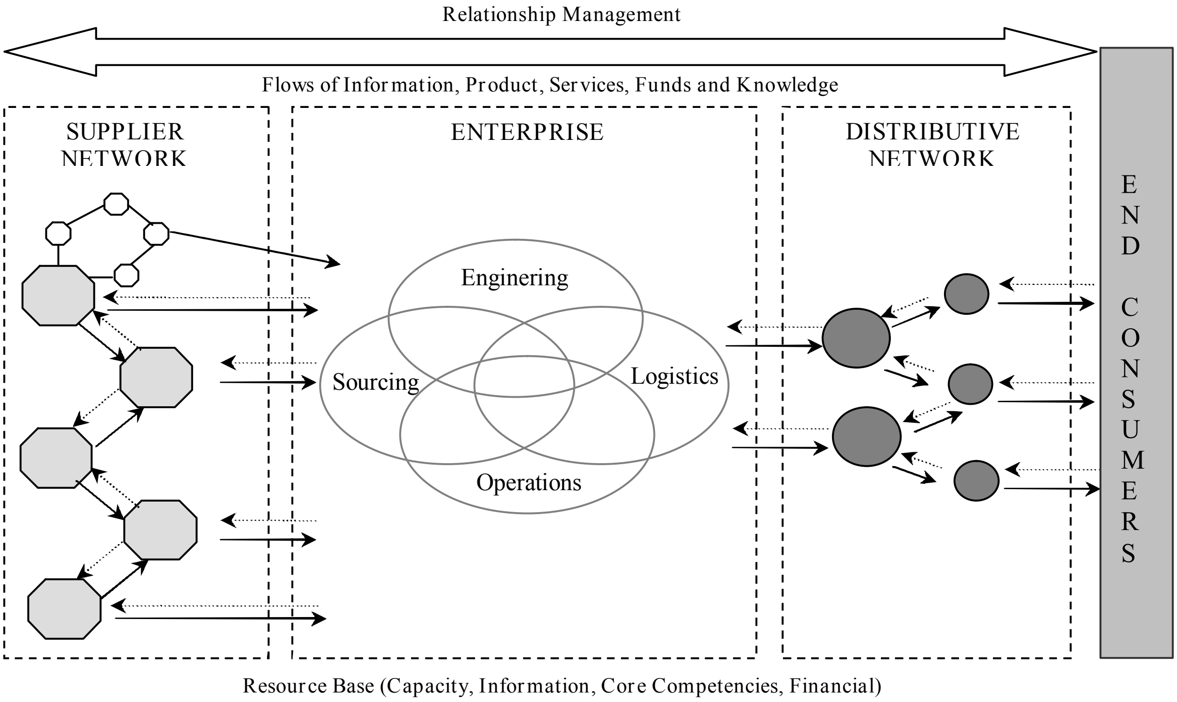


Figure 1. The integrated supply chain

## 2. Demand-Driven Strategies

Supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses, and stores. The challenge in supply chain integration is to coordinate activities across the supply chain so that the enterprise can improve performance by reducing cost, increasing service level, reducing the bullwhip effect, better utilizing resources, and effectively responding to changes in the market place. These challenges are met not only by coordinating production, transportation, and inventory decisions, but also, more generally, by integrating the front-end of the supply chain, customer demand, to the back-end of the supply chain, the production and manufacturing portion of the supply chain (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003).

Demand-driven supply chain is a system of technologies and processes that react to real-time demand across a network of customers, suppliers and employees. The demand-driven supply chain, integrates demand data and processes across the supply networks of customers, suppliers, and employees to balance revenue against costs. Instead of products being pushed to market by manufacturers and suppliers, they are pulled to market by customers.

Demand driven strategies require demand information generated by applying two different processes to integrate into the supply chain planning process (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003);

- *Demand forecast:* A process in which historical demand data are used to develop long-term estimates of expected demand.
- *Demand shaping:* A process in which the firm determinates the impact of various marketing plans such as promotion, pricing discounts, rebates, new product introduction, and product withdrawal on demand forecasts.

Lack of information or distorted information throughout the supply chain causes demand amplification termed as “bullwhip effect”. Although the bullwhip effect has been widely discussed in the literature over many years, it is still prevalent in many supply chains, generally leading to excessive inventory throughout the system, poor product forecasts, insufficient or excessive capacities, product unavailability and higher costs. Lee, Padmanabhan and Whang (1997) have identified four major causes of the bullwhip effect; demand forecasting, order batching rationing game, and price fluctuation. Several alternatives have been identified to minimize the supply chain dynamics. They are single control of replenishment (e.g., vendor managed inventory), lead time reduction, regular delivery schedule, and changing individual echelon decision rules, identifying inventory levels, improved information exchange (e.g., access to point of sale data), strategic partnerships, and type of information sharing (centralized, decentralized and coordinated).

Metters (1997) has measured the impressions of bullwhip effect on the supply chain performance and has concluded that supply chain performance is broken according to the increasing bullwhip effect.

The bullwhip effect can be eliminated by engaging in any of a number of strategic partnerships. These strategic partnerships change the way information is shared and inventory managed within a supply chain, possibly eliminating the impact of the bullwhip effect (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003). Collaboration in whole supply chain that requires information sharing is assumed as a solution to the bullwhip effect. In third section collaborative supply chain is discussed.

## 3. Collaborative Supply Chain

Collaboration and partnership are the new main subjects in organizations and SCM, with emphasis on collaborative design and planning.

The need to create increasingly customer-driven companies endowed with more flexibility and responsibilities has been expressed in various ways. One is the network enterprise and its different forms: integrated enterprise, extended enterprise and virtual enterprise. These network organizations raise the need for new business models and management tools. The collaboration between various responsible units is the driving element of the decision-making in the network enterprise. The overall performance of the firm is particularly expected to be improved when the demand planning processes are sophisticated and collaborative, and when they permit the integration between resources utilization and customers requirements (Abid, D'amours & Montreuil, 2004)

The term *supply chain collaboration* is used to refer to the activities including design, market, manufacture, and distribute products and services to end-consumers among supply chain partners concerned with the cost effective, timely, and reliable creation and movement of materials to satisfy customer requirements (Muckstadt, Murray, Rappold, & Collins, 2001).

Supply chain collaboration allows a company to share information with its suppliers in real time cutting materials costs, minimizing inventory, and reducing shortages and expediting. Hence, in recent years organizations have started to invest in systems that allow for collaboration with supply chain partners. Two types of systems have been developed; supplier relationship management (SRM) applications that drive the optimization of production goods and materials for manufacturers, and customer relationship management (CRM) applications that aims to drive and optimize the interaction with clients. These applications can span a variety of forms including access, data transfer, trading exchange and collaborative ventures such as product design and planning. (Simchi-Levi, Kaminsky & Simchi-Levi, 2003). SRM and CRM systems cause existing *demand chains* which are managed by customers' requests.

A company must change the nature of its alignment and collaboration not only with its first-tier customers and suppliers but also throughout its supply chain. In the future, the best supply chains will win and the managers must be aware of the actions and requirements for critical customers and suppliers in the network. Accessing to this information is difficult unless the scope and nature of relationships with the key supply chain member organizations is established and maintained. The key supply chain partners should be aligned with the organization's internal strategies in order to exploit their expertise and knowledge in creating value. Consequently, collaborative sharing of forecasting and demand information can better help to plan long-term capacity, inventory and human resource requirements. By working collaboratively, supply chain members can reduce costs of doing business, providing a means to improve profitability and/or to pass on the savings to end customers and benefit from higher market share. (Handfield & Nichols, 2002). Supply chain collaboration has been recognized to be one of the important issues in improving competition strength. However, implementation of supply chain collaboration encounters many barriers, such as type, scope and security of information sharing, equity in benefits sharing, joint decision making, coordination tasks, etc. (Chan, Chung & Wadhwa, 2004).

Effective supply chain collaboration requires the ability to establish functioning alliances, which can be formed and dissolved quickly in order to tackle rapid changes in demands and emerge new opportunities. When customer demand as well as production and distribution lines are frequently changed, it becomes necessary to endow every supply chain constituent to adjust its plan autonomously and at the same time to consider the optimum as a whole (Chiu & Lin, 2004).

## 4. Mathematical Models in Supply Chain Management

Linearization of real world conditions to fit mathematical models may create the lack of real-time adaptability in supply chain. A common example of this situation is the bullwhip effect that depicts wide fluctuations in the supply chain. The discrete, dynamic and distributed nature of data and applications require that supply chain solutions not merely respond to requests for information but intelligently anticipate, adapt and actively support users.

Effective supply chain decision making requires two types of mathematical models: descriptive and optimization models. *Descriptive models* aim to bring a better understanding of the functional relationships in a firm. Exemplar descriptive models include forecasting models, cost relationships, resource utilization relationships and simulation models. *Optimization models* help managers make better decisions. These models examine complex interactions to generate the guidelines that make a supply chain workable. This type of mathematical model is used to optimize various aspects within a firm, such as production scheduling, distribution scheduling, production planning, logistics, tactical, and strategical processes (Kwon, Im & Lee, 2005).

Traditional solution methodologies for solving mathematical models, i.e., optimization models, can be categorized into two groups, namely *exact* and *heuristic* models. *Exact models* rely on optimization techniques, such as linear programming and mixed integer programming. Mathematical models, or exact models, guarantee optimal solutions, but are only valid under specific constraints and assumptions. It is difficult to rely on such models when the constraints of models become more complicated due to increasing complexity and uncertainty. Moreover, to achieve the full advantage of exact models, supply chain managers need to be knowledgeable of both the models and data used. *Heuristic models* employ artificial intelligence based techniques, such as case-based reasoning (CBR), multi-agent, genetic algorithms and artificial neural networks. Heuristic models play a complementary role to exact optimization models and generate near-optimal solutions in a reasonable amount of time. These models occupy niche areas in which optimization models cannot or are difficult to reach. The potential areas that heuristic models can contribute include the revenue maximization problem and stochastic dimension (Kwon, Im & Lee, 2005).

Beamon (1998) divided multi-stage models for supply chain design and analysis into four categories by the modeling approach. These are; *deterministic analytical models*, in which the variables are known and specified, *stochastic analytical models*, where at least one of the variables is unknown, and is assumed to follow a particular probability distribution, *economic models*, and *simulation models*.

This study aims to present the current literature about demand-driven collaborative supply chain with the mathematical models used in.

## 5. Demand-Driven Collaborative Supply Chain Literature Survey

A supply chain comprises many systems, including various manufacturing, storage, transportation, and retail systems. Managing any one of these systems involves a series of complex trade-offs among different business function costs. To integrate different supply chain systems, entities must be coordinated incorporating the "systems' thinking" perspective (Liang & Huang, 2005). Therefore, SCM and other concerning terms as, *demand-driven strategies* and *collaboration* have become important subjects in increasing interest to the academicians, consultants and business management in recent years.

Demand forecast with information sharing and systems' thinking is an important coordination and communication issue in SCM. In order to increase supply chain effectiveness, minimize total cost, and reduce the bullwhip effect, integration and coordination of these different systems in the supply chain are required using information technology and effective communication (Liang & Huang, 2005). Traditionally, supply chain entities do not share the type and status of their inventory system with other entities, resulting in the bullwhip effect and difficulty in the control and forecast of inventories. Most research related to demand forecasting only focuses on a single echelon of the supply chain and the researches related to multi-echelon inventory management always assumes that all entities use the same inventory system. Little research focuses on the multi-echelon supply chain involving various inventory management systems (Liang & Huang, 2005) Hence, this paper focuses on demand-driven collaborative supply chain structure. Especially, multi-echelon supply chain systems and the entities involved in SCM are highlighted in this study.

Supply chain collaboration has been strongly advocated by consultants and academicians alike since the mid 1990's under the banner of concepts such as Vendor Managed Inventory (VMI), Collaborative Forecasting Planning and Replenishment (CPFR) and Continuous Replenishment (CR). Although past studies have shown that two-echelon supply chain systems including *one distribution center* and *multiple retailers* or *multiple suppliers* and *one distribution center* and their collaboration were examined, current research covers a wide variety of problems in multi-echelon supply systems and their network structure. The obvious question then is how the use of multiple suppliers can be linked to the traditional one-distributor, multiple-retailers scenario. All of these studies especially mention the coordination and cooperation of the entities in the whole chain systems. Specifically extensive researches contain, inventory problems between different entities in different levels, demand-order allocation and lead times disagreements, demand forecasting and networking problems. The future research will focus on agent-based systems and their networking problems generally used in complex dynamic environments. In below, literature that mention integration and especially demand concept will be examined and then collaborative structure will be reviewed.

Ganeshan (1999) has presented a near-optimal *(s, Q)*-type inventory-logistics cost minimizing model for a production/distribution network with *multiple suppliers* supplying *a distribution center*, which in turn distributes to *a large number of identical retailers*. The model was a synthesis of three components: the inventory analysis at the retailers, the demand process at the warehouse, and the inventory analysis at the warehouse. The decisions in the model were made through a comprehensive distribution-based cost framework that includes the inventory, transportation and transit components of the supply chain. The approximate model was verified using simulation.

Andersson and Marklund (2000) have considered a model for decentralized inventory control in a *two-level distribution system* with *one central warehouse* and *N non-identical retailers*. All installations use continuous review installation stock *(R, Q)*-policies for replenishing their inventories. The approach is based on an approximate cost evaluation technique where the retailers replace their stochastic lead-times by correct averages.

Axsäter (2001a) has provided a cost structure that can be used for decentralized control of a multi-echelon inventory system with *a central warehouse* and *a number of retailers* with Stackelberg game. In another study, Axsäter (2001b) has presented a *two-echelon* distribution inventory system with stochastic demand. Existing methods for evaluation and optimization of continuous review *(R, Q)*-policies are usually very efficient in case of relatively low demand. Hence, a technique where a high-demand system is approximated by a low-demand system is suggested and evaluated. In a later work, Axsäter (2005) has considered a *two-echelon* distribution inventory system with *a central warehouse* and *a number of retailers*. The retailers face stochastic demand. The system is controlled by continuous review installation stock *(R, Q)* policies with given batch quantities. This paper provided a simple approximate technique for determining the backorder cost to be used by the warehouse.

Tsiakis, Shah and Pantelides (2001) have presented the design of multi product, multi-echelon supply chain networks. They used scenario planning approach to describe demand uncertainties. The networks comprise *a number of manufacturing sites* at the fixed locations, *a number of warehouses* and *distribution centers* at the unknown locations (to be selected from a set of potential locations) and finally *a number of customer zones* at fixed locations. The system is modeled mathematically as a *mixed-integer linear programming* optimization problem. The decisions to be determined include the number, location and capacity of the warehouses and the distribution centers to be set up, the transportation links that need to be established in the network and the flows and production rates of materials. The objective is the minimization of the total annualized cost of the network, taking into account both infrastructure and operating costs.

Chen, Federgruen and Zheng (2001) have addressed a fundamental *two-echelon* distribution system in which the sales volumes of the retailers are endogenously determined on the basis of known demand functions. The paper studies a distribution channel where *a supplier* distributes a single product *to retailers*, who in turn sell the product to consumers. They have characterized an optimal strategy, maximizing the profits of total system in a centralized system.

Petrovic (2001) has described a special purpose simulation tool, SCSIM that treats a supply chain which includes a raw material inventory, a number of in-process inventories, an end-product inventory and production facilities among them linked in a series. Main sources of uncertainty inherent in the serial supply chain and its environment are identified including customer demand, external supply of raw material and lead times to the facilities. Uncertainties perceived in these supply chain data are described by imprecise natural language expressions and they are modeled in SCSIM by fuzzy sets. Two types of models are combined in SCSIM: (i) Supply chain fuzzy analytical models to determine the optimal order-up-to levels for all inventories in a fuzzy environment and (ii) a supply chain simulation model to evaluate supply chain performance achieved over time by applying the order-up-to levels recommended by the fuzzy models. The application of SCSIM in analyzing and quantifying the effects of changing uncertainty in customer demand is discussed. It is shown that uncertainty in customer demand, external supplier reliability and lead times to inventories in *a serial production* supply chain can be effectively described by fuzzy sets.

Tee and Rossetti (2002) have examined the robustness of a standard model of multi-echelon inventory systems. They developed a simulation model to explore the model's ability and to predict system performance for a *two-echelon one-warehouse*, *multiple retailer* system using *(R,Q)* inventory policies under conditions that violate the model's fundamental modeling assumptions. In particular, the impact of non-stationary demand on this stationary demand inventory model was examined. The results of the study help practitioners to better understand the assumptions of these models and to determine when or when not to apply these models in practice.

Rau, Wu and Wee (2003) have developed an integrated inventory model for a deteriorating item under a multi-echelon supply chain environment. A mathematical model with integrating *single supplier, single producer* and *single buyer* is derived to obtain the optimal number of deliveries and order lot-size, when the joint total cost of the supplier, the producer and the buyer is minimized. A computer code is developed to derive the optimal solution.

Gupta and Maranas (2003) have described A stochastic programming based approach to model the planning process as it reacts to demand realizations unfolding over time. The model provides an effective tool for evaluating and actively managing the exposure of an enterprises assets (such as inventory levels and profit margins) to market uncertainties.

Giannoccaro, Pontrandolfo and Scozzi (2003) have presented a methodology to define a supply chain inventory management policy, which is based on the concept of *echelon stock* and *fuzzy set theory*. In the study, the echelon stock concept is adopted to manage the supply chain inventory in an integrated manner, whereas fuzzy set theory is used to properly model the uncertainty associated with both market demand and inventory costs (e.g. holding and backorder costs). The methodology is applied on *a three stage supply chain* so as to show the ease of implementation.

Abdul-Jalbar, Gutiérrez, Puerto and Sicilia (2003) have introduced near-optimal policies for inventory / distribution systems with *one-warehouse* and *N-retailers* considering an instantaneous demand pattern at the warehouse. They study following two cases: the warehouse and the retailers belong to the same firm (*centralization)* and the warehouse and retailers belong to different firms (*decentralization*).

In another study, Abdul-Jalbar, Gutiérrez and Sicilia (2006) have addressed a *multi-echelon* inventory system with *one-warehouse* and *N-retailers*. The demand at each retailer is assumed to be known and satisfied by the warehouse. Shortages are not allowed and lead times are negligible. Costs at each facility consist of a fixed charge per order and a holding cost. The goal is to determine single-cycle policies which minimize the average cost per unit time, that is, the sum of the average holding and setup costs per unit time at the retailers and at the warehouse.

In recent years, a new software architecture for managing the supply chain at the tactical and operational levels has emerged. It views the supply chain as composed of a set of intelligent (software) agents, each responsible for one or more activities in the supply chain and each interacting with other agents in planning and executing their responsibilities. An agent is an autonomous, goal-oriented software process that operates asynchronously, communicating and coordinating with other agents as needed (Fox, Barbuceanu & Teigen, 2000). Therefore, agent technology provides the distributed environment in a great promise of effective communication (Liang ve Huang, 2005).

When designing a multi-agent supply chain system, agent decomposition allows the use of more sophisticated planning, scheduling and coordination methods to improve the overall quality of SCM. In addition, the dynamics of the supply chain functions can be handled effectively by taking both local and global criteria into account (Chiu and Lin, 2004).

Makatsoris and Chang (2004) have explained design architecture, requirements and concepts for collaborative planning and fulfillment system for distributed enterprises. Furthermore, they reviewed past researches in the field of collaborative production planning and supply-chain planning. A major contribution of this research is to bridge the gap between managing customer demands and managing supply in response to those demands. It also aims to bridge the gap between collaborative production/manufacturing research and supply-chain planning research.

Abid, D'amours and Montreuil (2004) have proposed a model to maximize the satisfaction of customers by an optimal arrangement of orders realization, which meets the demand according to available delivery time slots. The use of this model aims to improve the relation between the sales and the production department, which directly results in a better use of the workstations. To do this, *a mixed-integer program* was developed that takes into account on one side a set of manufacturing and logistics constraints associated to the mix of products, and on the other side clients' expectations and priorities. This tool is used in an interactive way through *NetMan multi-agents system* to help the planning team generate and estimate practical and optimal solutions for satisfying the orders. It has been developed in a Java programming environment by dynamically using the Cplex optimization software.

Zou, Pokharel and Piplani (2004) have presented a model to synchronize the assembly process. The optimal order quantities in a *two-echelon* assembly system with *one assembler* (facing a stochastic demand) and *multiple suppliers* with deterministic order processing times are determined. This paper focused on jointly solving order delivery quantity and order processing time variables in a decentralized assembly system to achieve overall channel coordination.

Chan, Chung and Wadhwa (2004) have considered a central coordinator structure for a hypothetical three-tier supply chain with four manufacturing plants, four warehouses and ten customers, in which each customer will release one order demand. They are coordinated / cooperated to implement supply chain collaboration, and thus are able to view the actual customer demands. This central coordinator gathers the orders from those customers, and then distributes them to the warehouses and manufacturing plants.

Chiu and Lin (2004) have proposed the application of the agent concept and the artificial neural network approach to formulate a paradigm of collaborative supply chain planning for an assemble-to-order system.

Chen and Lee (2004) have investigated the maximum total profit and the fuzzy sales prices problem in a typical supply chain network including factors such as *factories*, *distribution centers* or *warehouses*, and *retailers* or *market*. The problem is formulated as a *mixed integer nonlinear programming* model to achieve the maximum total profit of the whole network to guarantee the maximum acceptability of all participants' preference of sales prices.

Kawtummachai and Hop (2005) have tried to construct a method that will be used to allocate product orders (quantity) to the selected supplier in order to optimize the purchasing cost within the acceptable percentage of on-time delivery by guaranteeing high service levels to the retailers. The study is concerned with a model, in which *multiple suppliers*, *a warehouse* and *multiple* retailers involved. An integration of the *analytical hierarchy process* and *linear programming* has been proposed to consider both tangible and intangible factors in choosing the best suppliers and placing the optimum order quantities among them such that the total value of purchasing is optimized.

Demand management deals with forecasts, new demands, promised delivery dates, service levels as well as other connected factors. It also concerns other sources that touch upon the firm's production capacity, the intercompany needs and storage capacity. An effective management of demands requires the synchronization of internal as well as external factors (Abid, D'amours, & Montreuil, 2004).

Liang and Huang (2005) have developed a multi-agent system including four echelons (supplier, manufacturer, distributor and retailer) to simulate a supply chain, where agents operate these entities with different inventory systems. Agents are coordinated to control inventory and minimize the total cost of a supply chain by sharing information and forecasting knowledge. The demand is forecasted with a *genetic algorithm* and the ordering quantity is offered at each echelon incorporating the perspective of systems' thinking. By using this agent-based system, the results show that total cost decreases and the ordering variation curve becomes smooth.

Fung and Chen (2005) have presented a flexible agent-based systems architecture of supply chain integration. Agents coordination using extended contract net protocol is discussed. A heuristics and two programming models for the planning and coordination of demand-driven supply chains are suggested.

Chandra and Grabis (2005) have considered inventory management of a *two-stage supply chain* under autoregressive demand using an order-up policy without fixed cost. They have quantified the bullwhip effect, if order sizes are calculated according to multiple step forecasts obtained using autoregressive models. An inventory management approach based on materials requirements planning is proposed to reduce the order variance and is shown reduce magnitude of the bullwhip effect while providing the inventory performance comparable to that of a traditional order-up approach. Table 1 shows the literature that is classified according to echelon-model-variable types, operational decisions and objective functions.

In business world, practically, most companies forecast future demand based on historical customer orders or shipment levels and patterns. However, *actual consumer demand* may be very different from the order stream. Each member of the supply chain observes the demand patterns of its customers and in turn produces as set of demands on its suppliers. The decisions made in forecasting and setting inventory targets. However, lot sizing and purchasing act to transform and distort the demand pattern. Both manufacturers and distribution-company of the retail chain have recently implemented a new web-based vendor managed inventory solution. By providing business partner visibility into inventory and by collaborating on a single shared forecast of customer demand, supply chain partners can positively impact a set of key business drivers to create value across supply chain partners. As part of the integration mechanism among the entities in supply chain, the *Collaborative Planning, Forecasting and Replenishment (CPFR)* Model is a valuable technological innovation tool to strategically, tactically and operationally support the implementation of several types of transactions among the entities.

CPFR represents a paradigm-breaking business model that extents vendor managed inventory principles by taking a holistic approach to supply chain management among a network of trading partners. It has the potential to deliver increased sales, organizational streamlining and alignment, administrative and operational efficiency, improved cash flow, and improved return-on-assets performance.

The supply chain requires continuous monitoring of performance metrics to improve the processes and to ensure every entity in the supply chain that performs its tasks in a satisfying way. Hence, Rudberg, Klingenberg and Kronhamn (2002) have been introduced a sixth process in addition to the defined five collaborative processes (Figure 2).These are; demand planning, supply planning, promotion planning, transportation planning, product development and performance management.

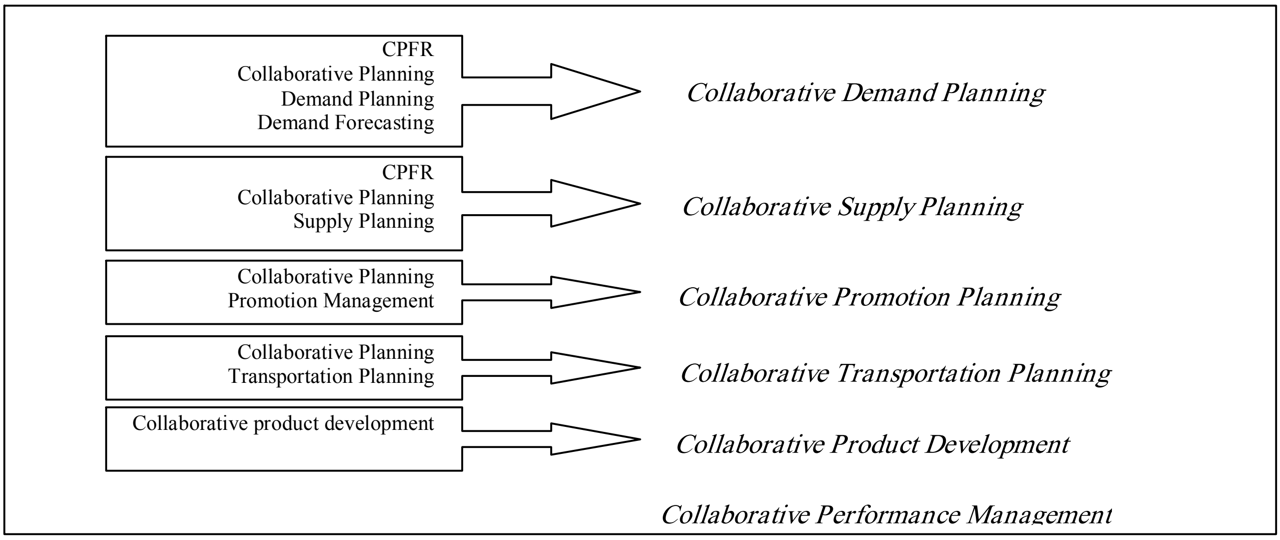


Figure 2. Available planning process for a collaborative structure

## 6. Conclusions

The changes occurring throughout global markets have resulted in an increasingly competitive environment in which managers must make decisions in a shorter time with less information and with higher penalty costs. To create and sustain competitive advantages for a supply chain, this operational uncertainty must be reduced and dealt with explicitly by all supply chain partners.

In this review, a model-based literature that addresses the “demand-driven supply chain collaboration concept” is focused. “Supply chain integration”, “supply chain collaboration”, “demand-driven” and the related keywords are used for the research literature. According to the search criteria, supply chain models are classified due to their echelon, model, variable types, operational decisions and objective functions (Table 1).

The benefits handled by this study are; a structured review that provides a guide to academicians studying on the subject of collaborative supply chain models; the development of a classification scheme that is focused on the academicals consideration and identification of research issues for future investigation.

*Table 1. Classification scheme of demand-driven collaborative supply chain models*

| Reference | Echelon Type | Model Type | | | Variable Type | | | Operational Decisions | | Objective function |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Deterministic | Stochastic | Heuristic | Deterministic | Stochastic | Fuzzy | Manufacturing decisions | Inventory levels | |
| Ganeshan (1999) | (m) S/ (s) W/ (m) R | | | * | | demand/lead times | | | * | lead time/cost minimization |
| Andersson and Marklund (2000) | (s) W/ (m) R | | * | | | demand/lead times | | | * | cost minimization |
| Axsäter (2001a) | (s) W/ (m) R | | * | | | demand | | | * | cost minimization |
| Axsäter (2001b) | (s) W/ (m) R | | * | | | demand | | | * | cost minimization |
| Axsäter (2005) | (s) W/ (m) R | | * | | | demand | | | * | cost minimization |
| Tsiakis, Shah and Pantelides (2001) | (m) S/ (m) P/ (m) W/ (m) R/ (m) C | * | | | | demand | | * | | cost minimization |
| Chen, Federgruen and Zheng, (2001) | (s) S/ (m) R | * | | | demand | | | * | | profit maximization |
| Petrovic (2001 | serial SC | | | * | | | demand/lead times/supplier reliability | | * | inventory |
| Tee and Rossetti (2002) | (s) W/ (m) R | | * | | | demand | | | * | robustness of system performance |
| Rau, Wu and Wee (2003) | (s) S/ (s) P/ (s) R | * | | | demand | | | | * | cost minimization |
| Gupta and Maranas (2003) | (m) S/ (s) P/ (m) R | | * | | | demand | | * | | order allocation/cost minimization |
| Giannoccaro ve diğerleri (2003) | three echelons (not clear) | | | * | | | demand, inventory costs | | * | inventory |
| Abdul-Jalbar, Gutiérrez, Puerto and Sicilia (2003) | (s) W/ (m) R | | * | | | demand | | | * | inventory |
| Abdul-Jalbar, Gutiérrez and Sicilia (2006) | (s) W/ (m) R | | * | | | demand | | | * | inventory |
| Makatsoris and Chang (2004) | | | | | *academical information about collaboration* | | | | | |
| Abid, D'amours and Montreuil, (2004) | multi agent system | * | | | - | - | - | * | | customer satisfaction |
| Zou, Pokharel and Piplani (2004) | (m) S/ (s) R | | | * | order processing time | demand | | * | | order quantity |
| Chan, Chung and Wadhwa (2004) | (m) P/ (m) W/ (m) C | | | * | | demand/capacity/lead times/costs | | * | | demand allocation |
| Chiu and Lin (2004) | multi agent system (m) S/ (m) P/ (m) W/ (m) R | | | * | - | - | - | * | | order allocation |
| Chen&Lee (2004) | (s) P/ (m) W/ (m) R | | * | | | | sales prices | * | | profit maximization |
| Kawtummachai and Hop (2005) | (m) S/ (s) W/ (m) R | * | | | order quantity | | | * | | order allocation/cost minimization |
| Liang and Huang (2005) | (s) S/ (s) P/ (s) W/ (s) R | | | * | | demand | | | * | cost minimization |
| Fung and Chen (2005) | multi agent system | | | * | - | - | - | * | | order allocation/cost minimization |
| Chandra and Grabis (2005) | (s) R/ (s) W | | * | | | demand | | | * | bullwhip effect |
| **(m): multi, (s): single** | **S: supplier, W: warehouse, P: plant (manufacturing or service site), R: retailer, C: customer** | | | | | | | | | |

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# CONSIDERATION OF THE SUPPLY CHAIN IN AN INTERDISCIPLINARY ENVIRONMENT: WHAT TO HAVE IN A UNIVERSITY COURSE STUDY

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## Abstract

*The supply chain is interdisciplinary in and of itself. Figuratively speaking and by definition, it spans both the most basic and the most widespread of disciplines, including business management, information technology, advanced science applications, geo-political and all of those network features that incorporate the needs of the entity by which to collaborate, plan, forecast and replenish for survival and for the continuation of the operation. Being able to arrive at more effective decision-making in the global business environment requires an extensive recognition of the overall big picture. Specifically, interdisciplinary study of the supply chain sets the student on a path to see the larger picture of the course being offered within that of a wide array of courses, as they are investigating the organizational and technical issues and the interactions with each other, as portrayed and illustrated by the seminal theorists of each discipline. Here in Turkey, there has been a budding and growing interest in the concept of supply chains as they have been brought to the forefront along movements having to do with policy, management, technology, science, politics and law determinants. Now it is important to engage ourselves onto the correct path by making the right decisions on the investment of our time and in our efforts, in the selection of desired technologies and the organizations that will require leadership to accept, develop, implement and operate those technologies for the greater good of the nation. To make this happen, the academic community – from student council leadership to business strategists to high level decision makers – may want to embrace the concepts of the supply chain in an interdisciplinary manner within the university learning and knowledge management support environment by training programs, seminars – all in an effort to engage self-learning as a modus operandi for the student. This may assist our future managers, technicians, theorists, and politicians to make better decisions within the globalize environment. With this focus on the acceptance and understanding of the need for a supply chain related emphasis and the benefits that will accrue to Turkey, our universities should become the leaders for the development of related academic training activities.*

Key Words: Academic Programs, Supply Chain Concepts, Innovation Strategies, Course Development

## 1. Introduction

There would appear to be movement for the concept of supply chains to be included in the planning sessions for academic course development and training programs. This is being observed in several countries and regional sites – most recently in Turkey. This movement in some organizations is referred to as "knowledge management support." It is somewhat an atypical approach in many types of work activities. In order for it to be effective in university course instruction programs, this support must help instructors and students to recognize and adapt to opportunities so that understanding and the sharing of values can be articulated to assure a "best practices" approach to learning (Carroll, Rosson, Dunlap and Isenhour, 2005; Carroll, Choo, Rossen, Dunlap, Isenhour, Kerr and Rosson, 2005). In order to better prepare the student to understand and participate in these processes, a course of study in most any course that involves the concepts of supply chains may prove to be integral to global industrial and socially responsible programs. This initiative comes at a time when curriculum planners are willing to promote methods that will breed resourcefulness, independence, initiative, risk-taking and collaboration (Guzdial and Kehoe, 2001). Taking the supply chain concepts into, for instance, the liberal arts model of education, educators are finding that the schooling being used to educate students in the many disciplines will imbue the students with a degree of flexibility by which to meet the spectrum of challenges that awaits them (Choo, 2000). It will also prepare the student with the right tools and capabilities to work on complex problems, thereby equipping them to develop new solutions by inference (Christopher and Lee, 2001; Geary, Childerhouse and Towill, 2002). School planners want to educate those smarter, more capable and talented in the population; there is a paramount need to realistically address

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the shortcomings in the school systems while making sure that students succeed in the math, sciences, technologies and engineering studies (Novak, 1990). This will overcome the perception that higher education is an exam/test centric system, lacking innovation, and short on creativity. The educational system's strengths will build an versatile and innovative approach to intelligence that will bolster chances for success and prosperity (Race, 1994).

Such a course orientation would serve as a tool for teaching/training students to become familiar with the methodology for the understanding and evaluation of such supply chain concepts within industry sectors of the global environment. Extensive deployment of case studies, attendance and participation at supply chain and logistics trade conferences, review of empirical sources and of trade literature about the strategies and tactics being utilized in today's globalized environment would provide the bases for classroom discussions and illustrations. Within the concept and framework of the collaboration, planning, forecasting and replenishment (CPFR) model, within the basic concept of knowledge management support, other course instructions could be covered, along with current movements and trend developments (refer to Figure 1 CPFR View).

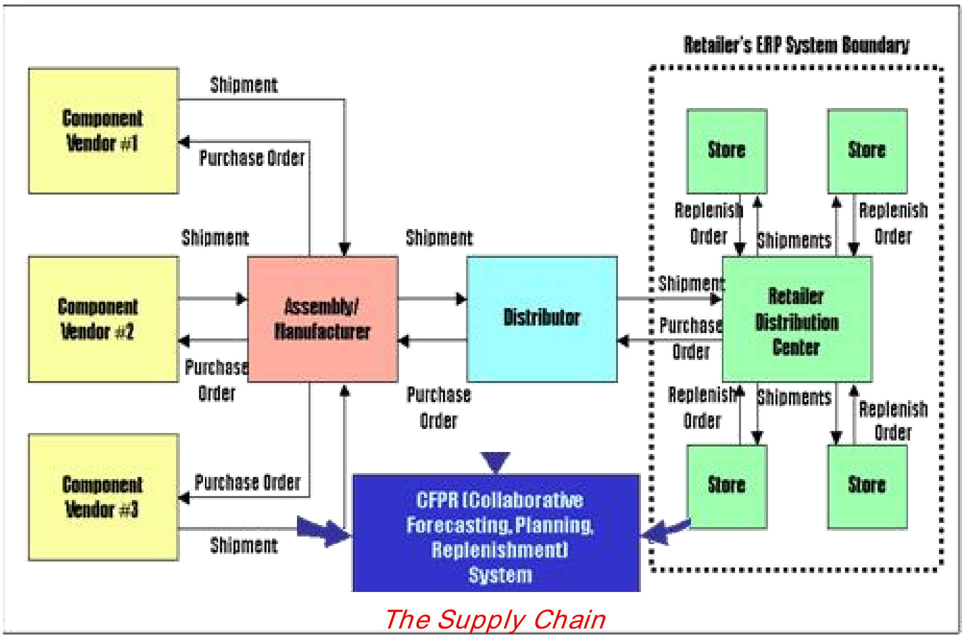


Figure 1. CPFR View
(Source: Adapted from http://www.cpfr.org/ProcessModel.html)

As the supply chain concept is deployed as a guide for course presentation of non-logistics disciplines, we begin to see the interrelationships between and amongst the course disciplines, in general, from the input of resources from the theorists (supply), the role of the course development partners (management of the study programs), the facilitating agents (enablers) and the users (customers), as portrayed in Figure 2. Supply Chain for Use in an Interdisciplinary Environment (below). The subsequent flows of ideas, the research results and resource planning, the 'fit' of the model influencing the contribution from the collaborating facilitators/players that influences the returns to the university, and subsequently to their students; ultimately the model encourages the simultaneous degrees of flexibility that will lead to breakthrough ideas and new trends (Carroll, ET AL, 2005).

By this concept, supply chain members are able to communicate and collaborate via the net system – in response to demand changes, thereby having capabilities for updating data by use of a common platform (Rybeck).

With this exposure to the role that supply chain concepts, namely CPFR, play in globalization today and therefore achieving an understanding of how the instructions of other courses may benefit the students' grasp of the material and better understand how Turkey may achieve further development as a world class technological center; the student would gain insight about how such programs may help create more robust discussion and innovative thinking about supply chain objectives in line with infrastructure development. One of Turkey's universities, the Izmir University of Economics, has undertaken to tie its logistics educational services development activities to the teaching and training of students about certain proactive supply chain concepts, specifically emphasizing CPFR activities. The university feels that such educated and trained students, during the course of their chosen career fields, may contribute by being included in the planning sessions for collaboration – on the basis of the supply chain within their chosen career paths in the various disciplines (finance and foreign trade, business administration, marketing, law, accounting, economics, etc.) – in industrial participation projects with the objective being to find new ways to strategize Turkey's participation in the various global business programs and thereby maximize returns to the country as it pursues membership within the EU.

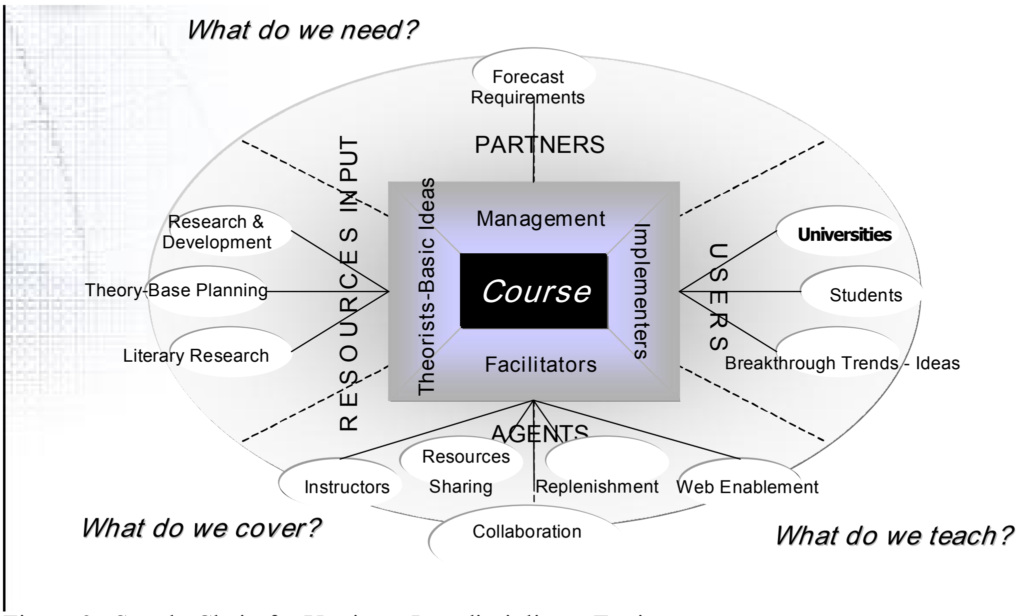


Figure 2. Supply Chain for Use in an Interdisciplinary Environment
(Source: Adapted from http://www.cpfr.org; Porter, 1980)

Further deployment for the adaptation of the supply chain model can be illustrated as in Figure 3 Adapting Supply Chain Orientation (below).

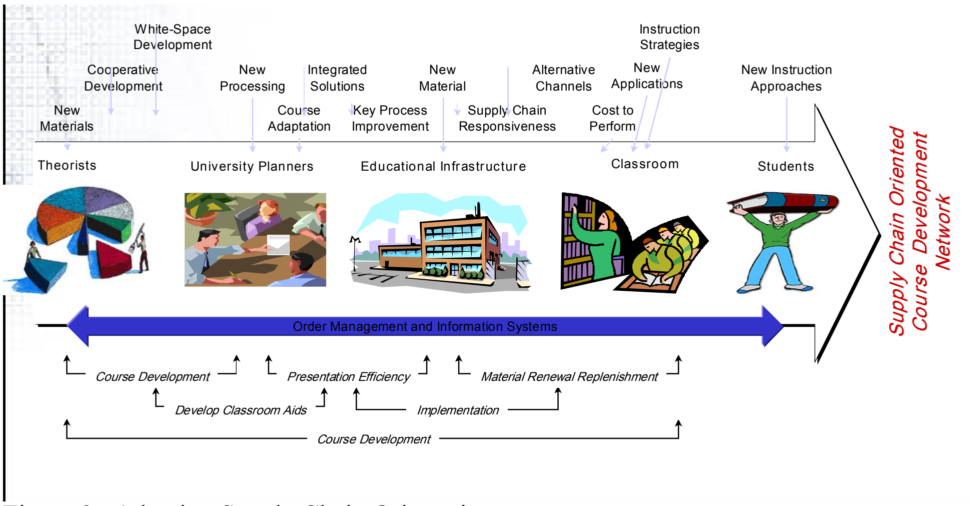


Figure 3. Adapting Supply Chain Orientation
(Source: Adapted from http://www.cpfr.org; Porter, 1980)

However, a review of both the academic and technology-oriented business literature reveals that very little has been written on the use or participation by the academic institution in the consideration of the supply chain attendant to a country's growing opportunities for global mergers and expansion of learning opportunities in an interdisciplinary way. Given increasing pressures to maximize the globalization returns to the recipient country, academic and technical institutions, acquisition planners and personnel need to be creative and find new ways to aggressively achieve the goals of participating in the attendant returns and rewards (Carroll, ET AL).

Strategic alliances between companies can bring about the adaptation to supply chains and may also provide an additional strategic approach to successful performance with greater efficiencies in related categories of program instruction and academic research endeavors (Roberts, 2003). Using primary research results taken from the survey responses of academic teachers and representatives at the Izmir University Economics and from personnel at Space Camp Turkey at the Aegean Free Zone in Izmir, Turkey, as well as from examples drawn from the trade press, the processes involved in supply chain concepts are examined in light of its place in the academic curriculum within university course offering and adaptations.

As the academic institution curriculum evolves into one that supports the study of supply chain processes, its place and effectiveness in the learning process will depend largely and in great measure on the perception of the contributions and how they are evaluated as a prime contribution to the students' learning processes about the strategic partnerships and alliances that deal with and await the students as they progress along their career paths.

How to structure the basis for these perceptions of the academic institution could best be approached by studying the nature of supply chains and the likelihood for these approaches to be included within the university programs of instruction. One of the most likely areas for the study of supply chains is that of logistics and supply chain management, where related activities are covered, i.e., make-or-buy, outsourcing, source management, etc (Christopher and Lee). A description of the basic concepts to be integrated and transferred to a multi-disciplinary learning environment at the time can be studied, along with the evaluation of the learning processes leading to acquisition of the student of the desired knowledge and technologies (Roberts; Carroll, ET AL).

Moreover, it is increasingly evident from the literature review that developing successful and productive examples and applications of the supply chain tied to infrastructure and industrial development programs can be help achieve differential advantage for the involved sectors.

Thus a basic rationale for this paper is to explore the academic institution as a supporting player for the supply chain oriented disciplinary educational program in the course of this research study, we may come upon the meaning of education and also reach an understanding of the human traits it is meant to develop. It is suggested that academic management professionals can utilize these features within the teaching of the university courses as part of their educational commitment to their students to add value to their service offerings.

## 2. Supply Chain Concepts brought about by international academic programs at university

Impressive as these numbers are, most companies have yet to engage with the university/academic institution in the area of teaching and training session offerings of supply chain concepts within course curriculum programs. An opportunity may have arrived for the university to affect positive relationships within the globalize environment in its efforts to maximize the return from such projects through well versed participants for the development of the country's infrastructure and the achievement of national goals.

## 3. University Program for the Orientation of the Supply Chain within an Interdisciplinary Academic Environment

Many courses are oriented toward current activities and new trends within the disciplines that are being taught at academic institutions. An added feature is the training of supply chain processes and technology across the academic landscape that features both the public and the private sectors.

From a general review of the syllabi for many of the courses being offered, the researchers are able to review the elements within the course offering that may lead to an appreciation of the tasks at hand necessary to master dealing with supply chain concepts.

Those elements include the definition of supply chain, rationale for using it in a interdisciplinary manner, how to evaluate it, potential challenges, recent activities, changes and trends, and several examples.

### 3.1 Definition of Supply Chain

From the Council of Logistics Management (www.Clm1.org; Cooper, Lambert and Pugh, 1997): Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies.

### 3.2 Rationale for an Interdisciplinary Approach

Universities and instructors are in perpetual search for new and effective teaching aids to improve on the effectiveness of classroom instruction techniques and approaches (Carroll ET AL).

### 3.3 Evaluation of Supply Chain Interdisciplinary Environment

The interdisciplinary supply chain concept may improve courses in 2 major areas: technical and social.

Technical issues deal with

- Metrics
- IT
- Network database
- Communication system requiring different knowledge and technical skills
- Technology generation
- Global positioning and competition

Social issues deal areas that are with economy related

- Make or buy (insource/outsource) analyses
- Cost benefit analyses
- Efficiency rates
- Profitability margins
- Politics
- Corporate policy goals/objectives
- National priorities
- Organizational interests

- Structure of industry sectors
- Market/product segmentation

(Alexander and Gupta, 2004; Christopher and Lee; Geary, Childerhouse and Towill).

Both categories lead students to reach the conclusion that supply chain concepts do not only apply to logistics and the movement or goods or services, but it is just a mechanism by which to address many challenges awaiting recognition and resolution. The concepts provide an interactive methodology to explore the larger picture environment by showing the connections and linkages with technology, politics, management, business and science (Lambert, Emmelhainz and Gardner, 1996). CPFR recognizes these links can better improve communication and linkages amongst and between them (Stevens, 1989). Given that the academic practitioners come from different backgrounds and interests, they are all connected to the larger picture that of the supply chain network connection – this is possible by thinking of the supply chain in a interdisciplinary manner. With this linkage, numerous advantages accrue to the actors and players within the chains in all sectors, ensuring that the decision making process are particularly will performed. Therefore understanding supply chain concepts in an interdisciplinary manner can become indispensable in the decision-making process (Wight, 2005).

### 3.4 Determining If Supply Chain Concept Can Be a Good Model

The decision to deploy the supply chain concept to reinforce the learning process in an interdisciplinary environment may take the form of a model (Singh, 2005). For instance, the education planner/instructor, who is seeking an improvement in student retention and understanding process of the teaching material of the classroom, should portray the two options – maintaining current teaching presentation methodology or utilizing the supply chain concept. Then under each option, each of the favorable factors (or teaching objectives and attributes) should be given a numerical significance (value of 1 to 10); each option is assigned a numerical score for every attribute; the score is multiplied by the significance rating; then the total of the results for each option is added up. For instance, if the instructor has decided to deploy the new concept, he/she identifies the objective (this could be to increase the average grade level of the class); the main players/factors of the supply chain (collaboration, planning, forecasting and replenishment/restoration); driving forces (improvement of teaching and learning skills); and the likely outcomes (will it work?). As data is collected during the initial introduction period as well as from the continuation period, the perspective of the teaching strategies will contribute to the examination to determine effectiveness and desirability. Using logical goals will ensure that the right outcome will eventually be achieved. This process will be effective when outside viewpoints (from other teachers and students) are solicited and brainstorming is encouraged to visualize all the options and perspectives; new information and feedback can be brought into this strategy to encourage enlightenment and understanding (Singh)

To assess the real value of the supply chain, the value can be based on inputs and outputs.

One example follows: THY receive tech services from USA/Boeing in exchange for Turkey purchase of airplanes. The seller must provide intellectual property and support THY in export markets. THY accepts and awards the value of, say, 50% of development cost. The transfer may also provide characteristic of “Dual Use” technology for a military defense program as well.

Another example is that of the Space Camp at Gaziemir at the Aegean Free Zone in Gaziemir. Space Camp Turkey has taken the subject of space exploration by which to expose and educate children further into the study of science and technology, brought about by collaboration, planning, forecasting and the replenishment of the business unite – within a process that melds companionship, teamwork and the building of self-confidence through the use of interactive processes at the Camp.

“Reading levels, cognitive learning skills and emotional maturity are just a few of the factors used to develop educational programs that will not only be fun, but ‘comfortable’ for young people of all backgrounds. Each program is a structured educational adventure that allows students the opportunity to explore the world’s largest interactive space education classroom in Turkey. Students have hands-on aerospace adventure and hand-on training while learning space-related science and technologies. The programs are also designed to help students encourage problem solving, confident decision-making skills, and working in challenging environment.” (Karadag and Gencel, 2006).

## 4. Research and Findings

### 4.1. Review Questionnaire Survey Form

This study is a descriptive study. A questionnaire will be used to examine several issues related to university course studies in order to consider the supply chain in an interdisciplinary environment. This research sampling methodology fits into convenience sampling since information was collected from the teaching staffs of area universities who are conveniently available to provide the answers of the survey questionnaire. The sample size is 30 instructors teaching at Izmir University of Economics. 21 of the respondents were female (72.3%), and 9 of the respondents were male (27.7%). The data was collected during the last week of September and first two weeks of October 2006. The questionnaires were applied with face to face interviews with each respondent.

4.2. Findings

The research reviews reveals that student class participation teaching aids play a dominant role in the university that all university academicians took place in the survey use this method in their courses. Table 1 below summarizes the teaching techniques used by the instructors with their relative shares. Quizzes included in the other category were the least preferable technique used by participants in classes.

Table 1: Table of teaching aids with their usage rates

| Responses to Survey Questionnaire: | Counts | % |
|---|---|---|
| Student Class Participation | 30 | 100 |
| Power Points | 26 | 86,6 |
| Case Study | 28 | 93,3 |
| Illustration | 25 | 83,3 |
| Presentation | 16 | 53,3 |
| Assignment | 30 | 100 |
| Others | 6 | 20 |

These findings also indicate that survey respondents seem to be accustomed to their current methodology of teachings and showed that that a skilled instructor could be a key factor for achieving excellence in the classroom teaching environment. In addition, instructors have more of a tendency to agree that they have all resources available for them in course development process.

Furthermore, it can be concluded that all the instructors consider assignments as inextricable part of the courses. On the other hand, the results show that only 26.6% of the participants require their students to inform the instructor about the process of assignments. Another remarkable point appeared by the survey is that only 7 of the 30 respondents, which means 23.3%, make an evaluation of their courses with their students except from the one university does every end of the semester.

The research also seeks to determine the instructors' knowledge about supply chain management from different specialization areas to be able to ask their opinions about the consideration of the supply chain in an interdisciplinary environment such as a university. Related to this, 77.7% of the instructors responded that they have some levels of knowledge about supply chain management. The Table 2 below summarizes the levels in terms of knowledge degree.

Table 2: Table of knowledge level of SCM – with response rates in groups

| Responses to Survey Questionnaire: | | |
|---|---|---|
| | Counts | % |
| High | 10 | 33.3 |
| Medium | 5 | 16.6 |
| Low | 11 | 36.6 |
| None | 4 | 13.3 |

Depending on the findings that only 4 of 30 instructors do not have any idea about the supply chain management concept were all giving courses in international relations and EU areas.

Another outstanding point revealed by the survey is that 93.3% of the instructors or in other words, 28 of the 30 participants respond that the supply chain oriented course development network which is shown in Figure 3 is quite similar to what they do when forming their courses. On the contrary, one of the university instructors who do not agree with this flow mentioned that it is impossible to view students as customers in accordance with the supply chain process. Because if so, we will need to satisfy our customers, and this can be achieved simply by giving high grades although they do not deserve. Again, another academician wanted to take attention on the differences between state universities and foundation universities. In state universities, the last part of the chain which is students is not important as in foundation universities, since students of state universities have restricted rights again their instructors in terms of education quality.

In addition to commenting on past supply chain experiences and involvement of academic institutions, the review reflects that a university study course that includes instruction on the supply chain concepts can be effective for the student in a multi-disciplinary way as they become participants in such international deals by understanding and mastering the application of information and services in relation to certain strategies and tactics throughout most industry sectors, as portrayed in Table 3 Classroom Teaching Strategies and Tactics.

Table 3: Classroom Teaching Strategies and Tactics

| Strategies/Tactics | Strategies/Tactics |
|---|---|
| tests or no testing, counseling, in-class presentations and "show and tell" sessions, training activities, | advocacy, coordination with planners, development and utilization of classroom visual aids and support equipment, technical assistance, other issues |

From a macro perspective, the implications for the inclusion of the academic course oriented toward supply chain concepts as part of the learning process for those within an interdisciplinary environment may be far-reaching and powerful, having a high impact on the nature of career-related experiences, learning and decision-making for the students' in Turkey.

Although, instructors provided insufficient cooperation in responses to the survey questionnaires, sample size of the research did not permit to make definitive determinations; only generalizations are arrived at since the sample size is 30 and it is not sufficient for making greater exact determinations. Since the findings are interpreted only for the sample, this study may constitute and serve as a base for further research efforts with larger sample sizes. Also, other instructors in other cities may be chosen for further research work. Finally, due to the fact that classroom instruction process depends on a triadic approach which also constitutes the relationship between instructor and student, this relationship may be analyzed in further research work.

### 4.1 Educational Use of the Supply Chain Concept as an Interdisciplinary Factor

The supply chain concept is used by instructors within logistics and supply chain management classes to train the students for career-related work when they graduate. The supply chain illustration in Figure 1 displays the linkage and interface networks amongst and between all player and actors within the chain. The course instruction is suitable for all candidate students with an interest and affinity toward the functions of procurement, logistics, inventory control, transportation, ITT and the desire to work in the various industry sectors where candidate employees are sought after in search of such career oriented work, possessing such working knowledge and with the desire for challenging responsibilities in these fields. It is very useful for students who are simply interested in gaining knowledge of how globalization and international factors affect business from an operational perspective.

The aim of the course is to give students the skills they require to become logisticians and supply chain strategists for modern business projects, gaining critical knowledge and experience in a work environment where hands on training or on the job training (OJT) can supplement the learning process, perhaps through internships. The acquired skills and knowledge are arranged to include the elements of CPFR. The course is presented through lectures. The course topics include:

- Introduction to supply chain management
- Organization & Specialization
- Systems & procedures
- Alliances and partnerships
- Strategic planning in purchasing & supply management
- Technology & E-commerce
- Quality specifiction & inspection
- Forecasting & inventory planning
- MRP, DRP, JIT – lean manufacturing
- Procurement & inventory controls, checks & balances
- Supplier selection activities
- Outsourcing; make vs buy
- IT and decision support systems strategies
- Price policies & strategies
- Transportation / integrated logistics systems
- Warehousing & store keeping
- Scrap disposal / environment; legal aspect
- Global sourcing

## 5. Conclusion

In this paper the supply chain concept in an interdisciplinary environment has been introduced, within a facilitative university environment of knowledge management support. Supply chain management in observation of the CPFR model is a challenge and an opportunity to gain proficiency in the needs and operation of each player in the chain (Alexander and Gupta). Especially for educational purposes the availability of training in and learning from the supply chain can be readily accessed. The key benefits of the interdisciplinary supply chain concept instruction process are:

- Synergistic training and learning academic environment

- Instructor training for proper guidance and real time response to the student
- Hands-on training during internships and cases analyses
- Ability to inject and highlight current activities and trends

(Haywood, 2002; Zsisisin, 2003).

In conclusion, the modeling of the academic course after the supply chain concepts and its benefit to those who will participate within interdisciplinary programs can be a useful and beneficial way to demonstrate how the student can acquire needed exposure and learning while gaining important progress in their development in career-oriented goals. In countries where this can be observed through the application of additional research may find that the global environment has created the ability in both companies and workers to develop new skills as needs evolve, and that the work force may better cope with practical and not abstract knowledge. Never-the-less, universities that need to gain new emphasis on course presentations and teaching may accept the option to achieve them through an interdisciplinary academic program oriented toward supply chain concepts. Multinational and globalized educational programs are growing in variations, frequency and size yet research shows that many countries have not yet tried to use the supply chain oriented academic course training across an interdisciplinary program as an innovative ingredient to their programs. Involvement of the academic institution offers a number of advantages, as reflected above. Specifically, it may be a useful process in technological goals and objectives. To some academic institutions faced with the obligation to review for update and the revitalization of existing course programs, it may have applications in the providing of improved learning and insight of the student facing a globalized world searching for the multi-talented team worker, schooled in an interdisciplinary environment that embraces the supply chain concepts.

Specifically, academic institutions with extensive experiences are most apt to benefit from the use of an academic course deploying concepts of the supply chain as a part of the course offerings commitment. While not a panacea to every specific difficulty that awaits the educator today as they cope with preparing the student for the globalized environment and the desire for the multi-talented team member by multi-national firms, the results of this approach suggests that there are specific advantages to be gained by the offering of an academic course using the concept of supply chain as a facilitative factor within that of an academic program. Education planners and academic managers who have not examined this tie-in involvement may be overlooking an opportunity to engage in more effective and rewarding interdisciplinary education programs. Additionally, the academic institution – through support from industry and others can develop an academic course based on supply chain concepts – and those corporations committed to engage new employees, formerly students, brought up in an interdisciplinary academic environment oriented toward supply chain concepts will want to carefully coordinate their activities if the multi-national company is to derive the greatest benefits from these academic programs.

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# LOGISTICS MANAGEMENT AS A COMPETITIVE TOOL IN GLOBALISATION PROCESS

Ceren Akman[1]

## Abstract

*Within the evolution of the internet, the competition becomes much more tough and fast than ever. The domestic based companies start going international and benefit using internet network effectively. Within the intergartion of the markets, companies' production costs become at approximate values. The companies benefit the advantage of buying raw materials at minimum prices and use the cheapest labor force where available. This fact eliminates price competition and pushs the companies to differentiation. In that sense, if cost minimization achieved in production phase then the companies should focus on differing their logistics services from other companies to stay competitive at competable prices. As logistics management is a process maangement in order to respond quickly to customer demand its better for the companies to outsource logistics activities.*

Key Words: Globalisation, internet, competition, logistics, outsource

## Introduction

Recent developments in IT technologies have great impacts on companies' business and management skills in current globalisation process. Within the evolution of the internet economy the competition becomes much more tough than ever. New economy brings new business skills and pushs the industries to serve more faster in every phases; production, manufacturing,marketing,sales,transportation and logistics. As the production costs become stable the companies should focus on decreasing their logistics and transportation costs and shorten their logistics and transportation processes in order to gain and sustain competetive advantage. Therefore the companies have to identify their core competences and outsource logistics services in order to streghten their position in the rough global market.

The logistis partner that offers innovative and creative solutions by applying IT technologies effectively can streghten the competitiveness of the companies. In that sense the purpose of the study is to implemet a case study that illustrates how programmed logistics services that ensures management of the entire supply chain of a product from raw materials to consumption by the end users, increase customer profitability by applying an infrastructure based on the most advanced technology.

## 1. Logistics

Over the past several years the term "logistics" evolved into a blanket term used to describe system-wide management of a company's supply chain (SC). Logistics describes the management of all supply chain management (SCM) processes from the acquisition of raw materials to the delivery and distribution of finished goods. When optimized, it can provide lowered inventory costs, lowered expenses and capital expenditures, and increased customer satisfaction.

Logistics is the art and science of managing and controlling the flow of goods, energy, information and other resources like products, services, and people, from the source of production to the marketplace. It is difficult to accomplish any marketing or manufacturing without logistical support. It involves the integration of information, transportation, inventory, warehousing, material handling, and packaging. The operating responsibility of logistics is the geographical repositioning of raw materials, work in process, and finished inventories where required at the lowest cost possible. As such, logistics is commonly seen as a branch of engineering which creates "people systems" rather than "machine systems".

Logistics also can be defiend as having the right quantity at the right time for the right price. It is the science of process. Incorporates all industry sectors, and manages the fruition of project life cycles, SCs and resultant efficiences. Logistics as its own concept in business evolved only in the 1950s. This was mainly due to the increasing complexity of supplying one's business with materials and shipping out products in an increasingly globalized SC, calling for experts in the field.

Logistics management can be the most important tool to decrease companies's costs. Logistic activities that can provide low cost input and serve the end products with competable prices to the markets, can maintain the market

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share in global scale. In order to respond customer demands and lower inventory costs, the firms should build their SC and accordingly their transportation chain properly. [1]

As internet information can be cheap, shareable, early, and …fast in today's SCs, the vast majority of the throughput time is taken up by information-related delays, not by the time required to physically process or transport the goods. The time saved through real-time planning, minimal inventories and more flexible operations can be used to compress, or shorten, the supply chain by removing one of the its links, and the associated costs, without suffering any loss of delivery performance. [2]

## 2. Globalisation and Rebirth of Logistics

Global growth and shifting customer demands required a new business model. It was recognized that logistics operations would be significantly affected, and that the logistics industry itself was undergoing a global evolution. In this respect globalisation can be defined as rebirth of logistics and transport. [3]

In the past decade, countless companies underwent the process of "globalization." These companies have developed their international presence through mergers, acquisitions and collaborations. Services that were traditionally driven by physical assets and centered on domestically scoped, industrial activities are becoming full-service, global activities that are information driven. An industry focused on legacy systems technology and manually driven communication is shifting to an industry characterized by high visibility, a focus on internet based applications and a utilization of collaborative solutions.

This new, information-driven logistics model is far more flexible and apt to keep in tune with changing customer demands. Traditional asset-centered management models are not suitable for the massive scope of most companies. The new model is far more effective in streamlining the logistics needs of a company than its predecessor. Globalization of the multi-national customer, demand on ability to provide consistent product solutions throughout all regions of the world. Therefore there is need to globalize logistical ability to meet the demands of customers, develop a global supply base, and position against emerging competition.

In recent globaliation process;

- Business models were changing from a production mindset to a solution mindset.
- Customer demands were for an end-to-end solution provider, not just a product provider.
- Global market changes saw that a country centric model was too slow and inflexible to meet needs.
- Heightened need for better control of the business.

Today's logistician must keep in mind that logistics management is 100% customer service when establishing logistics processes designed for servicing the global customer quickly. Before the demand was consistent and steady, lead-time met the industry norm. There is a sudden change in the focus of retail customers. They wanted more point of sale (POS) solutions produced with shorter lead times and more rapid deployment of product installations. Quick development and production was now the norm. Rapid growth and increased customer demand, although always healthy, was starting to require quicker responsiveness to needs and pushing higher levels of mass customization, while demanding flawless quality.

To stay competitive, companies are adopting sophisticated SC technology to speed up operations and improve customer service, tailoring it to buyer demand. Business logistics involves planning, designing and supporting the business operations of procurement, purchasing, inventory, warehousing, distribution, transportation, customer support, financial and human resources. Logistic activities that provide innovative and creative solutions take the production companies one step forward.

In order to identify the size of the company when analysing the effects of globalization Small and Medium Enterprises (SME) will be take into account. It has been known that SMEs are the most flexible firms that adopt the innovativeness faster. However they suffer from their financial capabilities. When thinking all activities of a company as a whole, the most costly part is production. As SMEs have invested most of their resources on production, they do not have chance to invest on research and development (R&D) and logistics.

In globalisation fact, the companies and the countries could not stay apart from each other. Because globalisation is integration. In that sense an international company can locate its production facility in Turkiye or a retailer can start to operate in Turkiye. Therefore competition takes place both in domestic and intenational market. So its hard for SMEs to invest and manage every phase together. Otherwise they can not compete with the other companies.

Value added products that are at competitive prices and served on time will gain importance in this process. Also a production company should produce its products cheap, do its markeing plan and provide logistics service fast in

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[1] http://en.wikipedia.org/wiki/Logistics

[2] Sharman Graham J., "E-Supply Chain Management: Venturing Beyond E-Commerce", page 5.

[3] Commiskey James, Scott Todd, Slawson Greg, "Case Study: Creating a Logistics Partnership with a Win-Win Implementation Strategy", page 1.

every phases. In order to decrease total costs, the companies should supply the cheapest raw material, lower its labor costs and logistics costs. Otherwise it'll be hard for the companies to survive in the tough competiton. Hence, the companies should focus on their core competences to benefit economies of scales and lower their logistics costs by outsourcing the logistics activities.

The starting point of all the activities are human needs. Its important to realize the demand and respond it with a right supply. In gloablisation the companies do not have chance to miss the market and the customers everywhere. Otherwise they can not stand.. Within "order to manufacture" system and by cross docking, SMEs can achieve less inventory costs.

To meet today's global customer service, SMEs had to:

- Eliminate excessive costs.
- Differentiate customer service.
- Improve inventory performance.
- Establish closer relationships with the customer.
- Increase flexibility by outsourcing logistics services.
- Meet the customer demand for solution delivery.
- Change the logistics model to meet the needs of the multi-national customer.
- Increase customer direct shipping from point of manufacturing.

As production companies' core business is to produce and logistics companies core business is to serve/manage the logistics activities, a well organized and competable SME should think logistics apart from the other activities. All product-oriented businesses have logistics as a cost of doing business. Some may think it only applies to large businesses, but companies of any size can benefit from logistics improvements. Logistics can help your company by:

- Cost savings
- Reduced inventory
- Improved efficiency
- Improved delivery time, which improves customer satisfaction and can be a competitive advantage if your competitors can't deliver as quickly [1]

## 3. Outsourcing Logistics

Third Party Logistics Approach (3PL) depends on outsouce of the logistics activities. There is a customer side, company side and the logistics company side. Customers are looking for SC integration through one-stop integrated logistics service providers and are therefore more likely to use a major 3PL. The industry will continue to see further consolidation as players want to be one-stop shops for their customers. [2]

Customers' views and wants are all different. There is no single program that can cover all the different needs of the customers, so when appropriate service providers will design special services for the customer. Customer service has to be customer specific. Basic level of service is prompt delivery and complete shipments from a scheduled delivery system, from this service providers establish new services at the design of the customer.

A logistic partner should first understand and analyse the company, then investigate the best solutions with a project and manage the company's requirements at a given time with its infrastructure. Tendency and quality are most important issues that'll be seeked in means of logisitic service providers.Also provided different value added services, creativity, innovativeness and IT infrastructure have to be taken into account while choosing a logistics company.. Because with the integration of two companies databases a real-time data flow can be achieved and control of the goods can made easily.

The logistic service that can increase companies' competitiveness demonstrates itself with its quality. Providing quality can be maintaned by infrastructure. Within the application of developed IT, quality of the logistic service increases. Logistics company that completes infrastructure projects for domestic distribution, storage, and information processing, has turned its attention to international transport organization and intermodal transport. Logistics company combines sea, ground, and rail transport, providing customers with the most effective solutions and door-to-door service.

In changing globalisation process its important for the companies to respond customer demand fast, produce and serve products at requested quality. This can be achieved by managing procurement, production, manufacturing, marketing, logistics phases much more fast than ever. For quicker respond and serve innovative products to the market, the companies also should do their R&D business properly and fast. So in the lights of all above explanations it'll be better for a company to do its core business and invest on developing its products.

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[1] http://logistics.about.com/od/logisticsbyindustry/a/aa111505.htm

[2] http://www.logisticsmngmt.com/article/CA6353748.html?industry=3PL&industryid=2028

As logistics management is a process management, by only managing production, manufacturing, marketing and R&D processes the firm can benefit the economies of scales and do not have to manage the logistics process additionally. Because logistics activities and managament needs investments which will increase the companies costs. SME's can not afford these costs at requetested quality level. So by chosing a right logistics partner the SMEs can focus on production and research to develop new producst then to the competition. In R&D level SME's will be seeking for the questions “what to produce”, “where to produce”, “whom to sell – either in domestic or international market-” and “how much to sell” , not on questions “how to distribute”, “where to locate the warehouse” and “how much will be the inventory costs”.

So reasons for outsourcing logistics can be described as follows;

- Return on assets
- Personal productivity
- Flexibility
- Increasing labor cost
- Management/Political considerations
- Customer service
- Information technologies
- Logistic service providers and their service quality
- Focus on core competence
- Operational productivity

Addressing ‘core’ SC costs will be the most challenging and time-consuming challenge, while at the same time promising the greatest payback. The basic activities of processing, storing, moving and handling materials along the chain can only be accomplished more effectively by radical restructuring and innovation in the SC. This involves changing the patterns of physical goods movement, as well as the planning and control regimes that manage those flows. Resistance to such change arises from the millions of dollars worth of facilities affected, and the thousands of planning and management jobs whose scope will change, or even disappear.

By focusing and investing on production and marketing SME’s can benefit economies of scales and within the increase of the transported goods' volume SMEs can provide logistics services at low prices. In warehose management (WM) the costs will decrease. Within an inventory management the inventory costs will decrease while customer service quality increases. Outsourcing logistics will also rationalize the distribution network and the unnecessary costs will be put out the system. There'll be low operational costs by increasing purchasing power.

Outsourcing logistics has also an advantage related with accounting. By outsourcing logistics SMEs can reflect only logistics expenditures as one item on the balance sheets. For instance they do not have to calculate the redemption of the trucks and they do not have to reflect administration and workmanship expenditures on the balance sheet.

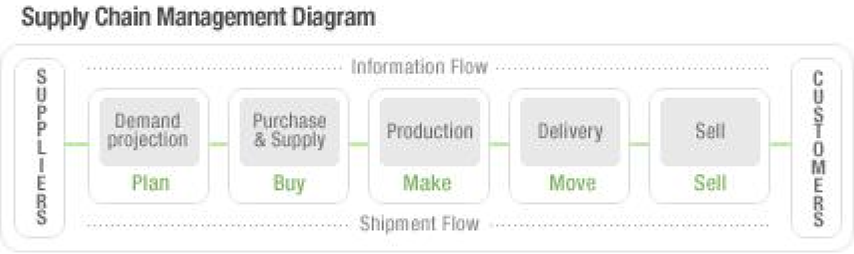
Also by means of 3PL, (SC and distribution network) companies can benefit profits. The companies go through milk-run system from manufacturer distribution. Before milk-run, suppliers distribute their products to the companies by their own vehicles. In increasing scale this method become more complex. In milk-run application, materials supplied from their suppliers in certain times and supplied frequent and little. The vehicle that'll get the materials stop by all the suppliers at given times and there'll be no need to find another vehicles to distribute the materials for the other suppliers on the same rotation. Eventually, approximately 80% daily inventory decrease and totally 60% logistics cost decrease can be achieved.

## 4. Case Study

Logistics has always been down stream of the delivery cycle. Very rarely does the logistician get the opportunity to sit with the customer to understand what the customer really wants when they place an order with a company. Customers can contract pass through the logistics discipline for review of the customers' required deliverable. No longer is a salesperson able to commit to a service that otherwise was a logistics hurdle in meeting the critical part of the project…that being the final delivery to the customer. Logistics now drives the delivery cycle through the contract and together with the customer, establishes the expectation and satisfaction of a successful solution long before the actual shipment happens. In addition, contract review now gives logistics opportunities for compensation for out of scope work, where before scope changes were seldom recovered.

By effective information share and, through Tracking system, companies can follow the progress of their shipment step by step wherever it is in the world. Logistics company’s ability to integrate SCM with transportation and IT management provide companies a custom designed logistics packages that address the customers requirements. By vendor neutral positioning logistics company provide a collaborative approach to SCM designed to drive cost out of the bottom-line, while enhancing profitability and customer service.

Starting point of the SC is customer demand. Within a customer order that has been inserted in integrated system, needed raw material has been shipped on the appropriate vessel and trucked to the production facility. After production process the goods have been distributed from the production facility to warehouse or distribution center. Then the goods cross docked to wholesaler/retailer. After the delivery process both face to face and B2B, B2C applications the goods have been received by the end user.



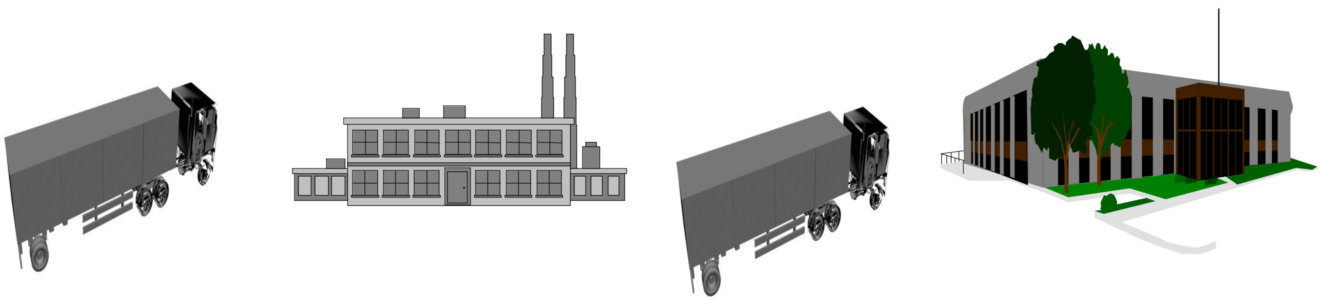

*Source: http://www.hanjinlogistics.com/main/main.jsp

In order to convince companies to outsource logistics, a case study will be implemented to illustrate the difference of the project based logistics activities and logistics packages from the basic logistics activities. A logistics company should provide different projects that includes different service packages to the companies that have different needs. After a meeting with the company and collecting the requested datas and services, a project and logistics plan can be made and with combining below mentioned services a suitable service package can be provided to the company.

Service Scope of the Logistics Company:

- Interstate Transportation Service
- Consolidation, Warehousing, CY Operation, Trucking
- Freight Management
- Warehouse Management (WHM)
- Storage, Inventory Management
- Ocean Shipping Service
- Consolidation, Vendor Management
- Inland Transportation Service
- Distribution, Less Truck Load (LTL), Full Truck Load (FTL), Intermodal
- Consolidation Service
- Transloading, Merge-in-Transit
- IT Service
- Electronic Data Interchange (EDI) Service, IT Service
- Value Added Service
- Vendor Managed Inventory, Wrapping,Packaging,Labeling,Barcoding,IT Support, Consulting, Project Management

For instance a company produces special products that need to be kept in 30-35 C temperature and % 60-65 humidity and these products should be shipped from the factory to the warehouse. Firstly, trucks sent to the factory and the logistics process starts. The goods are shrinked and pallet services have been made at the factory. Then the goods loaded to truck to be transhipped to the warehouse. Barcoding of the palletted and shrinked goods can be either made at the factory or at the warehouse. By barcode readers the barcodes that have been made on the palletted goods defined to the system.



1st trucking to the Factory = > Arrival to the Factory => 2nd trucking to warehouse = >Arrival to Warehouse

Warehouse conditions prepared before trucks' arrival. The temperature and the plan of the layout has been arranged as per the company's requests. The warehouse staff has been informed about where the goods will be stored. By hand terminals the warehouse staff can check the inserted datas and re-check the place of goods. When the trucks arrive to the warehouse the forklifts carry the goods from trucks to the shelves, or the reserved place for the goods.To enable effective inventory cost barcode numbers read by the barcode readers.

Radio Frequency Identification (RFID) system enables inventory control that all the read barcodes have been inserted in the system. Its easy to check the input or output data by RFID. After barcoding completes the pallettes and shrinks have been removed and the boxed goods kept in the warehouse till their last movement to the end user.


*Source: http://www.hanjinlogistics.com/ourservice/warehouse.jsp

When a transport order received to a specified destination from the company an offer prepared due to the transportation mode-whether its only road transportation,both road and ship transport(intermodal transportation), or only ship transport. After identifying the transportation mode, freight will be determined. The most costly part of logistic activity is transportation. Approximately 70 % of logistics cost are covered by transportation. A logistics company that can serve all the transportation modes is appropriate for the ompanies.

After deal in freight, sufficient quantity of containers shipped to the warehouse from the container yard. By reading barcodes again by barcode readers outputted quantity of boxes have been deducted from the inventory in RFID system.Then the boxes stuffed to the containers. When stuffing completed the containers closed, sealed and ready to be shipped to the destination to meet the end users.

## Conclusion

In fast varying globalization process its seriously important for the companies to focus on their core competences in order to stand in tough competition. By outsourcing the support activities like logistics management, companies will gain the advantage of managing their main activities properly.They can also benefit the economies of scales and can be able to develop new products. When outsourcing decision made its important to select the right logistics partner. "Quality sells" should be the slogan and mission of the selected logistics partner. As services are intangible, the companies can evaluate the service with its quality.

As a consequence, with working with a logistics company the production companies spend less time and effort on logistics activities, minimizes their logistics costs, transports their cargoes effectively and on time. They will be in relation with only one logistics company and pay one bill for logistics activities and will reflect one item as logistics expenditures on its balance sheet.

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# URBAN LOGISTICS PLANNING

Mehmet Tanyas [1] and Metin Canci[2]


## Abstract

*Urban logistics, as a basic approach, can be expressed as the total of logistics actions related to the urban area. Hence, transportation and transportation modes make up the main components of urban logistics. In this context, logistics, which can be expressed as nodes-campuses, terminals and flows is also a major component of urban logistics.*

*Nodes, or in other words, logistics focal points or campuses, can be described as the strategic locations where movements start, end or are transferred.*

*Terminals are centers where freight movements are collected or distributed, and movements between logistics focal points are organized. They are the facilities that provide access to networks. Terminals are characterized with their central positions and the links that come out from them.*

*Flows represent the connection points between logistics focal points and terminals on the network where freight flow takes place as well as the demand and connection capacity in terms of amount of traffic.*

*Investigation, planning, sustaining and improvement of logistics activities within the urban area are also within the subject area of urban logistics.*

*Urban logistics is also referred to as city logistics and urban freight transportation. Urban logistics, in this context, is an optimization study in market economy that takes into account environmental effects such as urban traffic, safety, noise, accidents and energy consumption.*

*Logistics activities have grown in parallel to the growth of the city; however, the logistics infrastructure has not developed at the same rate and logistics problems have increased rapidly in developing countries such as Turkey that are at industrialization phase.*

*In this study, main approaches to logistics and urban transportation will be stated and the importance of urban logistics will be emphasized.*


*Keywords: Logistics, transport, city logistics, urban logistics, urban freight transport.*

## 1. Introduction

Urban logistics can be basically described as the total of all logistics activities related to urban area. Therefore, transportation and modes of transportation are main components of urban logistics. In the viewpoint of urban logistics planning, urban logistics infrastructure, terminals, equipments and networks occupy a large area in the city. These functions represent a significant part of the complex structures within the spatial system of the city.

Urban logistic planning defines the relations between nodes, terminals and freight flow. Nodes, also known as focal points, are strategic points where freight movement starts, ends or transfer takes place. Terminals are centers that regulate the movements between focal points and provide access to transportation networks. Freight flow represents the amount traffic, demand and capacity on the network between the nodes and the terminals.

Logistics is essentially focused on two activities. One is to provide freight movement, that is, transportation and the other is storage. Planning, control and application of these two activities are the other activities that complement logistics. In short, logistics is a network consisting of interactions among production, transportation and storage. Hence, logistics has a compulsory relationship with the city.

## 2. The Concept of Logistics

Logistics is a very important concept for contemporary economies and trade. As defined by the Council of Supply Chain Management Professionals (CSCMP): "Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all levels of planning and execution—strategic, operational, and tactical. Logistics management is an integrating function which coordinates and optimizes all

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logistics activities, as well as integrates logistics activities with other functions, including marketing, sales, manufacturing, finance, and information technology.”

## 3. The Concept of Urban Logistics

Logistics in general is a concept that has been developing and gaining importance in the recent years. Regional, national and international freight transportation activities have been continuously increasing.

One of the most important concepts that has come forward lately is “urban logistics”. Some of the recent major studies in urban logistics are Taniguchi (1999, 2000, 2003, 2004), Munuzuri (2005), Crainic (2004) and Hensher (2005).

Taniguchi, Noritake, Yamada, Izumitani (1999) introduce public logistics terminals that are proposed in Japan and develop a mathematical model to determine optimal locations and sizes of these terminals. Their model has been applied successfully in Kyoto-Osaka area.

Taniguchi and Van der Heijden (2000) present a methodology for city logistics using dynamic traffic simulation with optimal routing and scheduling. They try to minimize total costs and carbon dioxide emissions on a test road network.

Taniguchi, Thompson and Yamada (2003) evaluate mathematical, computer-based models used in the evaluation and planning of city logistics schemes. Dynamic flow simulation, logistics terminal location models, city logistics simulation models, multi agent systems and network models are evaluated.

Taniguchi and Shimamoto (2004) perform a simulation of dynamic vehicle routing and scheduling model with real time information using variable travel times. Their model achieves both trip times of vehicles and costs.

Crainic et. al. (2004) propose an organizational and technical framework for integrated management of urban freight transportation and identify planning and operation issues. They study the applicability of satellites, which are freight terminals where loads are transferred to smaller trucks for urban delivery. Their model city is Rome.

Munuzuri et. al. (2004) examine urban logistics from the viewpoint of local administrations and compile solutions and initiatives to improve freight deliveries in urban areas. These solutions are related to public infrastructure, land use management, access conditions and traffic management.

Hensher and Puckett (2005) develop an economic-based framework to evaluate the behavior of stakeholders in the supply chain to policies to reduce congestion such as congestion charging.

In developed countries, most of the population lives in cities. Manufacturing activities of cities are performed usually inside or in the vicinity of urban areas. In this context, urban logistics planning is the physical area planning of all logistics activities that take place in the city. Urban logistics benefits healthy growth of the economy as well as the sustainable development of the city in terms of society and environment. Furthermore, undesired effects such as traffic congestion, energy consumption, noise are minimized and high quality, standardized services of just-in-time logistic deliveries will be possible.

### 3.1 Major Functions and Related Areas of Urban Logistics

Urban logistics is related to many other areas such as geography, population movements, urban settlements, commerce and industry. In order to interpret urban logistics, the needs and expectations of logistics sector should be understood. In this context, it is of primary importance to ensure commercial competitiveness of the city. Logistic functions should be planned in a way to minimize costs of operation in the urban area and utilize economies of scale and ensure fast flow of goods. Hence, urban logistics should be characterized according to these expectations of logistics sector.

Another important aspect of urban logistics planning is that, to be successful, it should not only be limited to the framework of work performed by commerce and industry, but a multi-disciplinary approach should be adopted that includes dimensions like environment, statistics, demographics, engineering among others.

In order to achieve sustainable urban logistics planning, environmental and societal dimensions should be considered before the economic dimension. In the EU White Paper (Time to Decide, 2001), where transportation policy of the European Union is outlined, sustainability is taken as an indispensable aspect of transportation. In these times when Turkey’s integration with EU has accelerated, the fundamental viewpoint determined by the White Paper is expected to have increasingly more influence on the fields of transportation and logistics in the future. In this context, even though urban logistics is a new concept for our nation, it should be evaluated with these dimensions and political and strategic measures should be taken.

### 3.2 Components of Urban Logistics

Urban logistics has three major components. First of them is the logistic node, which is a point where freight flow initiates or ends. The second component is terminal, where a change of transportation mode, consolidation or distribution of goods takes place. The third component is the flow of freight between nodes and terminals.

City planners are concerned with principles of selection of locations for nodes and terminals, whereas optimization of locations is performed mostly by industrial engineers. Topography of the selected area is the interest area of geologists, and growth of the urban area is considered by architects, civil engineers, city planners and others. Finally, city planners determine the locations according to these data.

### 3.2.1 Nodes

A logistic node can be any point where a freight movement starts or ends. Some examples of major nodes in a city are warehouses, depots, organized industrial zones, cargo terminals and retail stores. In case of door to door delivery, customer's home is also a node. Nodes are usually scattered inside an urban area. For a better performance of urban logistics, major modes should be located at an optimal distance from the city center and have sufficient connections to the transportation infrastructure.

### 3.2.2 Terminals

A freight terminal can be defined as any facility where freight is assembled or dispersed. Major types of freight terminals are seaports, airports, rail stations, and customs areas. A change of transportation mode or transfer of goods within the same mode is possible. Freight terminals require specific equipment and infrastructure according to the type of goods being carried, and they occupy large amounts of the urban area. Terminals are extremely important in freight transportation. Efficiency of terminals is crucial for high speed and low cost logistics operations.

Terminals should be located in optimal positions in order to minimize urban congestion and transportation cost. For example, a port that is too far away from city center will cause high transportation costs and be less competitive with respect to other ports. On the other hand, if the port is trapped in the middle of city center, freight traffic will disrupt urban passenger transportation. It is also crucial that terminals are well connected to the transportation network with adequate infrastructure like roads and rail connections.

Ports are the largest type of freight terminal, and there are many technical criteria for a location to be possible to have a port, such as minimum depth of water, tide height and the need to build breakwaters. Maritime transport has been the most feasible mode of carrying freight throughout history. For this reason, all major seaside cities are built around ports, as in the examples of London, Barcelona, Hamburg, Istanbul and Izmir. Recent increases in international trade volume, bigger ship sizes and increasing use of containers force ports around the world to expand and change the functions of ports. Around the world, old port areas in the city center are becoming obsolete and being abandoned while modern, specialized port facilities in the peripheries of the city are being built.

Air transportation is the fastest and most expensive mode of transportation. While this may be a desired characteristic for passenger transportation, only very valuable, lightweight and urgently needed cargo is carried by air. Usually an airport handles both passenger and cargo traffic of a city. Major metropolitan areas can have more than one airport, as in the examples of New York, London and Istanbul.

Railway freight terminals do not require so much space as sea and air terminals. They are usually located in places of high freight traffic like ports and industrial zones. They also need to have good access to road transportation.

### 3.2.3 Freight Flow

Many varieties of freight flow can be present in an urban area. Most obvious ones in the city center are distribution of goods to retail stores, mail and parcel distribution and collection and solid waste collection. In industrial areas, raw materials are transported to factories and finished goods are carried from factories either to the urban areas or out of town. Transit flow also occurs in most cities, especially in those that have a seaport.

Ensuring smooth and fast flow of freight in urban areas is one of the most important objectives of urban logistics planning. This includes selecting optimal locations for nodes and terminals, as well as building adequate transportation infrastructure of roads and railways.

## 4. Urban Logistics Planning

The basic principle of urban logistics planning is balanced distribution of logistic units in accordance with the geographical position of the city and to provide physical infrastructure that allows easy transfer between transportation systems. In this context, first basic task is to determine the current status of logistic activities. Volume of freight traffic entering the city and exiting the city towards other cities or countries, structure of urban storage and delivery activities and future growth potentials should be revealed in mid and long terms. To prepare such an inventory, logistic nodes, terminals and flows, especially the major centers with largest influence, should be taken into account. With an accurate logistics inventory, needs of the logistics sector can be revealed and logistics functions can be recorded on the city plans. Development of urban logistics plan that takes future growth into account will benefit all parties in terms of its results.

Urban logistics, on one hand, is a concern for city planners; and also, on the other hand, for providers and users of logistics services, including public administration, and eventually the whole society. Even though urban logistics is concerned with physical planning as a part of city planning, needs of the logistics sector should be clearly expressed and all aspects needed by the sector should be taken into consideration. Some of these aspects are:

- efficient operation of freight transportation systems
- establishment of logistics terminals
- accessibility of the terminals and nodes
- easy transfers between transportation systems
- development of sea and rail transportation.

Therefore, in the planning of urban logistics, should be approached with an interdisciplinary viewpoint. In this point of view, urban logistics is closely related to fields such as economics, history, political science, sociology, mathematics, computer science and environmental science.

### 4.1 Importance of Urban Logistics Planning

In terms of its results, urban logistics planning will be most influential on logistics service providers and service users. Urban logistics planning will, on one hand, provide benefits like time and cost savings, safety, standardization for users of logistics services, on the other hand, it will benefit service providers with respect to regular services. In addition, concentration of logistics activities will provide the necessary environment for the city and the region to develop in a planned way.

The societal dimension of urban logistics planning is that the negative effects of freight movement on city residents such as heavy vehicle traffic, pollution, degradation of roads, noise pollution and congestion will be reduced to minimum levels. Furthermore, establishment of planned logistics regions will shift some logistics functions that are located in the urban environment into these regions and therefore the urban social life will be improved. Development of planned urban logistics is an important first step in the direction of becoming a logistics hub. Availability of regular, high quality, standardized logistics services will turn the city into a center of attraction.

## 5. Comments

Urban logistics planning is a multi-disciplinary area that is still under investigation by many researchers. Logistics is a vital component of economy of a city and a nation. Globalization and the increase of international trade, as well as just in time production practices have increased the importance of logistics in the recent years. Increase of freight traffic, on the other hand, disrupts urban traffic, which also suffers from increasing private car ownership in most major metropolitan areas of developed and developing nations. To ensure fast and smooth flow of freight and passengers, urban logistics planning plays a vital role.

In most developing nations as well as Turkey, urban logistics planning is at a preliminary stage. In general, terminal and major node locations are not chosen with urban logistic planning perspective and the transportation infrastructure is not sufficient. This situation has both economic and environmental negative effects besides causing unnecessary traffic congestion. For this reason, urban logistics planning should be a priority for major cities of developing nations.

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# MULTIMODAL CARRIAGE IN TURKISH LAW (A COMPARATIVE STUDY)

Huriye Kubilay[1], Zeynep Demirçivi Mineliler[2]

## Abstract

*Growth and development of international trade and logistics services enabled the door-to-door services involving more than one mode of transportation. Over the years, several sets of modal rules for regulating of multimodal transport have been established. But none of these has brought about international uniformity.*

*The lack of uniform liability regime caused different national and regional legislation. Currently, Turkey has no specific law governing the legal framework of multimodal transport. Existing provisions, found in Turkish Commercial Code and in the conventions, which Turkey is the State Party, have solved disputes arising out of a multimodal transport contract. However, the Draft of Turkish Commercial Code brings basic principles, which will be applied, to multimodal transport.*

Keywords: Multimodal transport, United Nations Convention on International Multimodal Transport of Goods UNCTAD/ICC Rules, The Draft of Turkish Commercial Code

## 1. Introduction

The latter half of the twentieth century has seen substantial changes to the methods practices of commercial shipping. Ports have been automated, ships have been redesigned, there have been technological advances in mechanical stowage, and computers have revolutionized the issue of shipping documents. Significant part of this change has been the introduction of containerization. Container shipping is now conducted on all major trade routes and carries a substantial amount of the world's shipped goods. Road, rail and air carriage has also adapted to the carriage of containers and this has led to the development of "door-to door" transport under which the container can be carried from the shipper's place of business for delivery to the place where buyer wants them delivered (Templeman, Sellman & Evans, 1999:196-197).

The so-called container revolution has altered the transport of goods enormously. The use of cargo containers has caused technical, economical and legal problems. Many of technical problems seem to be have solved, although cargo handling and port development are continuously evolving in order to obtain greater speed and efficiency. The economic problems, such as the colossal investments are absorbed by new techniques (Wit, 1995:4). But legal problems continue by reason of lack of uniform regime.

## 2. International Law

United Nations Convention on International Multimodal Transport of Goods defines multimodal transport as the carriage of goods by at least two different modes of transport from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place designated for delivery situated in a different country. The multimodal transport agreements are not restricted to container carriage, nor all containers carried by multimodal transport. It is however, containerized cargo that best suits the fully integrated transport services, and the carriers who offer this service are usually referred to as multimodal transport operators or through transport operators (Templeman, Sellman & Evans, 1999:197)

While much of international trade is now carried out on door-to-door services, under one contract and one with party bearing contractual responsibility, the current legal framework governing multimodal transport fails to appropriately reflect these developments. No international uniform regime is in force to regulate liability for loss, damage or delay arising from multimodal transport. Instead, the present legal framework governing multimodal transport consists of a complex array of international conventions designed to regulate unimodal carriage, diverse regional/sub regional agreements, national laws and standard term contracts. So, both applicable liability rules and the degree and extent of a carrier's liability vary greatly from case to case and are unpredictable. Also where the goods are carried in sealed containers (Full Container Load/FCL), it is often difficult to identify the stage/mode of transport where a loss, damage or delay in delivery occurs. Under the present regulatory framework, however, both the incidence and the extent of a carrier's liability may depend crucially:

On whether a loss can be attributed to a particular stage and mode of transport,

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On which of a considerable number of potentially applicable rules and/or regulations is considered to be relevant by a court or arbitral tribunal in a given forum (UNCTAD report *Multimodal Transport: The Feasibility of an International Legal Instrument*, UNCTAD/SDTE/TLB/2003/1, 7)

Over the years several attempts have been made at drafting asset of rules to regulate liability arising from international multimodal transportation, but none of these has brought about international uniformity. In 1980, the United Nations Convention on International Multimodal Transport of Goods was adopted, but it did not attract the necessary number of ratifications and thus has not entered into force. Article 36 of the Convention states as follows: "1. This Convention shall enter into force 12 months after the Governments of 30 states have either signed it not subject to ratification, acceptance or approval or have deposited instruments of ratification, acceptance or approval or accession with the depositary. 2. For each state which ratifies, accepts, approves or accedes to this Convention after the requirements for entry into force given in paragraph 1 of this article have been met, the Convention shall enter into force 12 months after the deposit by such State of the appropriate instrument." The status is shown in Table 1.

Table 1. Participants

| Participant | Signature | Ratification, Accession (a), Definitive Signature(s), Acceptance (A), Approval (AA) |
|---|---|---|
| Burundi | | 4 Sep 1998 a |
| Chile | 9 July 1981 | 7 Apr 1982 |
| Georgia | | 21 Mar 1996 a |
| Lebanon | | 1 Jun 2001 a |
| Liberia | | 16 Sep 2005 a |
| Malawi | | 2 Feb 1984 a |
| Mexico | 10 Oct 1980 | 11 Feb 1982 |
| Morocco | 25 Nov 1980 | 21 Jan 1993 |
| Norway | 28 Aug 1981 | |
| Rwanda | | 15 Sep 1987 a |
| Senegal | 2 July 1981 | 25 Oct 1984 |
| Venezuela (Bolivarian Republic of) | 31 Aug 1981 | |
| Zambia | | 7 Oct 1991 a |

In the early 1990's, a set of standard contractual terms was prepared for incorporation into commercial contracts (UNCTAD/ICC Rules for Multimodal Transport Documents 1992, hereafter UNCTAD/ICC Rules). However, as these rules are contractual in nature, they are by definition subject to any applicable mandatory law and thus are not effective means of achieving international uniformity (UNCTAD Report *Development of Multimodal Transport and Logistics Services,* TD/B/COM.3/EM.20/2: 13)

## 3. Turkish Law*

In international transportation law one of the controversial and difficult issues is the problem determining, which liability regime will be applied to multimodal carriage. Currently, Turkey has no specific law governing the legal framework of multimodal transport. Existing provisions, found in Turkish Commercial Code and in the Conventions of, which Turkey is the State Party, have solved disputes arising out of a multimodal transport contract.

There are many international conventions for each type of transportation. Turkey is a state party of CMR for carriage of goods by road; COTIF, CIV and CIM for carriage of goods by rail; International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading, which is also referred to as the Hague Rules for carriage of goods by sea and finally Warsaw/Montreal Protocol for carriage of goods by rail. Also Turkish Commercial Code, Turkish Civil Aviation Act and other various codes mainly govern domestic carriage of goods. However much of international trade is now carried out on a door-to-door basis, under one contract and with one party bearing contractual responsibility. For example, the carriage of a good produced in Dusseldorf Germany to Manisa Turkey there is process like that: first the good is placed to a container in the factory in Dusseldorf and carried to the port of Rotterdam Holland by rail, from there carried by ship to Izmir, and from Izmir to Manisa by road to the delivery place. The container is not opened during the way, so damage is not detected until the good reached the delivery place. If the location where the damage occurred is not obvious, then it is difficult to determine the regime of the liability of the carrier. If we examine individually, CIM will be applied to Dusseldorf –Rotterdam railway carriage, Hague Rules or domestic law will be applied to Rotterdam-Izmir seaway carriage and domestic law will be applied to Izmir-Manisa road carriage. In fact, all these rules differ in the limit of liability, burden of

* The explanations of this part are translated from the Preamble of Turkish Commercial Code Draft. http://www2.tbmm.gov.tr/d22/1/1-1138.pdf

proof, and the liability for servants and agents, limits of no liability, time of notification and limitations of actions. So, it is very important to determine which rules should be applied to the liability of the carrier. To create a uniform regime, United Nations Convention on International Multimodal Transport of Goods was signed at Geneva on 24 May 1980, but this convention has not yet entered into force. Also it is seen that there are various regulations in different domestic laws.

According to view of Clarke and Yates "The scope of article 2 of CMR is determined by the fact that, when a new stage of the overall carriage starts, the goods are not unloaded form the road vehicle on the previous stage. Thus CMR applies when the entire vehicle (with the goods) or the goods and trailer (without the tractor) are sent on by the other mode. Distinguish the cases of multimodal through carriage, to which CMR does not apply, as when goods are loaded from both vehicle and trailer and put on a ship or a train-a series movements by different modes, which may or not by governed by separate contracts. Unloading means unloading for the purpose of transfer to another vehicle or another means of transport as contemplated by the contract of carriage. Hence, the case is not taken out of CMR by unloading to achieve some purpose (usually of the carrier's) is not contemplated by the contract of carriage or to safeguard to goods or better to perform the contract, for example, transfer from a defective vehicle to another road vehicle or even to an alternative mode such as the railway-CMR applies (Clarke, Yates, 2004:6).

If the place where occurrence has taken place is not determined by taking the facts of the actual event, as is mostly the case where the goods carried in sealed containers, the court must by analogy apply the mandatory rules relating to carriage of goods by sea, land or air, whichever is in greater conformity with the nature of the combined carriage and with the interests of parties, before contractual terms. Article 2(1) of the CMR seems to support this conclusion with reservation. Article 2(1) of the CMR seems to support this conclusion above with a reservation. Thus, if the event occurred during the carriage in a road vehicle on the sea stage, the liability of the carrier shall be in principle governed by the CMR. However, if such a loss, damage or delay in delivery was not caused by an act or omission of the road carrier, but by some event, which could only have occurred in the course of and by reason of sea carriage, then the liability shall be subject to the law appropriate to the sea stage. It means that the carriage by road begins and ends with the receipt or loss of "effective" control of goods by road carrier. However, it might be difficult to draw a line between the scopes of the Hague Rules and CMR with this respect (Karan, 2006: 31-32).

In order to govern the legal framework of multimodal transport and to solve these problems, The Draft of Turkish Commercial Code introduces basic principles, which will be applied, to multimodal transport. The articles of the Draft related to multimodal transport are as follows:

*Carriage Using Various Modes of Transport*

*Art.902 Contract*

*The provisions of the first and second part of this book, shall apply to contract of multimodal carriage contract, if all conditions exist together as stated below:*

- *The carriage of goods is based on a single contract of carriage*
- *If carriage of goods is performed by various modes of transport.*
- *If separate contracts had been concluded between the parties for each part of the carriage which involved one mode of transport (leg of carriage), at least two of these contracts would have been subject to different legal rules*
- Unless the following special provisions or applicable international conventions provide otherwise

*Art. 903 Known Place Of Damage*

*If it has been established that the loss, damage or event which delay in delivery occurred on a specific leg of the carriage, the liability of the carrier shall be determined in accordance with the legal provisions which apply to a contract of carriage covering this leg of carriage instead of the provisions of the first and second part of this book. The burden of proof belongs to the party who claims the type of transport, which causes loss, damage or delay.*

*Art.904 Notice of Damage and Limitation of the Actions*

*(1) Article 889 shall apply irrespective of whether the place of damage is unknown, is known or becomes known later. The form and time limit prescribed for the notice of damage shall also be observed if the provisions, which would be applicable to contract relating to the last leg of carriage, are complied with.*

*(2) When the limitation period for claims based upon loss, damage or delay in delivery runs from delivery, delivery to the consignee, is the relevant point of time. Even if the place where the damage occurred is known, the claim shall be time-barred in accordance with article 855.*

Art.905 Carriage of the Removal of Household Goods

*If the contract of carriage relates to the removal of household goods using various kinds of transport, the provisions of third part of this book shall apply. Article 903 only applies if an international convention binding on the Republic of Turkey cover the leg of carriage on which the damage occurred.*

In the Draft, the new solution of German law, which is predicated on the general rules of carriage contract, is accepted. According to this system, the articles 902 and 905 will be applied when there is one contract of carriage with at least two different modes of transport. As a rule, even this contract, is subject to the provisions, which are regulated in the first and second part of the fourth book in the Draft. The reason of this is that the carriage of goods by different modes is a special type of contract of carriage defined in art.850 of the draft. However, in accordance with this general reference before application of articles 850 and 893, special provisions 903 and 904 and the provisions of international conventions shall be applied in the concrete case.

The article 903 of the Draft is taken from the German Commercial Code art. 452a that is amended by Transport Law Reform Act dated 25/06/1998. Article 903 brings an exception to article 902 in which the place of damage is known. If the mode of transport, which results the damage or delay, is determined (for example the container fall over in the ship, and the goods are damaged or the container is burned during the carriage of truck), than the general rule that is in art.902 shall not be applied. In these circumstances, there is the presumption that the carrier and consignor had make a carriage contract for the mode of transport in which the damage or delay occupied, then the regulations which would be applied to the provisions of that contract shall be applied for the liability of the carrier in multimodal transport. So if the mode of transport, in which damage or delay occupied is proved, than the regime of that carriage shall be applied to the liability of the multimodal transport operator. The burden of proof belongs to the party who claims the type of the transport, which causes delay or damage in accordance with the general rule of the burden of the proof in Turkish Civil Law.

The article 904 of the Draft is taken from the German Commercial Code art. 452b that is amended by Transport Law Reform Act dated 25/06/1998. First paragraph of the article states that the notice of the damage in the good is subject to article 889, which is the general rule for notification. However if the person who takes delivery of the good at the delivery place, gives notice duly to the rules of the last transportation mode, than it will be accepted that the notice is given accurately according to article 889.

The article 905 of the Draft is taken from the German Commercial Code art. 452c that is amended by Transport Law Reform Act dated 25/06/1998. If the subject matter of agreement is carriage of moving out goods, than this contract is subject to the articles 894 and 901. Also to regulate a basic system, the scope of the application of 903 is restricted. According to this system, general rules of third part shall be applied even in the cases where the place of damage is known unless applicable international convention exists. If an international convention exists, then art.903 of the Draft shall be reapplied.

The short review of the Draft, United Nations Convention on International Multimodal Transport of Goods and UNCTAD/ICC Rules is supplemented by the comparative table-2 to analyze the differences and similarities of all these rules. (UNCTAD report *Implementation of Multimodal Transport Rules (Comparative Table),* UNCTAD/SDTE/TLB/2/Add.1)

| Regime | United Nations Convention on International Multimodal Transport of Goods | UNCTAD/ICC Rules for Multimodal Transport | Draft of Turkish Commercial Code |
|---|---|---|---|
| Scope of obligation | Convention applies to all contracts of multimodal transport between places in two States, if the place of taking in charge or delivery of the goods as provided for in the transport contract is located in a Contracting State (art.2).<br>Provisions of the Convention apply mandatory to all multimodal transport contracts governed by the Conventions (art.3 (1)). | Rules apply when they are incorporated into a contract of carriage, irrespective of whether it is unimodal or or multimodal transport contract involving one or several modes of transport or whether a document has been issued or not (R.1).<br>Rules only take effect to the extent they are not contrary to the mandatory provisions of international conventions or national law applicable to the multimodal transport contract (R.13). | The draft applies to contract for unimodal carriage of goods overland, on inland waterways and by air, an do all multimodal transport contracts including a sea-leg. Draft's general provisions governing contracts of carriage also apply to multimodal transport except for cases of localized damage where relevant conventions apply (Draft art.902) |
| Documentation | Convention includes extensive provisions on the issuance and use of negotiable and non-negotiable multimodal transport documents (art.5 to 10). | Rules regulate the issuance and use of negotiable and non-negotiable transport documents (R.2.6 and 3). | Carrier may require sender to issue a consignment note. Carrier may issue a consignment bill, which generally has the same effects as a bill of lading (Draft art.856-858). |
| Period of responsibility | Multimodal transport operator's responsibility covers the entire period from the time he takes the goods in his charge to the time of their delivery (art.14) | Multimodal transport operator's responsibility covers the entire period from the time he has taken the goods in his charge to the time of their delivery (R.4.1). | Carrier is liable for loss or damage while goods are in his charge and for delay in delivery (art.875). |
| Basis of liability | Multimodal transport operator is liable for loss resulting from loss of, or damage to, the goods as | Multimodal transport operator is liable for loss resulting from loss of, or damage to, the goods as well as from delay in delivery, | Provisions are based on CMR Convention on road transport. Carrier is liable for loss, damage or delay in delivery, unless he proves |

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|---|---|---|---|
| | well as from delay in delivery, unless he proves that he, his servants, agents or sub-contractors took all measures that he could reasonably be required to avoid the occurrence and its consequences (art.16(1)). | unless the multimodal transport operator proves that no fault or neglect of his own, his servants, agents or sub-contractors has caused or contributed to the loss, damage or delay in delivery (R.5.1). | that it was caused by circumstances, which he could not avoid even by exercising the utmost diligence and the consequences of which he was unable to prevent. Carrier is also relieved of liability to the extent it was caused by some of the listed particular grounds for exclusion of liability (Draft art. 876, 878). |
| Delay in delivery | The same provisions govern multimodal transport operator's liability for delay in delivery of the goods as the liability for loss and damage. Delay in delivery occurs when goods have not been delivered within the time expressly agreed upon or, in the absence of such an agreement, within the time it would be reasonable to require of a diligent multimodal transport operator, having regard the circumstances of the case (art.16 (2)). | Multimodal transport operator is not liable for delay in delivery unless the consignor has made a declaration of interest in time delivery, which has been accepted by the multimodal transport operator (R.5.1). Delay in delivery occurs when goods have not been delivered within the time expressly agreed upon or, in the absence of such an agreement, within the time it would be reasonable to require of a diligent multimodal transport operator, having regard the circumstances of the case (R.5.2). | Carrier must deliver the goods within agreed period or, if no agreement, within such period as should reasonably be conceded to a diligent carrier having regard to the circumstances of the case. Same provisions govern liability for delay in delivery as liability for loss and damage (Draft art.875-876). |
| Liability of servants and agents | Multimodal transport operator is liable for the acts and omissions of his servants or agents, or of any other person, of whose services he makes use for the performance of the contract, as if such acts and omissions were his own (art.15). | Multimodal transport operator is liable for the acts and omissions of his servants or agents, or of any other person, of whose services he makes use for the performance of the contract, as if such acts and omissions were his own (R.4.2). | Carrier is liable for acts and omissions of his servants, agents and sub-contractors to the same extent as for his own acts and omissions provided they are acting within the scope of their employment (Draft art.879) |
| Limitation of liability | Multimodal transport operator's liability for loss of, and damage to, goods is limited to an amount not exceeding 920 units of account (SDR) per package or shipping unit or 2.75 units of account per kilogram of gross weight of the goods lost or damaged, whichever is the higher (art.18). | Unless the nature and value of the goods have been declared by the consignor before the goods have been taken in charge by the multimodal transport operator and inserted in the multimodal transport document, his liability for loss of, damage to, goods is limited to an amount nor exceeding 666.67 SDR per package or shipping unit or 2 SDR per kilogram gross weight of the goods lost or damaged, whichever is the higher (R.6). | Loss or damage: 8.33 SDR per kg of goods lost or damaged. Delay in delivery: amount equals to three times the freight (Draft art.882). |
| Localized damage | Convention adopts a uniform rules for basis of liability of the multimodal transport operator for both localized and non-localized damage (art.16 (1)). | Rules contain a uniform system for the basis of liability of the multimodal transport operator for both localized and non-localized damage (R.5.1). | Carrier's liability is governed by the legal provisions, which would apply to a transport contract covering the leg of transport where the loss, damage or delay was caused (Draft art.903). |
| Liability of the consignor | Consignor guarantees to the multimodal transport operator the accuracy, at the time the goods are taken in charge by the operator, of particulars relating to their general nature, marks, number, weight and quantity and, if applicable, to their dangerous character, as furnished by him for insertion in the document (art 12). | Consignor guarantees to the multimodal transport operator the accuracy, at the time the goods are taken in charge by the operator, of all particulars relating to their general nature, marks, number, weight, volume and quantity and, if applicable, to their dangerous character, as furnished by him for insertion in the document (R. 8)). | Sender is liable, even if not at fault, for: insufficient packing or labeling; incorrect or incomplete statements in consignment note; failure to disclose dangerous nature of goods; and absence, incompleteness or incorrectness of document or information necessary for official processing prior to delivery of good. Limitation: 8.33 SDR per kg of consignment (Draft art.864). |
| Time-bar | Any action relating to a | Multimodal transport operator is, | Actions relating to the carriage are |

| | | | |
|---|---|---|---|
| | multimodal transport governed by the Convention becomes time-barred if legal proceedings are not instituted within a period of two years from the day the goods are delivered or where the goods are not delivered, on the day after the last day on which they should have been delivered (ar.25 (1&2)). | unless otherwise expressly agreed, discharged of all liability under the rules unless suit is brought in 9 months after the delivery of the goods, or the date when goods should have been delivered, or the date when, in accordance with Rule 5.3, failure to deliver the goods would give the consignee the right to treat the goods as lost (R.10). | time-barred within one year from the date the goods were or should have been delivered. Limitation period is extended to three years in cases of fault or intent to cause loss or damage (Draft art.855). |
| Jurisdiction | In judicial proceedings relating to a multimodal transport governed by the Convention, the plaintiff may sue in one of the following places: (a) the principle place of business of the defendant; (b) the place where the contract was made; (c) the place of taking the goods in charge or the place of delivery; or (d) any other place agreed upon and evidenced in the multimodal transport document (art.26) | | Court of the place where the goods were received for carriage or of the place designated for delivery have jurisdiction to hear disputes arising from carriage (Draft art.890). |

## 3. Conclusion

Several attempts have been made to regulate multimodal transport, both making mandatory international rules governing the subject and by creating model rules which the parties to a contract for multimodal carriage may voluntarily incorporate into their contract. Where a mandatory international regime is concerned, the almost incredible laboriousness with which the United Nations Convention on International Multimodal Transport of Goods was finally brought about is a clear indication of the difficulty of the problem (Wit, 1995:221). However the convention did not attract necessary numbers of ratifications and has not entered into force. Also UNCTAD/ICC Rules for Multimodal Transport Documents 1992, which are contractual in nature, are by definition subject to any applicable mandatory law and are thus not an effective means of achieving international uniformity.

In Turkish law, there are no special rules regulating the legal framework of multimodal transport. Existing provisions, found in Turkish Commercial Code and in the Conventions of, which Turkey is the State Party, have solved disputes arising out of a multimodal transport contract. In order to govern the legal framework of multimodal transport, The Draft of Turkish Commercial Code introduces basic principles, which will be applied, to multimodal transport. The draft is under consideration in Grand National Assembly of Turkey and expected to become a law soon.

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UNCTAD Report Implementation of Multimodal Transport Rules (Comparative Table), UNCTAD/SDTE/TLB/2/Add.1

http://www2.tbmm.gov.tr/d22/1/1-1138.pdf

# OPTIMIZING WASTE COLLECTION IN AN ORGANIZED INDUSTRIAL REGION: A CASE STUDY

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## Abstract

*In this paper we present a case study which involves the design of a supply chain network for industrial waste collection. The problem is to transport metal waste from 17 factories to containers and from containers to a disposal center (DC) at an organized region of automobile parts suppliers. We applied the classic mixed-integer programming (MIP) model for the two-stage supply chain to the solution of this problem. The visualization of the optimal solution provided us with several interesting insights that would not be easily discovered otherwise.*

*Keywords: Logistics of industrial waste, Supply chain network design, Waste collection, Waste management, Facility location, Organized industrial regions.*

## 1. Introduction

The problem presented in this paper consists of planning the logistics of industrial waste collection from factories located in an organized industrial region, to suitable intermediate points which are possible container locations, and finally to disposal centers. The main process leading to solution of this waste collection problem is designing a network model according to the cost analysis, and determining waste container locations based on their capacities and locations. The problem can be treated as a transhipment problem aiming to select the best intermediate points for waste transfer while minimizing transportation costs in the waste collection network (Section 2). After building the model and reaching the optimal solution minimizing the total cost, a Java program that can read input files was coded in order to visualize the solution (Section 3). At the visualization stage, the values of the parameters and variables were mapped to the sizes of the nodes and thickness of the arcs.

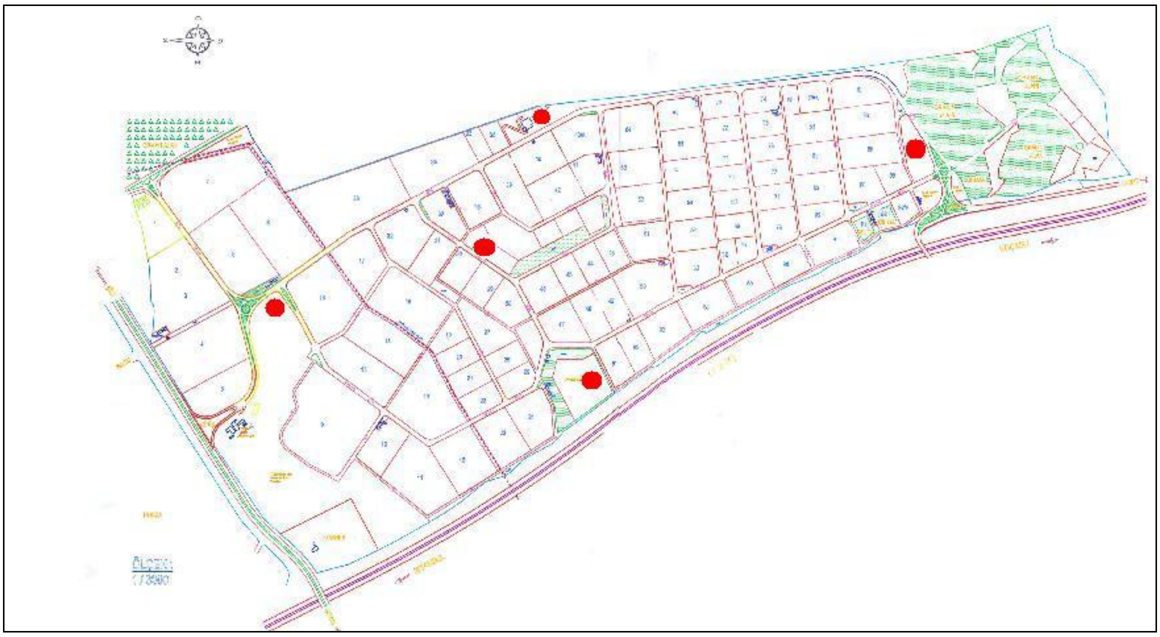

*Figure 1. The candidate container locations displayed on a map of TOSB.*

The industrial waste collection problem discussed in this paper was done as a graduation project at Sabancı University in 2005-2006 academic year. Distinguishing aspects of this study are that the problem is an example of

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environmental operations research is based on an estimate of real world data and that visualization is carried out. The used method and obtained solution have practical aspects which make them be easily adoptable to the one of the problems of organized industrial regions. This has also environmental contributions because of the fact that collected industrial waste such as metals are recycled. Furthermore, network visualization obtained by Java in the final phase leads to a better understanding of the solution and assessment of the designed supply chain network.

In the model, data from TOSB (TAYSAD Organize Sanayi Bölgesi - TAYSAD Organized Industrial Region) was used. The reasons for selecting to develop a model with TOSB (TOSB) data were as follows:

- TAYSAD (Taşıt Araçları Yan Sanayicileri Derneği, Association of Automotive Parts & Components Manufacturers), founded in 1978, is the most powerful association in the automobile parts supplier industry with %65 market share in Turkey. TAYSAD companies operate especially in Istanbul, Kocaeli and Bursa. TAYSAD is also a member of CLEPA, European Association of Automotive Suppliers.
- TOSB consists of 59 of 170 members of TAYSAD. Founded on a 625 acre (2.53 $km^2$) of land, TOSB is one of the most important industrial regions chosen by Turkish and as well as foreign automotive parts manufacturers. Additionally, Turkish automotive parts supplier industry has approximately 700 firms operating with latest technology and makes %70 of its exports to European Union countries. This industry has a considerable *contribution to the Turkish economy: In 2003, $2.4 billion of exports were achieved by Turkish automotive parts suppliers.*
- *The fact that TOSB is located in Gebze, within close proximity of Sabancı University has highly motivated us as the project team, since we would have a chance to suggest a solution to a practical real-world problem in our neighbourhood. Meanwhile, Sabancı University has close ties with TAYSAD thanks to common projects between The Competitiveness Forum (Competitiveness Forum) of Sabancı University and TAYSAD.*

## 2. The Model

In TOSB, 17 factories, 5 candidate container locations and one disposal center (DC) where total waste will be sent are available (Figure 1). Different amounts of waste from each factory are sent to suitable container locations from where they will be than transferred to the DC. The objective is to minimize total transportation cost under capacity constraints for the containers. This supply chain network design problem contains three sets of nodes (factories, containers and DC) and two sets of arcs (from factories to containers and from containers to the DC), hence the name two-stage supply chain. The set $I$ represents factories which are the source nodes producing $w_i$ tons of waste monthly. Intermediate nodes representing candidate container locations constitute the set $J$. In these sites indexed by $j$, container location decisions are reflected by binary variables $z_j$. There are three sets of decision variables: $z_j$, $x_{ij}$, $y_j$ representing location and flow decisions. Since binary variables are present in the model together with continuous variables, the problem can be classified as a mixed integer programming (MIP) problem. The model is given bellow:

SETS

$I$ : set of factories, $i = 1,\ldots,n$

$J$ : set of candidate container locations, $j = 1,\ldots,m$

PARAMETERS

$a_{ij}$: cost of sending one ton of waste from factory $i$ to container location $j$

$b_j$: cost of sending one ton of waste from container location $j$ to DC

$w_i$: monthly waste amount of factory $i$

$C$: maximum monthly capacity of each container

$f_j$: monthly fixed cost of operating a container at container location $j$

VARIABLES

$z_j$: 1, if a container is located at container location $j$; 0 otherwise

$x_{ij}$: amount of monthly flow of waste from factory $i$ to container location $j$

$y_j$: amount of monthly flow of waste from container location $j$ to disposal center (DC)

$$\text{Min} \sum_{i\in I}\sum_{j\in J} a_{ij}x_{ij} + \sum_{j\in J} f_j z_j + \sum_{j\in J} b_j y_j$$

s.t.

$$y_j \le C z_j \quad \forall j \in J \qquad \text{(1) Capacity and Linking constraints}$$

$$\sum_{i\in I} x_{ij} = y_j \quad \forall j \in J \qquad \text{(2) Flow balance constraints: Containers}$$

$$\sum_{j\in J} x_{ij} = w_i \quad \forall i \in I \qquad \text{(3) Flow balance constraints: Factories}$$

$$z_j \text{ binary; } x_{ij}, y_j \ge 0 \qquad \text{(4) Binary } z_j \text{ and Nonnegativity}$$

In the objective function, the total cost in the supply chain is to be minimized: The first summation represents the total cost of transferring waste from factories to container locations; the second summation represents the total fixed cost of opened containers (assuming that each container has a lifetime of one year); and the last summation represents the total cost of transferring waste from containers to the DC.

The constraints are as follows:

1) The first constraint set representing capacity constraints assures that monthly flow of waste from container location $j$ does not exceed the maximum monthly capacity. As can be observed, the capacity of every container is assumed to be identical, namely $C$. This constraint set also links the selection of container location $j$ to the monthly waste flow from that container to DC. There can be a monthly flow from container location $j$ to DC only if a container is located at a container location $j$.
2) The second constraint set assures that the total amount of waste coming from different factories to a container $j$ is the same as the total amount of waste transferred from that container $j$ to the DC.
3) The third constraint set ensures that outgoing waste from a factory $i$ is equal to its monthly amount of waste.
4) The fourth constraint set specifies that the $z_j$ are binary and that the other variables are nonnegative

In order to solve the model presented above, we have decided to use GAMS (General Algebraic Modelling Systems), a high-level modeling system for mathematical programming and optimization (GAMS). We have decided to use CPLEX (ILOG) as the MIP solver. The model is built based on the TOSB data, which contains 17 factories, 5 candidate container locations and one DC. The complete GAMS model is given in Appendix A. We would like to remark that the real world values are distorted and thus hidden in the given GAMS model due to confidentiality issues. However the magnitude of costs are of the same scale. Construction of the model required the declaration of sets $I$ and $J$ and their elements as $I$ = {f1, f2, f3,…., f16, f17} and $J$ = {c1,c2, c3, c4, c5}, respectively. The maximum monthly capacity $C$ of each container is taken as 600 tons. Distances are calculated based on the actual road structure of TOSB for each arc and then the costs on the arcs are determined by taking fuel costs and staff expenses into account. All of the costs are monthly and in terms of YTL (new Turkish lira).

In the optimal solution, minimum monthly cost of the waste transfer from factories to container locations and then to the DC is 70,338 YTL (approximately $48,000). Three container locations (c1, c3, c4) out of the five candidates were selected to be opened by the solver.

## 3. Network Visualization

Following the development of the mathematical model and the GAMS model, we have carried out a visualization of the solution that was found by CPLEX. Visualization can dramatically enhance one's understanding of the optimization results and enable perception of useful and interesting insights. Some supply chain design/optimization software (CIMPEL, HKUST, Llamasoft, LogisticTools, Logistics Simulation, The Logistics Institute) are known to visually represent supply chain networks. Meanwhile, the paper by Camm et al. (1997) is a supply chain classic from the operations research / industrial engineering literature. In their paper, the authors describe an optimization based information system that is supported by GIS (Geographical Information System) visualization. The system they describe is reported to save more than $200 million for the consumer products giant Procter & Gamble.

The visualization in our study (Figure 2) was carried out through a simple Java program that reads two input files, namely `problem.txt` and `solution.txt` (given in Appendix B with distorted parameter values, ex: factory coordinates and flows). In this visualization only the containers that appear in the optimal solution are displayed. Each factory is represented by a circle filled with blue. The magnitudes of the flows between nodes are reflected in the thickness of the arcs. Flows in the first stage (factories and containers) of the supply chain are represented by red arcs and flows in the second stage (containers and DC) are represented by black arcs. The arc labels denote the amount of flows on the arcs in tons.

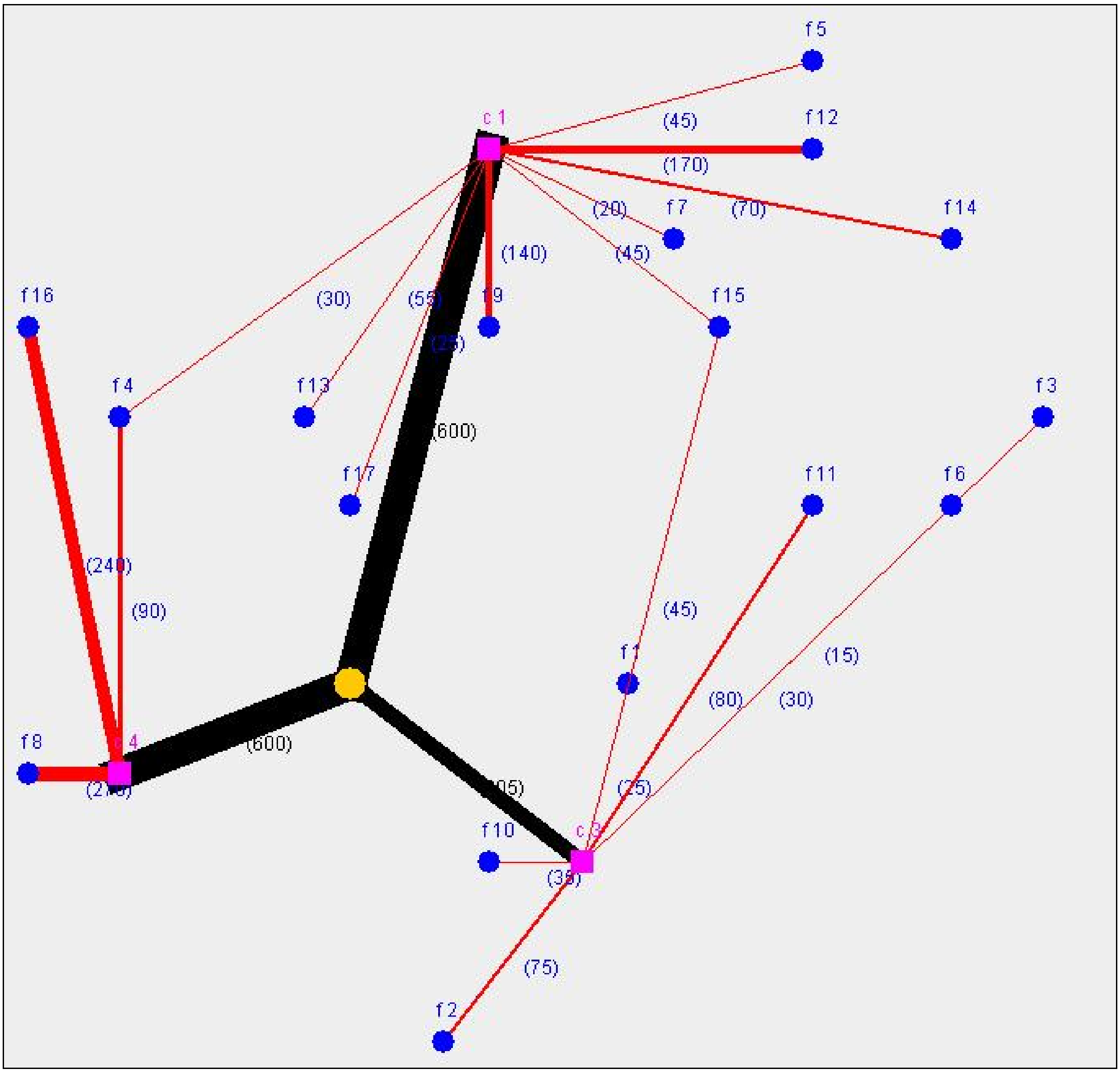


*Figure 2. The Java visualization of the optimal supply chain network.*

From Figure 2 one can observe that there exists a significant amount of flow from factories 8 and 16 (f8, f16) to container 4 (c4). Meanwhile there exist relatively significant amounts of flow from factories 4, 9, 12 (f4, f9, f12) to container 1 (c1). By observing the thickness of the black arcs from containers 1 and 4 to the DC, one can conclude that these two containers are utilized to full capacity. On the other hand, container 3 is not utilized to full capacity, since the arc from that container to the DC is approximately half as thick as the other black arcs. All the factories send their waste to a single container (single-sink), except factories 4 and 15 (f4, f15).

The visualization of the network allowed us to make the above observations, which would be very hard to make by looking at the text output of the GAMS solution. Thus we believe that the extra effort spent for the visualization is highly justified.

## 4. Related Literature

Amponsah and Salhi (2004) argue that waste collection problem is one of the most crucial problems for large cities and local authorities. Waste collection and solid waste management pose importance since some wastes contain toxic and hazardous ingredients, where some others are recycled. Literature contains studies focusing on efficient waste collection, supply chain network designs leading to operational cost savings. There are many related problems, including Vehicle Routing Problem (VRP), where the main aim is to incur the minimum total cost while routing multiple numbers of vehicles, going out from a depot, visiting intermediate nodes and returning back to the depot. (Tung, D. V., Pinnoi, A., 1999). Minimizing number of vehicles can be another objective in VRP. Vehicle Scheduling and Routing Problem (VSRP) can be considered as an extension of VRP with time periods and place requirements constraints (Johansson, O. M., 2005). Additionally, Vehicle Routing Problem with Time Windows (VRPTW) includes time windows between which the nodes have to be visited (Kim, B. I. et al., 2005). Other problem variants include Periodic Vehicle Routing Problem (PVRP) (Teixeira et al., 2004) and Capacitated Arc Routing Problem (CARP) (Chu, et al., 2004).

The model which is most related to the network design problem in this paper is presented by Rahman et al. (1995). The authors refer to the problem as the Solid Waste Transfer Stations (SWTS) location problem and solve it for the City of Phoenix, Arizona. Their model aims to select the most suitable intermediate nodes to transfer materials with the objective of minimizing transportation costs. In their paper, they also develop an additional approach to SWTS by minimizing public opposition.

It is also possible to find out several works about waste management in Turkey. For example, Koçer et al. (2003) investigated waste collection, waste transfer costs and waste disposal areas in Elazığ, Turkey. In their research, they considered criteria such as location of the waste area, population, daily amount of waste, container capacities, weight of waste, costs, time, and productivity in waste management. They conclude that first of all, records for waste quantities and costs should be kept and secondly the number of workers, distances of transportation, capacities of the containers and their technical capabilities affect productivity. Another research is done by Karagüzel and Mutlutürk (2005), who considered geological, hydro geological, topographical criteria and observed environmental protection areas, land sliding and flooding in order to select the most suitable waste area in Isparta, Turkey. Demir et al. (2001) studied the design of waste transportation and waste collection in Yenimahalle, Ankara, Turkey. They have developed a long-term and short-term plan for waste collection and logistics and selected the transfer stations. They have developed a mathematical model similar to the one presented in our paper but additionally, they also considered allocation of trucks to collection areas, frequency of the collections and definition of the optimal roads. Their study also includes financial analysis.

## 5. Conclusions

We have presented the application of optimization to a real-world industrial waste collection problem. Two distinguishing aspects of our study are the following:

- The model was built using real-world data provided by the management of the industrial region and estimated values which we believe are close enough to the real values (however, the values given in the paper for the model and its solution are distorted due to confidentiality agreements).
- The optimal solution was visualized, enabling the observation of several interesting issues.

Mathematical programming, specifically mixed integer programming (MIP) is an essential tool to model and solve strategic and tactical managerial problems of industrial regions. Industrial regions in developing countries such as Turkey can highly benefit from this approach, as illustrated in our study. Meanwhile, visualization can contribute greatly to the usability and thus acceptance of optimization models in industry.

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## Appendix A. The GAMS Model

```
SETS
       I   Factories   / f1*f17 /
       J   Container Locations   / c1*c5 /
       DC   Disposal Center          /d1/ ;
  PARAMETERS

       F(J)  fixed monthly cost
         /    c1    626
              c2    626
              c3    1252
              c4    750
              c5    750
                        /
       W(I)  average monthly waste amount of factory i
         /
f1  25
f2  75
f3  15
f4  120
f5  45
f6  30
f7  20
f8  270
f9  140
f10 35
f11 80
f12 170
f13 55
f14 70
f15 90
f16 240
f17 25
         /

      B(J)     unit cost per ton from location j to dc
                  / c1     36
                   c2      40
                   c3      36
                   c4      32
                   c5      44
                                / ;

      TABLE A(I,J) unit cost per ton from factory i to location j
         c1        c2        c3        c4        c5
f1       26        16        6         32        24
f2       32        16        10        20        34
f3       30        32        22        46        6
f4       18        14        28        4         46
f5       14        24        24        34        16
f6       28        30        18        44        10
f7       8         14        20        30        28
f8       26        22        32        4         54
f9       4         6         20        20        30
f10      24        12        6         22        32
f11      26        24        14        40        14
f12      16        30        26        38        16
f13      12        6         18        12        38
f14      22        34        24        44        10
f15      14        20        16        34        24
f16      26        20        34        12        52
f17      14        2         16        16        42
```

```
SCALAR capacity /600/;

VARIABLES obj ;

  POSITIVE  VARIABLES
      X(I,J)
      Y(J) ;

  BINARY VARIABLES Z(J) ;

EQUATIONS
         COST         objective function
         CAPLINK(J)
         FLOW(J)
         FLOW2(I);

  COST ..        OBJ  =E=  SUM((I,J),A(I,J)*X(I,J)) + SUM(J, F(J)*Z(J))
                           + SUM(J, B(J)*Y(J));
  CAPLINK(J)..   Y(J) =L= CAPACITY*Z(j) ;
  FLOW(J)..      SUM(I, X(I,J)) =E= Y(J) ;
  FLOW2(I)..     SUM(J, X(I,J)) =E= W(I) ;

  MODEL TOSB_PROJECT /ALL/ ;

  option lp=CPLEX;
  SOLVE TOSB_PROJECT USING MIP MINIMIZING OBJ ;
```

*Appendix B*

```
problem.txt
PROBLEM_FILE
NO_OF_FACTORIES
17
NO_OF_CONTAINER_LOCATIONS
5
FACTORY_COORDINATES
16 10
12 14
…
10 8
CONTAINER_LOCATIONS
13  4
12  8
15 12
5  11
26  5
DISPOSAL_CENTER_LOCATION
10 10
a_ij
26 16 6 32 24
…
b_j
36 40 36 32 44
w_i
25 75 15 120 45 30 20 270 140 35 80 170 55 70 90 240 25
C
600
f_j
25 75 15 120 45 30 20 270 140 35 80 170 55 70 90 240 25
```

```
solution.txt
SOLUTION_FILE
x_ij
0 0 25 0 0 0 0 75 0 0 0 0 15 0 0 30 0 0 90 0 45 0 0 0 0 0 0 30 0 0 20 0 0 0
0 0 0 0 270 0 140 0 0 0 0 0 0 35 0 0 0 0 80 0 0 170 0 0 0 0 55 0 0 0 0 70 0 0
0 0 45 0 45 0 0 0 0 0 240 0 25 0 0 0 0
y_j
600 0 305 600 0
z_j
1 0 1 1 0
```

# 3PL PROVIDER SELECTION IN REVERSE LOGISTICS: AN ELECTRE/AHP METHODOLOGY

Semih ONUT[1], Selin SONER[2]

## Abstract

*In business sector, firms try to produce durable products, but every product has a product life cycle. When this cycle ends, product became useless. But today environmentally conscious firms increase and these firms try to collect their products for re-use. This activity emphasizes the importance of reverse logistics concept. However, in Turkey, reverse logistics does not improve sufficiently. Many manufacturing companies do not constitute their own reverse network. Hence, 3rd party logistics (3PL) providers have become important for reverse logistics activities. Evaluation procedures involve several objectives and so decision analysis has to be done in the multi-criteria environment. Decision-maker has to be free to include multiple evaluation criteria in his/her evaluation. ELECTRE (Elimination et choix traduisant la realite) is a useful multi-criteria decision making method that uses the outranking principle to rank the alternatives, combined with the convenience of use and decreased complexity. It evaluates alternatives in order to rank them with respect to a number of criteria. This paper presents an implementation of a specific ELECTRE ranking method for a manufacturing company in 3PL providers selection procedures in Turkey. Also, analytical hierarchy process (AHP) is used for evaluating selection criteria' weights.*

Keywords: 3rd Party Logistics Providers Selection, Reverse Logistics, ELECTRE, AHP, Multi-Criteria Decision Making

## 1. Introduction

In reverse logistics there are many different activities. One of the important activities is collecting end-of-life (EOL) products from users. Reverse logistics is a new issue for different sectors in Turkey. Many manufacturing companies do not constitute their own reverse network. Hence many firms outsource reverse logistics activities by using 3rd party logistics (3PL) providers.

Outsourcing is an increasingly important issue pursued by corporations seeking improved efficiency. Briefly, it can be defined as a managed process of transferring activities to be performed by others. Logistics outsourcing or 3PL involves the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions performed by the third party can encompass the entire logistics process or selected activities within that process. A key rationale for this form of outsourcing is that with intensified global competition, firms are concentrating their energies on core activities that are critical to survival and leaving the rest to specialized firms. There are numerous reports of the increasing use of logistics outsourcing and several authors have indicated that in many industry areas logistics outsourcing has become a rapidly expanding source of competitive advantage and logistics cost savings (Isıklar, Alptekin & Büyüközkan:1).

The outsourcing of logistics activities to the 3PLs has now become a common practice. The commonly known drivers for outsourcing are needs of the organizations to concentrate on core competencies, cost reduction, development of supply chain partnerships, restructuring of the company, success of the firms using contract logistics, globalization, improvement of services and efficient operations, etc. One of the most important reasons for outsourcing is the capabilities of the providers to support their clients with the expertise and experience that otherwise would be difficult to acquire or costly to have in-house. Keeping in view the growing trend of logistics outsourcing, many providers are now offering a variety of services. These services mainly involve business-to-business relationships, where not only the user is a critical stakeholder but also his customers who are directly affected by the quality of service of the provider. Therefore, the user must exactly identify what it needs from the provider. Regarding logistics outsourcing, many researchers have discussed, besides other issues, the criteria for the selection of a provider (Jharkharia & Shankar:1).

In today's highly competitive environment, an effective 3PL providers selection process takes place a key role to reap a success of any manufacturing organization. Selecting the right 3PL is always a complicated task for the companies. There are varied strengths and weaknesses which 3PLs have, thus it requires careful evaluation by the firms.

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To account for the integrated aspect of a supply chain, 3PLs such as UPS, FedEx, Genco, etc. are playing an increasing role in logistics elements. The main advantage of outsourcing services to the 3PLs is that these 3PLs allow companies to get into a new business, a new market or a reverse logistics program without interrupting forward flows, in addition, logistics costs can be greatly reduced. Some 3PLs offer complete supply chain solutions on warehousing, order fulfillment and especially value-added services such as repackaging, re-labeling, assembly, light manufacturing and repair. In addition, 3PLs have also become important players in reverse logistics, since the implementation of return operations requires a specialized infrastructure needing special information systems for tracking/capturing data, dedicated equipment for the processing of returns and specialist trained nonstandard manufacturing processes (Ko & Evans:2).

There are different kinds of techniques which are used for selection or evaluation problems such as mathematical programming approaches, statistical techniques, scoring models and multi-criteria decision-making (MCDM) methods. MCDM methods are frequently used method for selection problems. The most preferred MCDM approaches are analytic hierarchy process, analytic network process, TOPSIS, ELECTRE and PROMETHEE.

Evaluation procedures involve several objectives. Hence decision analysis has to be done in the multi-criteria environment. MCDM techniques offer solutions to the problems involving contradictory and multiple objectives. Traditional single criteria decision making is normally dealt with one perspective and the aim is to maximize outputs or to minimize inputs. This paper presents an implementation of a specific ELECTRE ranking method for a manufacturing company in 3PL providers selection procedures in Turkey. Also, analytical hierarchy process (AHP) is used for evaluating selection criteria' weights.

The rest of the paper is organized as follows. First, we review the literature on reverse logistics outsourcing. In the next part of this paper, we explain reverse logistics concept. Then, we represent ELECTRE and AHP methodology for the selection of a provider, respectively. Finally, the case study is given and we conclude the paper with a discussion and managerial implications. The overall procedure of the study is shown in Figure 1.

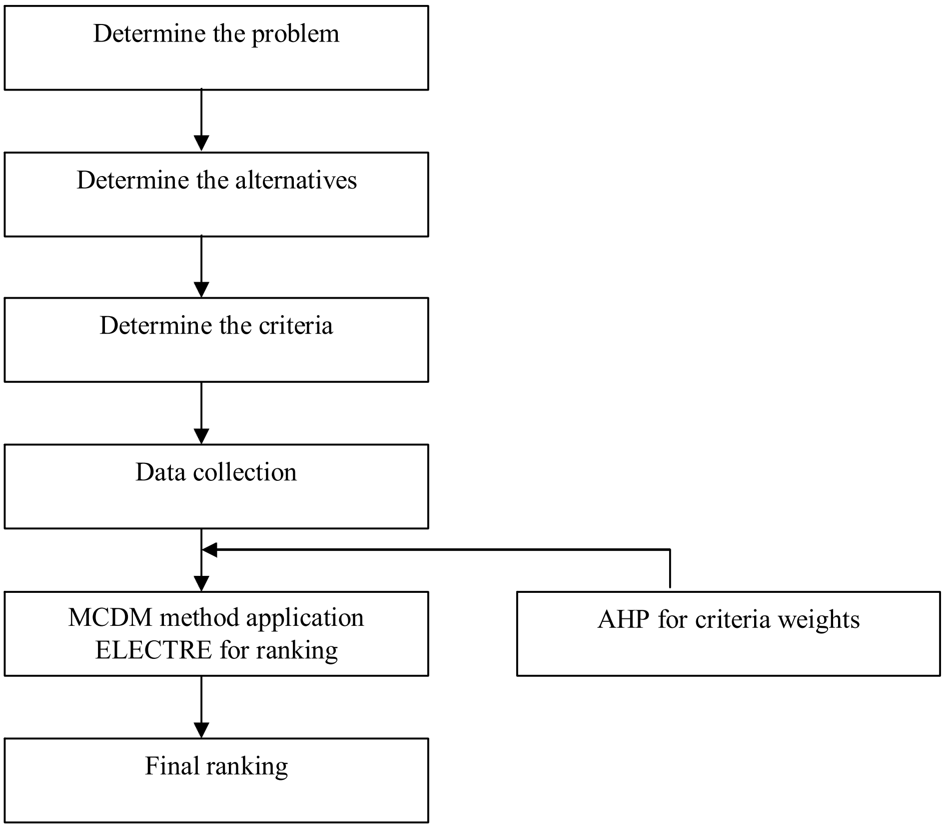


Figure 1. The overall procedure

## 2. Literature Review

Many authors, in refereed journals and websites, have come out with their suggestions on logistics outsourcing. But there are limited surveys about 3PL providers selection. Yan, Chaudhry & Chaudhry, (2003) is postulated a case-based reasoning model framework for a 3PL evaluation and selection system. Jharkharia and Shankar proposed a comprehensive methodology for the selection of a logistic service provider by using analytic network process. Also Isıklar, Alptekin & Büyüközkan executed an application of a hybrid intelligent decision support model in logistics outsourcing by integrating case-based reasoning, rule-based reasoning and compromise programming techniques in fuzzy environment.

In reverse logistics, 3PL providers play a key role because of the absence of manufacturers' own reverse network. Thus, this absence impels researches to deal with 3PL providers in reverse logistics activities. Krumwiede & Sheu, (2002) examined the issues and processes that an organization has to address to engage in the reverse logistics business. A reverse logistics decision-making model is developed to guide the process of examining the feasibility of implementing reverse logistics in 3PL providers, like transportation companies. Spicer & Johnson, (2002) discussed the benefits and challenges of third-party demanufacturing in detail, and also introduced a particular example of the approach. Ko and Evans presented a mixed integer nonlinear programming model for the design of a dynamic integrated distribution network for 3PLs to account for the integrated aspect of optimizing the forward and return network simultaneously. A genetic algorithm-based heuristic with associated numerical results is also presented and tested in a set of problems by an exact algorithm.

## 3. Reverse Logistics

Many authors defined reverse logistics concept. Reverse logistics is the movement of the goods from a consumer towards a producer in a channel of distribution. It is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal (Ravi, Shankar, & Tiwari, 2005:329). A reverse logistics defines a supply chain that is redesigned to efficiently manage the flow of products or parts destined for remanufacturing, recycling or disposal and to effectively utilize resources (Dowlatshahi, 2000). The typical reverse logistics operations include the activities a firm, which uses returned merchandise due to product recalls, excess inventory, salvage, unwanted or outdated products, etc. In addition, it includes the recycling programs, hazardous material programs, disposition of obsolete equipment and asset recovery. The reverse flow of the product originates from several points and is consolidated at just a few (or one) destinations. The various functions executed throughout the reverse logistics activities include gatekeeping, compacting disposition cycle times, remanufacturing and refurbishment, asset recovery, negotiation, outsourcing, finance management and customer service. Thus, the reverse logistics focuses on managing flows of material, information, and relationships for value addition as well as for the proper disposal of products. Reverse logistics has been used in many industries like photocopiers, single-use cameras, jet engine components, cellular telephones, automotive part, refillable containers, computer hardware industry, etc (Ravi, Shankar, & Tiwari, 2005:330).

A reverse logistics flow is a reactive flow with less visibility. Figure 2 depicts a typical reverse logistics information flow for the retail channel. When a consumer returns an item to a retail store, the store collects the items to be sent to a centralized sorting facility. At the time of the return, information about the item and its condition may be entered into the retailer's information system, and forwarded to the returns processing center. Unfortunately, this information capture rarely occurs, or is inaccurate.

The retailer typically collects the product from the store using trucks making "milk runs" that is always stopping at the same stores in the same order. Theoretically, the forward distribution center could be used to process returns but, there is a great temptation for reverse logistics personnel to be redirected to work on the "more important" forward logistics every time the forward distribution part of the facility experiences high demand (Tibben-Lembke & Rogers, 2002:272).

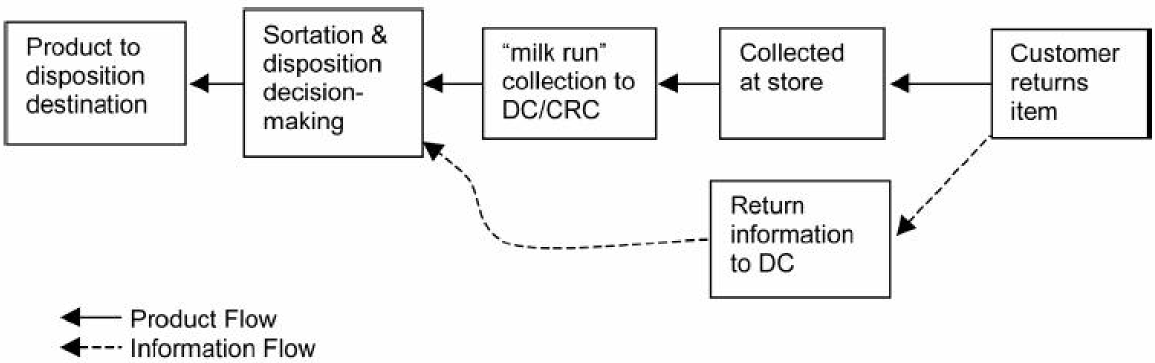


Figure 2. Reverse Logistics information flow for retail (Tibben-Lembke & Rogers, 2002:273)

There is a variety of differences between forward and reverse logistics. Table 1 shows a comparison of how various features of logistics systems differ for forward and reverse.

Table 1. Differences in forward and reverse logistics (Tibben-Lembke & Rogers, 2002:276)

| Forward | Reverse |
|---|---|
| Forecasting relatively straightforward | Forecasting more difficult |
| One to many transportation | Many to one transportation |
| Product quality uniform | Product quality not uniform |
| Product packaging uniform | Product packaging often damaged |
| Destination/routing clear | Destination/routing unclear |
| Standardized channel | Exception driven |
| Disposition options clear | Disposition not clear |
| Pricing relatively uniform | Pricing dependent on many factors |
| Importance of speed recognized | Speed often not considered a priority |
| Forward distribution costs closely monitored by accounting systems | Reverse costs less directly visible |
| Inventory management consistent | Inventory management not consistent |
| Product lifecycle manageable | Product lifecycle issues more complex |
| Negotiation between parties straightforward | Negotiation complicated by additional considerations |
| Marketing methods well-known | Marketing complicated by several factors |
| Real-time information readily available to track product | Visibility of process less transparent |

Product life cycles are shortening and this is evident in the computer industry. New designs are brought on in the market at an ever-quickening pace to persuade consumers to increase the frequency of their purchases. While consumers have benefited from greater variety and enhanced performance, this trend inevitably results in increased unsold products, increased returns, increased packaging materials and increased waste. Therefore, shorter product life cycles have increased the volume of product returns, waste entering the reverse logistics network and the cost of managing them. 3PL providers are expected to provide complete solutions for collection, transportation, and other value-added services. In fact, manufacturers are increasingly producing goods based on customer demands and requirements so as not to flood the channel with unwanted inventory. Inventory is being pushed upstream to suppliers, who find it increasingly compelling to manage inventory more efficiently to maintain their competitive edge (Tan & Arun, 2002:61).

## 4. The ELECTRE (Elimination et choix tradusiant la realite)

The ELECTRE dichotomizes preferred alternatives and nonpreferred ones by establishing outranking relationships. An acyclic digraph which is called KERNEL is constructed by combining the nodes in a cycle for explaining outranking relationships. The kernel of an acyclic digraph is a reduced set of nodes that is preferred to the set of nodes that do not belong to the kernel. In other words the kernel is a set of preferred alternatives defined by the ELECTRE. The kernel K should satisfy the following two conditions:

1. Each node in K is not outranked by any other node in K.
2. Every node not in K is outranked by at least one node in K.

Basic steps of the ELECTRE can be explained as follows:

*Step 1*: Decision matrix is formed.

$$A_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

In $A_{ij}$ matrix, m is the number of alternatives and n is the number of attributes.

*Step 2:* Normalize decision matrix.

Different normalization formulas are used for benefit and cost criteria. For cost criteria

$$r_{iJ} = \frac{\frac{1}{r_{ij}}}{\sqrt{\sum_{i=1}^{m}\left(\frac{1}{r_{ij}}\right)^2}} \qquad i = 1,2,\ldots\ldots m \quad j= 1,2,\ldots\ldots n \qquad (1)$$

and for benefit criteria

$$r_{iJ} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{n} r_{ij}^2}} \qquad i = 1,2,\ldots\ldots m \quad j= 1,2,\ldots\ldots n \qquad (2)$$

*Step 3:* Weighted normalized matrix is calculated. Weights of criteria are multiplied with normalized matrix.

$$v_{ij} = w_{ij}.r_{ij} \qquad (3)$$

*Step 4:* Concordance and discordance sets are formed. For each pair of alternatives $A_p$ and $A_q$ (1, 2,…, m and p≠q), the set of attributes is divided into two distinct subsets. The concordance set, which is composed of all attributes for which alternative $A_p$ is preferred to alternative $A_q$, can be written as

$$C(p,q) = \{j | v_{pj} \geq v_{qj}\} \qquad (4)$$

where $v_{pj}$ is the weighted normalized rating of alternative $A_p$ with respect to *j*th attribute. The complement of concordance, discordance set contains all attributes for which $A_p$ is worse than $A_q$.

$$D(p,q) = \{j | v_{pj} < v_{qj}\} \qquad (5)$$

*Step 5*: Calculate concordance and discordance indexes. The relative power of each concordance set is measured by means of the concordance index.

$$C_{pq} = \sum_{j^*} w_{j^*} \qquad (6)$$

where $j^*$ are attributes contained in the concordance set $C(p,q)$. The discordance index is calculated as follows:

$$D_{pq} = \frac{(\sum_{j^0} |v_{pj^0} - v_{qj^0}|)}{(\sum_{j} |v_{pj} - v_{qj}|)} \qquad (7)$$

*Step 6*: Do outranking relationships. The dominance relationship of alternative $A_p$ over alternative $A_q$ becomes stronger with a higher concordance index $C_{pq}$ and a lower index $D_{pq}$. The method defines that $A_p$ outranks $A_q$, when $C_{pq} \geq \overline{C}$ and $D_{pq} \leq \overline{D}$, where $\overline{C}$ and $\overline{D}$ are the averages of $C_{pq}$ and $D_{pq}$, respectively.

The ELECTRE may not indicate a preference among nodes in the kernel K. The net outranking relationship is introduced to address these problems. Complementary ELECTRE defines the net concordance index $C_p$, which measures the degree to which the dominance of alternative $A_p$ over competing alternatives exceeds the dominance of competing alternatives over $A_p$. An alternative $A_p$ has a greater preference with higher $C_p$ and a lower $D_p$. Hence the final selection should satisfy the condition that its net concordance index should be at a maximum and its net discordance index at a minimum (Yoon & Hwang, 1995:48-52).

$$C_p = \sum_{\substack{k=1 \\ k \neq p}}^{m} C_{pk} - \sum_{\substack{k=1 \\ k \neq p}}^{m} C_{kp} \qquad (8)$$

$$D_p = \sum_{\substack{k=1 \\ k \neq p}}^{m} D_{pk} - \sum_{\substack{k=1 \\ k \neq p}}^{m} D_{kp} \qquad (9)$$

## 5. Analytical Hierarchy Process (AHP)

The AHP is a multi-attribute decision tool that allows financial and nonfinancial quantitative and qualitative measures to be considered and trade-offs among them to be addressed. The AHP is aimed at integrating different measures into a single overall score for ranking decision alternatives. Its main characteristic is that it is based on pairwise comparison judgments (Rangone, 1996). The desired description is developed in three steps (Saaty, 1980:51).

*Step 1*: Compose pairwise comparison decision matrix (A). Saaty constitutes a measurement scale for pairwise comparison. Table 2 summarizes the measurement scale.

$$A = (a_{ij}), \qquad i,j = 1,2,...,n \qquad (10)$$

Table 2. The measurement scale (Saaty, 1980:54)

| Verbal Judgment | Degree of preference |
|---|---|
| Equally preferred | 1 |
| Moderately preferred | 3 |
| Strongly preferred | 5 |
| Very strongly preferred | 7 |
| Extremely preferred | 9 |
| Intermediate values between adjacent scale values | 2,4,6,8 |

*Step 2:* Normalize decision matrix. Each column values are summed. Then each value is divided by its column total value. Finally the average of rows is calculated and the weights of the decision maker's objectives are obtained. A set of n numerical weights is $w_1, w_2, \ldots, w_i$ , $i = 1, 2,..., n$.

*Step 3:* Do consistency analysis.

$$A * w_i = \lambda_{\max} * w_i \qquad i = 1,2,...,n \qquad (11)$$

Observe that since small changes in $a_{ij}$ imply a small change in $\lambda_{max}$ , the deviation of the latter form *n* is a measure of consistency. Then consistency index (*CI*) is calculated.

$$CI = \frac{\lambda_{\max} - n}{n - 1} \qquad (12)$$

The consistency index of a randomly generated reciprocal matrix from the Table 3 shall be called to the *random index* (RI), with reciprocals forced. An average RI for the matrices of order 1-15 was generated by using a sample size of 100. Table 3 shows the random indexes of the matrices of order 1 to 15.

Table 3. Random indexes (Saaty, 1980:21)

| N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.51 | 1.48 | 1.56 | 1.57 | 1.59 |

The last ratio that has to be calculated is CR (C*onsistency Ratio*). Generally if *CR* is less than 0.1, the judgments are consistent. The derived weights can be used. The formulation of CR is:

$$CR = \frac{CI}{RI} \qquad (13)$$

## 6. Case Study

We used a multi-criteria approach for strategic reverse logistics decision-making. Our study is based on literature review and interviews with the logistics manager of a firm that re-use computer components. The interviews were informal with conversation directed around their perceptions of issues that would affect their desire to choose a 3PL provider for reverse logistics market. The 3PL providers chosen were very interested in performing the reverse logistics market. The companies' primary service was the forward movement of goods between facilities for other companies. The aim of 3PL selection is to choose the optimal 3PL who represents the best performance of services for the customer. Four 3PL providers are evaluated in this study. Different kinds of evaluation criteria can be defined for 3PL providers selection problem. According to the interview with the manager and the related literature, four evaluation criteria are included in this study. First, second and last criteria are the benefit criteria. The third criterion is the cost criteria. These are:

Speed (S) = On-time delivery/ Total delivery (0-100 scale)
Reliability (R) (0-100 %)
Working cost (WC) = Collection cost+ Delivery cost+ others ($)
Duration of existence (DE) (year)

Table 4 shows data about four 3PLs according to four criteria.

Table 4. Data about 3PLs

| | 3PLs | | | |
|---|---|---|---|---|
| Criteria | A | B | C | D |
| Speed (S) | 93,5 | 90 | 81,3 | 94,5 |
| Reliability (R) | 90% | 100% | 85% | 95% |
| Working Cost (WC) | 3503 | 3422 | 3731 | 3734 |
| Duration of Existence (DE) | 4 | 6 | 5 | 7 |

After data are formed, steps of the ELECTRE are carried out. Eq. 1 is used for cost criteria and Eq. 2 is used for benefit criteria normalization. Normalized values are shown in Table 5.

Table 5. Normalized decision matrix

| | A | B | C | D |
|---|---|---|---|---|
| Speed (S) | 0.520 | 0.500 | 0.452 | 0.525 |
| Reliability (R) | 0.486 | 0.540 | 0.459 | 0.513 |
| Working Cost (WC) | 0.512 | 0.524 | 0.481 | 0.481 |
| Duration of Existence (DE) | 0.356 | 0.535 | 0.445 | 0.624 |

Criteria' weights are obtained by using AHP. Table 6 summarizes pairwise comparison of criteria and AHP calculation. Table 2 is used for pairwise comparison. Weights are calculated and consistency analysis is done. As can be seen in Table 6, CI is 0.04 and is less then 0.1, hence AHP calculations are consistent.

Table 6. AHP calculations

| Criteria | (S) | (R) | (WC) | (DE) | weights(w) | A.w | A.w/w |
|---|---|---|---|---|---|---|---|
| (S) | 1 | 1/3 | 1/9 | 3 | 0.096 | 0.383 | 3.987 |
| (R) | 3 | 1 | 1/5 | 5 | 0.209 | 0.869 | 4.155 |
| (WC) | 7 | 5 | 1 | 9 | 0.647 | 2.800 | 4.330 |
| (DE) | 1/3 | 1/5 | 1/9 | 1 | 0.048 | 0.194 | 4.008 |
| | | | | | | $\lambda_{max}$ | 4.120 |
| | | | | | | CI | 0.040 |
| | | | | | | RI | 0.9 |
| | | | | | | CR | 0.044 |

Subsequently, weighted normalized table is formed by using Eq. 3. Table 7 shows weighted normalized table.

Table 7. Weighted normalized table

| | A | B | C | D |
|---|---|---|---|---|
| Speed (S) | 0.050 | 0.048 | 0.043 | 0.050 |
| Reliability (R) | 0.102 | 0.113 | 0.096 | 0.107 |
| Working Cost (WC) | 0.331 | 0.339 | 0.311 | 0.311 |
| Duration of Existence (DE) | 0.017 | 0.026 | 0.022 | 0.030 |

On the next step concordance and discordance sets are formed by using Eq. 4 and Eq. 5. Concordance indexes are calculated by using Eq. 6 and discordance indexes are calculated by Eq. 7:

$C_{AB}$ = { Speed }
= 0.096

$C_{AC}$ = { Speed, Reliability, Working Cost }
=0.096+ 0.209+0.647=0.952

$C_{AD}$ = { Speed, Working Cost }
= 0.096+0.647=0.743

$C_{BA}$ = { Reliability, Working Cost, Duration of Existence }
= 0.209+0.647+0.048=0.904

$C_{BC}$ = { Speed, Reliability, Working Cost, Duration of Existence }
= 0.096+ 0.209+0.647+0.048=1

$C_{BD}$ = { Reliability, Working Cost }
= 0.209+0.647=0.856

$C_{CA}$ = { Duration of Existence }
= 0.048

$C_{CB}$ = { ø }
= 0

$C_{CD}$ = { Working Cost }
= 0.647

$C_{DA}$ = { Speed, Reliability , Duration of Existence }
= 0.096+ 0.209+0.048=0.353

$C_{DB}$ = { Speed, Duration of Existence }
= 0.096+0.048=0.144

$C_{DC}$ = { Speed, Reliability, Working Cost, Duration of Existence }
= 0.096+ 0.209+0.647+0.048=1

$D_{AB}$ = { Reliability, Working Cost, Duration of Existence }

$$= \frac{|0.102-0.113|+|0.331-0.339|+|0.017-0.026|}{|0.050-0.048|+|0.102-0.113|+|0.331-0.339|+|0.017-0.026|}$$

= 0.937

$D_{AC}$ = { Duration of Existence}
= 0.118

$D_{AD}$ = { Reliability, Duration of Existence }
= 0.469

$D_{BA}$ = { Speed }
= 0.063

$D_{BC}$ = { ø }
= 0

$D_{BD}$ = { Speed , Duration of Existence }
= 0.165

$D_{CA}$ = { Speed, Reliability, Working Cost }
= 0.882

$D_{CB}$ = { Speed, Reliability, Working Cost, Duration of Existence }
= 1

$D_{CD}$ = { Speed, Reliability, Duration of Existence }
= 0.991

$D_{DA}$ = { Working Cost }
= 0.517

$D_{DB}$ = { Reliability, Working Cost }
= 0.835

$D_{DC}$ = { ø }
= 0

Outranking relationships are summarized in Table 8.

Table 8. Outranking relationships

| $C_{pq}$ | $C_{pq} \geq \overline{C}$ | | $D_{pq}$ | $D_{pq} \leq \overline{D}$ | | $A_p \rightarrow A_q$ |
|---|---|---|---|---|---|---|
| $C_{AB}$ | 0.096 | NO | $D_{AB}$ | 0.937 | NO | NO |
| $C_{AC}$ | 0.952 | YES | $D_{AC}$ | 0.118 | YES | A→C |
| $C_{AD}$ | 0.743 | YES | $D_{AD}$ | 0.469 | NO | NO |
| $C_{BA}$ | 0.904 | YES | $D_{BA}$ | 0.063 | YES | B→A |
| $C_{BC}$ | 1 | YES | $D_{BC}$ | 0 | YES | B→C |
| $C_{BD}$ | 0.856 | YES | $D_{BD}$ | 0.165 | YES | B→D |
| $C_{CA}$ | 0.048 | NO | $D_{CA}$ | 0.882 | NO | NO |
| $C_{CB}$ | 0 | NO | $D_{CB}$ | 1 | NO | NO |
| $C_{CD}$ | 0.647 | NO | $D_{CD}$ | 0.991 | NO | NO |
| $C_{DA}$ | 0.353 | NO | $D_{DA}$ | 0.517 | NO | NO |
| $C_{DB}$ | 0.144 | NO | $D_{DB}$ | 0.835 | NO | NO |
| $C_{DC}$ | 1 | YES | $D_{DC}$ | 0 | YES | D→C |
| $\overline{C}$ | 0,667 | | $\overline{D}$ | 0,333 | | |

As can be seen from Table 8, B outranks A, C and D; D outranks C and also A outranks C. Hence the best alternative is B. Figure 3 explains this situation. In Figure 3, none of the alternatives can outrank B, so only B alternative is in kernel. The best alternative is determined and then complementary analysis is not done. A relationship between A and D can't be determined. The ranking can be formed by using complementary analysis. But the last alternative is C.

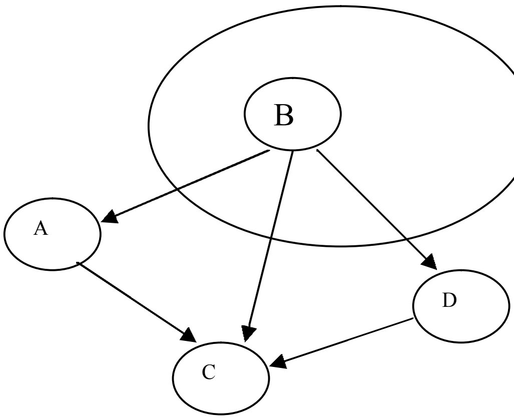


Figure 3. Kernel outranking

## 7. Conclusion

3PL providers have become important for reverse logistics activities. 3PL providers selection process is an important issue for evaluating the basic suitable 3PLs and selecting a limited number of 3PLs by using a detailed evaluation. The objective of this study is to analyze the potential 3PL providers and to choose the best candidate by using a multi-criteria approach. This paper used the ELECTRE approach for 3PL providers selection. Criteria weights are derived by using the AHP based on pairwise comparison. Outsourcing of logistics activities has become an extensive trend and this paper provides an insight into the diversified aspects of logistics outsourcing. The results guide organizations to choose the 3PLs among the candidate alternatives. For further research developing a group decision making system can be very useful. In this way different authorities' opinions can be compromised. Also, different hierarchical and detailed objectives can be incorporated into the study. The usage of the fuzzy sets in describing uncertainties in different factors simplifies the complex structure of the decision phase. In other words, using linguistic preferences can be very useful for uncertain situations. Lastly, mathematical models or metaheuristics can be combined with the existing method.

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# PLANNING PRODUCT DESIGN ACTIVITIES FOR SUPPLY CHAIN MANAGEMENT

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## Abstract

*Packaging costs account for a substantial amount of the total cost of the product due to the cost of the material used and associated labor costs, but these costs explain the half of the problem. The unseen part of the iceberg is transportation and warehousing costs of products. Packaging plays an important role from this perspective, and there is a complex design issue to be resolved in order to minimize the dimensions of the final package that is to be shipped. The product's design, design of the package of the product, and the final package that carries a sum of products determine the physical form of the final package that is to be shipped. Therefore the most important implication is for product designers; they should consider the physical infrastructure details deeply in the product development, since design affects logistics activities in the supply chain. Aspects of reducing weight and dimensions, designing products that are able to be stacked or shipping items unassembled are directly dependent on the product design, and have to be considered early in the product development process; otherwise it will be very expensive. This paper tries to shed some light on product design activities' effect on supply chain management in product development and post-development stages and how product design activities in the new product development stage should be redefined towards achieving excellence in supply chain management.*

## 1. Introduction

Transportations costs compromise a substantial amount of the total cost of a product. When the transportation cost according to the mode of transportation used (rail, highway, water, pipeline, air) for a single shipment is thought, it becomes more obvious why firms are trying to reduce logistics costs. A method to reduce this cost is to make the scheduling and routing of the shipment. A more general and optimizing perspective is to consider the benefits associated with scheduling and routing taken for granted, and try to ship the maximum amount of products per trip. However, the vehicle used for transportation has a maximum amount of volume, and a maximum amount of weight it can carry. Resolving this problem can be possible by planning the product design and development activities in the development and post-development stages throughout the supply chain according to logistics activities in terms of both the product itself and its package.

## 2. New Product Development

Today's market environment is highly competitive, dynamic, where product life cycles are short and uncertainty is high. Because successful new products contribute to financial and market performance measures, and offer new opportunities to become visible and reputable in the market (Tseng, 2006: 133), firms have to pursue innovative strategies so as to be able to gain competitive advantage over rivals (Hsiao and Chou, 2004; 422: Rungtusanatham and Forza, 2005; 258). The path to being innovative is possible by reviewing new product processes from idea to launch, and incorporating winning ideas for successful new products (Hsiao and Chou, 2004; 421). Innovative strategies have to be accompanied with strategies regarding mover advantages, fast product introductions, more demanding product functionality, and shortening life cycles. Consequently, competitive advantage may be gained by relying upon designing, manufacturing and outperforming competitors in new product development process (NPD) (Davila, 2000; 383).

New product development process is one of the most important activities of business enterprises (Lee, Lee &Souder, 2000: 497) necessary for maintaining a healthy modern organization (Hsiao, 2002; 41) that requires expertise and experience in many varied disciplines. The innovativeness of new product development requires attributes that may exist within one person, but more importantly the construction of a well-structured organizational system (Tseng, 2006: 133). As a result, firms have to engage in interdisciplinary studies related with strategy, management, R&D, production, marketing, and decision-making in new product development process, which has to be managed effectively (Hsiao and Chou, 2004; 421). On the other hand it should be noted that new product development process is a risky and uncertain process where different set of problems may emerge and high rates of failure may be faced (Hsiao, 2002; 41-42; Hsiao and Chou, 2004; 421; Davila, 2000; 387). Organizations need to reduce or eliminate risks, solve problems and control uncertainties by gathering information from resources, or by generating the needed information themselves (Davila, 2000; 387).

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In the new product development process, ideas are tried to be translated into tangible physical assets in phases (Davila, 2000; 385: Hunt and Jones, 1998: 137), and audits should take place at each phase. This allows the establishment of some formal tools to aid product and process development. Firms' expectation is to optimize product introduction cost, to minimize time scale and to accomplish production smoothing by controlling and reviewing these phases. The actions that are to be taken had better been documented formally (Hunt and Jones, 1998: 137).

In the early phases of NPD process, product design process is a vital factor, which consists of generating ideas, developing concepts, modifying details, and evaluating proper solutions (Hsiao and Chou, 2004; 422). Product development process starts with a planning phase and during this phase an idea for a new product is proposed, the requirements of the process are established, the target market and the features (i.e. functionality, price, performance, and expected release time) of the product is defined and the process is managed by the organization (Davila, 2000; 385: Vuola & Hameri, 2006: 5). At the end of these phases, the firm incorporates decision-making techniques and decides about the future of the project (Davila, 2000; 385). After the decision to start manufacturing is given, the finished products are finally launched onto the market (Vuola & Hameri, 2006: 5).

Proposed solutions may also include efforts that consider the new product development process as a whole, and the interfunctional mechanisms that have to be developed between business units may be defined. At this point, the business model design plays an important factor, which is not only concerned with manufacturing a product, but considering production as an integrated system. Relying upon the study of Hunt and Jones (1998; 137), it can be concluded that the need to concentrate on the core competences of the business, such as industrial product design, has forced companies to develop a high level of competence in management of their product supply chain. In terms of new product development process, possible integration with supply chain management and logistics activities have better been planned in order to foresee the evaluation of the process with regard to the objectives that are determined beforehand. Product development taking place in this stage located on variables are related to the efficiency and effectiveness of manufacturing/production functions such as ease of design, ease of manufacturing, manufacturing cost, and materials requirement.

In this phase, firms usually ignore important concepts such as consumer needs, potential demand, and product usability whereas identifying needs of customers' form an integral part of new product development process. Since taking such variables into account helps in building up closely related issues such as conceptual design, design selection, competitive benchmarking and the establishment of product specifications. Manufacturers should consider of recognizing the importance of customer needs. But it is worth to note that it is not very easy to realize a process that incorporates user's viewpoint and implicit needs on a product, so the task of product designers' is to foresee and articulate what users' may be in need of and may like to use (Lee, et al., 2001; 272).

The task of handling design specifications, related documents, and services may be new to firms. Services may include elements such as design help, assistance with related technical problems and with manufacturing difficulties. Firm's broader responsibilities within the design program may offer opportunities for firm's effectiveness in transmitting its supply chain management expertise to build successful relationships (McCutcheon, Grant &Hartley, 1997: 276).

## 3. Basics of Supply Chain Management for Product Design

In logistics the product is not an issue that is directly important, more important is the package of the product, which determines the shape, volume, and weight of the item that is going to be shipped (Jahre & Hatteland, 2004: 125). However, it should be noted that the final package of a product is dependent upon the product's dimensions that has to fit in the package, and that some products may be shipped without any extra packaging. Therefore, in order to reap the benefits of supply chain management, product design activities should be directed towards achieving excellence in supply chain management. What is implied by product design in this paper covers a wide range of activities such as industrial design, engineering design, and packaging design.

Industrial design can be expressed as the function that decides upon the form of the outer shelf of a product. Even though innovative products generally has to have a design ingredient that is ahead of the society, the most importance input for industrial designers when designing a product is customer needs and expectations. Being innovate or being customer oriented lies on one side of the coin, whereas on the otherside lies the cost benefits that can be achieved by making use of the capabilities imposed by industrial design. One way of achieving cost advantage is aligning industrial design practices with supply chain management activities in such a way that the design of the product allows itself to be packed optimally in order to fulfill the means of transportation used while carrying all the parts (electronic or mechanical parts) in itself.

Engineering design covers activities that enable the product to perform the assigned function to it. It is clear that a minimization philosophy is needed in order to reap the most out of the integration of business functions with supply chain management. Involving in engineering design activities just for loading the maximum number of products into the truck may seem to be strange, but it should be realized that customers' expectations are also towards smaller and lighter products that can perform the same function because such products are more easily operated and they occupy less space. In this paper, especially the effect of industrial design's and package design's effect on supply chain management activities will be emphasized more because engineering design is a more technical issue which shows a slower development.

Packaging design is important because the package of the product is the final parameter that determines how many products can be shipped with a single shipment. The only importance of packaging does not lie in specifying the number of products per one trip, but also in ensuring safety of the products during shipment. In many cases, the use of reusable packages for transportation reduces logistical operation costs since the reusable containers can be designed to increase cubic efficiency for transport and storage as well as ease of packing, handling, and unpacking. Reusable packaging can also be designed to provide higher levels of product protection as well (Mollenkopf, Closs, Twede, Lee & Burgess, 2005: 171).

The emergence of design activities aligned with supply chain management needs establishing both intra-organizational and inter-organizational cooperative relationships, which is discussed extensively in literature (Fulconis & Paché, 2005: 92). Joint product development between buyers and suppliers with a supply chain management perspective, which is called as "design chain management" has also been discussed (Mills, Schmitz &.Frizelle, 2004: 1020). However, collaboration between logistics and product design, including the product itself and its packaging, which this paper addresses, has not been adequately analyzed (Fulconis & Paché, 2005: 97).

## 4. Developing New Products and Designing for Supply Chain Management

Traditional logistics activities are managed as a value-added system. Emphasis is on achieving maximum efficiency, the primary goal is to control costs, and the focus is on rationalizing complex activities into an efficient value-added system from a process based strategy (McGinnis & Kohn, 2002: 2). Effective supply chain management provides strategic opportunities (Fulconis & Paché, 2005: 92), but integration with all business functions enhances its success. Product design, packaging and logistics are functions that are interlinked with each other; and their effect on the supply chain activities has important implications. It is also evident from the case study conducted by Klevas (2005; 130) that there is a tight connection between the product, the packaging of the product and the logistics activities held for that product.

Product design, packaging and logistics are highly interdependent, and together they have a great impact on supply chain activities. It has been recognized that the product design can make excellent logistics possible or impossible, since it strongly affects logistics in terms of modularization, stacking, handling, packaging, manufacturing, transporting, etc. that product designers should consider the physical infrastructure in product development, since the design affects logistics activities in the supply chain. It is stated that product design must include consideration of the impact that design decisions will have on operations, maintenance, transportation and supply. However, most of the decisions that affect logistics support of a product are taken long before it is manufactured (Klevås, 2005: 116-117). Thus, product design activities should be planned to every other functions' requests beforehand, and logistics is one of them. When the whole supply chain is considered, what is expected from product design should not be limited with logistical excellence, the supplier and consumer part of the chain should also be taken care of. The relationship with customers and suppliers are explained in the part of this paper explaining inter-organizational relationships.

Product design problem has direct impacts on the entire supply chain, from the types and varieties of component parts necessary to manufacture the product, to the distribution of the finished goods to customers. The product design problem is critical to business success in part because it impacts supply chain volume, variety, and structure as well as inventory levels, transportation practices, and, perhaps most importantly, customer satisfaction levels (Stapleton, Hanna & Ross, 2006:110).

The volume of the supply chain is directly related with the demand of that product. The total customer demand determines the number of products that has to cycle between the firms, its suppliers and retailers. The variety of the products that are launched to the market are also a result of the efforts of marketing and product design and developments; and the diversity of products brings diversity of different sized products, which covers a wide range of packages for those products with different weights and dimensions. The structure of the product is important in deciding upon how the product should be wrapped so that the safety precautions when carrying those products are not ignored. Different kinds of transportation practices have to be developed and time constraints has to be taken care of for different kinds of products depending upon the infrastructure of the product as well as the pre-specified inventory that is thought to be hold at the retailer. The same range of products may have to be shipped by railway or by airway in different circumstances such as urgency, difference of the location, safety regulations and etc. Since the number of products that are to be shipped are determined by the total demand of customers and satisfaction of the customers is the key in arranging all these business activities related with product design and logistics.

There is a recognized need to consider packaging in product development in order to enhance logistics activities and the combined performance of the product and the packaging. But this is an area still in its infancy, where very little research has been conducted (Klevås, 2005: 117). By adapting logistics and packaging activities to each other, the package becomes more efficient in fulfilling its logistics role (Jahre & Hatteland, 2004: 126). Since nearly all logistics activities are affected by packaging utilities, effective distribution and materials handling require a proper packaging solution. But the packaging is usually not considered until the product design has been decided upon, which makes the packaging design limited by the product design, hence restraining possible logistics solutions throughout the supply chain (Klevås, 2005: 117).

Packaging is usually viewed either as a marketing tool or as a logistics facility, for example when protecting the product during distribution and facilitating handling operations. More seldom, packaging is viewed as an integrated part of the product itself. Packaging should be thought as a part of the logistics organization. Logistics support emphasize the importance of integrating packaging design into the product development process instead of developing the product and the packaging sequentially but apart, which would make the packaging function a part of the product development process. Another alternative may be to suggest packaging as a part of the product development organization but still let it be connected to the logistics organization (Klevås, 2005: 124).

The package design and the possibility of unitization are greatly influenced by the product design. The aspects of minimizing air in the primary packaging, reducing weight or shipping items unassembled are directly dependent on the product design, and have to be considered early in the product development process. Otherwise it will be very expensive, since it might require changes in product design. It is well known that design changes are more difficult and expensive to achieve late in the product development process (Klevås, 2005: 124), thus activities both inside the firm, and the firm's activities within its supply chain has to be considered and reviewed carefully so as to be able to take corrective actions.

### 4.1 Intra-organizational Relations' Effect

Intra-organizational connectedness "refers to the degree of formal and informal direct contact among employees across departments". There is agreement that corporate functions need to be connected (Lambert, Garcia-Dastugue & Croxton, 2005: 32). In organizations, individuals can be classified in groups based either on their function or according to the project they may be involved in. Functions that are always central to a product development project are marketing, design (engineering design, industrial design and packaging design) and manufacturing (including purchasing, distribution and installation) (Klevås, 2005: 125). Supply chain management may be handled by marketing and/or production management teams. Logistics may be a part of the supply chain management activities or may be another function of the firm. In either case, the integration of logistics and supply chain management activities has to be coordinated with the abovementioned functions that are central to product development to maximize customer satisfaction.

Interaction between functions refers to information dissemination (sharing), to increase information flow among corporate functions in an interactive process through, for example via meetings and written reports. Cross-functional integration includes functional interaction but also incorporates interdepartmental collaboration, which is characterized by shared goals, mutual respect, and cross-functional teams (Lambert, Garcia-Dastugue & Croxton, 2005: 32).

Management of inter-departmental connectedness, across corporate functions, is necessary for the successful implementation of business processes (Lambert, Garcia-Dastugue & Croxton, 2005: 32) so that integration among functions is achieved. Designing a product from top to toe has to involve not only product design but also the design of packaging as well.

Customer satisfaction is the reason of designing new products that are able to achieve such objectives. And the importance of structural design emerges due to its ability to convert original goals of design and manufacturing into practice. Without the basic structure, information and discipline design provides for logistics, there would be no control over the supply chain, essential o bringing the right new products –and the right packaging- to the market faster (Vanover, 2005: 25).

Product packaging is the science, art and technology of protecting products for the purposes of containment, protection, transportation/storage and information display (Lee & Lye, 2003: 163). Industrial packaging, including boxes, crates, pallets, banding, and void fill packaging is the focus of this research with emphasis on product protection, ergonomics, and shipping considerations (Mollenkopf, Closs, Twede, Lee & Burgess, 2005: 171).

In research as well as in practice, there is much focus on finding the package that is adapted to, and fits well with, not only the logistical system, but also the marketing system and environmental demands; "the optimal package". Standardization of packages such as the use of a limited number of (ideally one) different types of packages, for example the EURO-pallet and the ISO container, with similar requirements for handling and transportation equipment, is considered optimal from a logistics viewpoint (Jahre & Hatteland, 2004: 126). The implementation of unit loads (in this case the Euro pallet) is a consequence of the logistics department's demands (due to the automatic storage system), but it is also due to distributional problems in the supply chain. In this way, product damage is reduced, and as a result the unloading times decreased (Klevås, 2005: 127).

Using palletization, software designers can make intelligent decisions about how a product is packaged, how the package is contained in a shipping box, how these boxes are stacked on a pallet and how these pallets fit on the truck. Interfaced with shelf-planning systems, designers provide valuable information about the product's behavior when placed on its side or upside-down on the shelf –extremely important when shop shelves are sold at premium. These decisions have a major impact on the cost-efficiency and timeliness of the distribution process (Vanover, 2005: 25).The idea to disassemble the products in order to achieve more efficient and effective transport is most likely due to an early packaging awareness and a focus of making cheap furniture of good quality for consumers. Having a department that can focus only on packaging-related issues may facilitate implementing packaging projects, and the authority that department possesses may make it possible to distribute the ideas to the rest of the company. The flat packaging solution in combination with products being adapted to the standard pallets may also minimize air in the transports (Klevås, 2005: 127). Using lightweight packaging whenever possible –such as using cardboard boxes instead of wooden crates- is another method to save transportation costs (Lee & Lye, 2003: 186). And all such activities needs intra-organizational relations to be tied up and to be strong.

4.2 Inter-organizational Relations' Effect

The analysis of the interaction mechanism between supply chain management and product design should not be limited with intra-organizational activities connecting purchasing departments with new product engineers in the choice of component supplier, but should also include the inter-organization activities between customer and supplier firms for the strategic positioning of a firm in its supply network (Mills, Schmitz &.Frizelle, 2004: 1014-1015).

In intra-organizational point-of-view, trade-offs occur within a firm (e.g. between purchasing and materials management, materials management and production, etc.), but also there are issues to be resolved inter-organizationally about the firms belonging to the same supply chain (e.g. between purchasing and first-tier suppliers, marketing & sales and customers, etc.). The objective is to find overall solutions through an intra- and inter-organizational collaboration that will avoid waste of resources and increase the profitability of supply chain members (Fulconis & Paché, 2005: 93).

Supply chain management is composed of a network structure in today's environment. The trend is extending the supply chain network towards "technology chains" and "knowledge networks" in order to establish a fully integrated cooperative relationship with other firms (Mills, Schmitz &.Frizelle, 2004: 1015).

The major logistics processes that facilitate the flow of a product or service from the point of origin to the point of consumption include customer service, service support, demand forecasting, inventory management, material handling, packaging, procurement, reverse logistics, transportation, and warehousing (Lin, Collins &Su, 2001: 705). The development and quality of the customer service should be drawn upon the requirements of customers, and the knowledge about customers can be developed either from marketing researches or from the retailers. Retailers, according to the claims made by customers, may realize a problem emerging due to a problem in logistics activities and inter-organizational coordination may play an important role in the realization of this problem so that improvements can be accomplished. This is called as the reverse information flow, and this forms the service support component of customer satisfaction with the designed product by making use of supply chain management. As stated earlier in this paper, demand is the driving force for product design, and supply chain management and logistics activities are held due to the desire of a product to be available for the target customers. Forecasting customer demand is essential in the design of products so that the design parameters are adjusted according to supply chain management activities. This adjustment should be made with respect to the available inventory so that excess inventory is not stored and materials handling process is appropriately managed. As demand gives idea about producing how much of which product, materials resource planning should effectively be managed in order to reap the most benefits out of supply chain management so that the procurement procedure works well. When the products are returned from customers and/or retailers, or when the firms want to return the parts, supply chain management activities should be reversed so that both the physical items and information is carried to the firm. Especially the reverse flow of information through supply chain management is a very powerful input for product design and development activities.

Some of these processes contained activities that managers generally considered a part of the marketing effort. For example, new product development and commercialization are outside the management domain of logistics executives. However, close co-ordination between supply chain managers and product developers appeared critical to the successful roll-out of new products, However, especially in business-to-business transactions where the efficiency and effectiveness of the transaction flow is largely determined by the operations and logistics functions (Mills, Schmitz &.Frizelle, 2004: 1014); supplier involvement in the product development stage is a necessary, iterative process..

In present-day supply chain logistics, the influence of packaging is even more significant. A new methodology called "packaging scorecard" was developed to assess the overall packaging contributions of all partners in the supply chain. Tested on two different types of packaging systems for fast-moving consumer goods, it was found that retail made more efficient use of cardboard containers, while distribution was least efficient (Lee & Lye, 2003: 163).

Packaging is the first supply chain management/logistics inside-out process to occur. Once the conversion process is complete, the finished output must be packaged (which includes labeling) to prevent damage and to facilitate efficiency during storage, material handling, and transportation of the product. Packaging also serves the marketing function through promotion, providing product information, and allowing the products to be used by customers conveniently. Many manufacturers and their distributors have fallen behind in improving internal processes to increase efficiency and customer satisfaction, especially when it comes to implementing technology. Packaging is one area where there are abundant opportunities to reduce costs and to simultaneously improve customer service through the application of technology (Tracey, Lim & Vonderembse, 2005: 182).

These changes put pressure on how to design packages that are material efficient and easy to recycle, provide efficient transportation, warehousing and handling while at the same time provide better possibilities for branding and communication. According to the literature, many requirements impose potential trade-offs between three basic functions; marketing, logistics and the environment. This implies that an increase of the package's value with regards to one function may result in reduced benefit with regards to another function and that packaging should be optimized with regards to the different requirements (Jahre & Hatteland, 2004: 124).

## 5. Conclusion

The literature shows that product design activities should be in line with supply chain management activities so that both the customer and the supplier edge of the chain feed product design and development activities. Products should be thought and designed with their packages from the view of supply chain management because that the package is a very important issue in logistical activities. When the packaging of a product is the issue, not only the product's package that is seen by the customers at the market should be the concern, there may be other extra packages that are used in the transportation of products which also necessitates a development task so that safety is assured in transportation and maximum products per shipments is achieved by designing the outermost packages in an optimized, efficient manner. It is worthy to keep in mind that the industrial design of a product determines the shape and dimensions of the package, which duplicates the importance of product design and new product development for supply chain management activities together with its package.

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# PRODUCTIVITY PERSPECTIVE OF THE INTEGRATED LOGISTICS PROCESS AND AN APPLICATION OF GAP ANALYSIS

Fahriye Uysal[1], Orhan Kuruüzüm[2]

## Abstract

*In today's competitive arena, one of the significant topics that logistics managers and engineers major upon is the performance of logistics. The productivity indicators that are prevalently used in performance measures do express the relationship between the produced outputs and the inputs used by the system for their production. In this research, a model was developed to evaluate the productivity by constituting the integrated logistics process, and the interaction of the process with the supply chain management in conceptual and functional terms is elucidated. In this context, outputs of the input logistics, and inputs and outputs of the production logistics are evaluated linearly with the inputs of the output logistics. With this model, the productivity indicators that should be considered (supply, labour, transportation capacity, inventory, etc.) arose from the literature reviews and the inquiry made with the logistics firms' managers. So as to assess the obtained indicators en bloc, GAP analysis was applied by using the data of logistics firm. The results of the GAP analysis were presented to the managers of the firm to provide them with the opportunity to 1) evaluate the degrees of the firm's products that are subject to logistics, 2) compare the products, and 3) make research in accordance with the targeted direction.*

Keywords: Integrated Logistics, Productivity, Gap Analysis

## 1. Introduction

Business activities are typically modelled as transformational processes converting inputs into outputs through some applied work. The overriding objective of the manager, then, is to maximize the output while minimizing the input consumed. The transportation function, for example, is often modelled as converting labour, equipment, and other resources(usually aggregated into monetary value) into ton-km produced with the transportation manager's overriding objective being to produce the requested ton-km and service levels at the lowest possible cost (Caplice and Sheffi,1994:18).

Supply, manufacture and product logistics, that constitute the basic components of the integrated logistics process, are considered with a modelling of supply chain management. This integration does not impede the individual working of basic components thanks to the network structure.

## 2. Integrated Logistics

Integrated logistics includes the planning, implementation, and control of the flow and storage of raw materials, in-process inventory, finished goods, services, related information, and payments among suppliers and consumers from the production of raw materials to the final recycling or disposal of finished goods (Integrated Logistics Committee on the Impact:2003).

In general, the integrated logistics process features;

1) Inbound logistics,
2) Manufacturing logistics,
3) Outbound logistics as the basic components as seen in Figure 1 (Bowersox and Closs,1996:48).

Inbound Logistics: Several activities or tasks are required to facilitate an orderly flow of materials, parts, or finished inventory into a manufacturing or distribution complex. They are (1) sourcing, (2) order placement and expediting, (3) transportation, and (4) receiving. These activities are required to complete the procurement process. Once materials, parts, or resale products that were procured are received, the subsequent storage, handling, and transportation requirements to facilitate either manufacturing or redistribution are appropriately provided by other components. Because of the limited scope of procurement operations, it is currently being widely identified as inbound logistics. The typical goal in procurement is to perform inbound logistics at the lowest cost. The lower value of materials and parts in contrast to finished products means that a greater potential trade-off exists between cost of maintaining inventory in transit and time required to use low-cost modes of transport.

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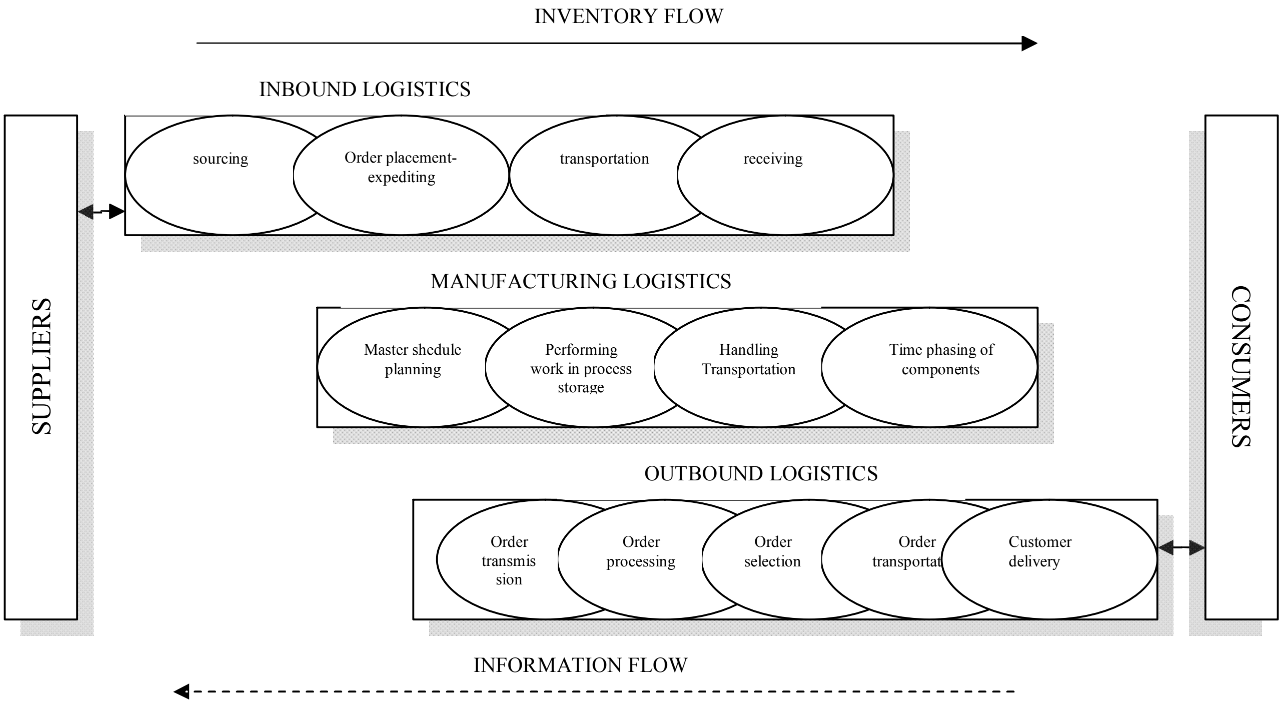


Figure 1. Integrated Logistics and Basic Components

Manufacturing Logistics: Manufacturing logistics can be viewed as being positioned between inbound logistics and outbound logistics operations of a firm. It has the primary objective of establishing and maintaining an orderly and economic flow of materials and work in process inventory to support production schedules. Specialization desired in outbound logistics and inbound logistics can create a grey area concerning responsibility for positioning and timing of inventory within the manufacturing enterprise. The movement and storage of product, materials, and semi-finished parts and components between enterprise facilities represent the operational responsibility of manufacturing logistics. Manufacturing logistics involves four related activities which are master schedule planning, performing work in process storage, handling transportation, time phasing of components.

Outbound Logistics: Physical distribution operations involve processing and delivering customer orders. Physical distribution performs the physical-fulfilment activities. The typical physical distribution involves five related activities. They are order transmission, order processing, order selection, order transportation, and customer delivery. All these facilities are termed as outbound logistics. The very fact that outbound logistics deals with customer requirements means that related operations will be more erratic than characteristic of manufacturing logistics and inbound logistics.

To be fully effective in today's competitive environment, firms must expand their integrated behaviour to incorporate customers and suppliers. This extension, through external integration, is referred to as supply chain management.

## 3.Logistics Performance

The competitive priorities in operational strategy, according to Krajewski and Ritzman (1993:47), are cost, quality, time and flexibility. Hence, any productivity or performance gauges in logistics should embrace these factors.

Conceptually, logistics performance may be viewed as a subset of the larger notion of firm or organizational performance. The latter has attracted a large volume of diverse research over the years and illustrates the futile nature of the search for the "one best way" of defining performance (Chow, Heaver and Henriksson,1994:23). For example, Gleason and Barnum chose to distinguish between effectiveness and effiency. They defined effectiveness as "the extent to which an objective has been achieved", while effiency was defined as "the degree to which resources have been used economically". Simply put, effiency is "doing the right things" (Gleason and Barnum:1986,380). Sink and his colleagues, on the other hand, defined seven dimensions in order to capture their conception of "what performance means": they are effectiveness, effiency, quality, productivity, quality of work life, innovation and profitability/budgetability (Sink,Tuttle and DeVries,1984:266).

Logistics management has always contained basic performance indicators, as expounded by Fawcett et al. (1992:16-17), such as costumer service effectiveness and distribution effiency. However, as Heap (1992:9) explains, although efficiency and effectiveness are the cousins of productivity, they are not its clone. Effectiveness is the ability of an organization to fulfil its objective while efficiency is the relationship between actual and standard performance. Productivity, therefore, can be seen as the combination of effectiveness and efficiency and described as the value of performance achieved in relation to the cost of resources used.

Many authors have categorised performance measurement. Neely et al. (1995) consider four main categories: quality, time, flexibility, and cost; while Lockamy and Cox (1994) define customer, resource and finance as primary categories of performance measurements. According to Caplice and Sheffi(1994), a good metric has to capture the critical elements of the logistics process: three primary groups of performance measures: financial, quality, and resources (English et al.,1999). Moreover, a "good" logistics performance measurement system should be comprehensive, horizontally integrated, internally comparable, and useful (Caplice and Sheffi, 1995).

Three primary forms of measurement can be used to capture the performance of a transformational process: utilization, productivity, and efficiency. While these are commonly used terms, the specific definitions are not consistent between authors or fields. The term "norm" used in these definitions refers to any value selected by the process manager to be used in comparison with the actual values. They can be historical values, values from related organizations, expected targets, or engineered standards, such as capacity.

Utilization is a measure of input usage and is usually presented as a ratio or percentage of the actual amount of an input used to some norm value.

Productivity is a measure of transformational effiency and is typically reported as the ratio of actual outputs produced to actual inputs consumed.

Efficiency is a measure of the quality of process output and is typically reported as a ratio of actual output to a norm (predetermined or competitive standards) output.

Each of these forms of measurements (sometimes called performance dimensions) play a role in achieving the manager's overriding objective by capturing a particular aspect of the process(Caplice and Sheffi,1994:12).

The literature review provided by Rhea and Shrock suggests that care must be taken to incorporate multiple goals in defining performance. In order to begin the task of conceptualizing what the various dimensions of logistics effectiveness might look like, we identified a representative set of answers to the question, "what is logistics performance?" The results of this exercise are shown in Figure 2. Logistics performance may be defined as the extent to which goals such as those suggested in Figure 2 are achieved.

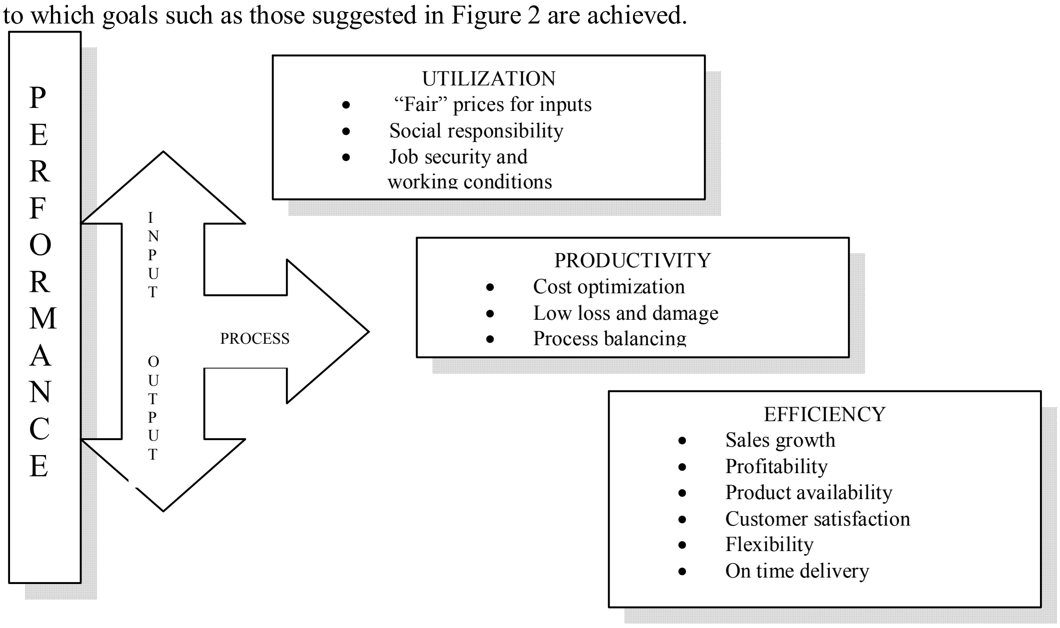


Figure 2.The Three Performance Dimensions under Defining Logistics Performance

Figure 2 incorporates various possible dimensions of performance in a single envelope to help highlight the numerous interdependencies and conflicts between the goals. For example, interdependency is likely to exist between service and profitability. A conflict would occur if a pay rise of employees were postponed to achieve a short-term financial improvement- a move which may inhibit the firm's ability to attract and retain employees who are capable of delivering quality customer service for the benefit of long-run profits(Chow, Heaver,1994).

### 3.1. Productivity

Productivity is one of the most widely used measures of performance. Unfortunately, people often confuse its meaning, assuming that it is the amount of work done by each person. There are really several kinds of productivity. The broadest picture comes from total productivity, which relates throughput of a supply chain to the amount of resources used(Waters CDJ,2003:201).

Total Productivity = total throughput / total resources used

The productivity of a specified resource(s) is generically measured as the ratio of the output of the resource(s) to the consumption of the resource(s):

Productivity = Output / Consumption(Input)

The utilization of specified resource(s) is generically measured as the ratio of the output of the resource(s) to the capacity of the resource (Frazelle Edward H.,2001:491):

Utilization = Output / Capacity

Unfortunately, this definition has a number of drawbacks. Throughput and resources must use consistent units, so they are normally translated into units of currency. This depends on the accounting conventions used - so we no longer have an objective measure. Another problem is finding values for all the inputs and outputs. This is particularly difficult for intangible inputs (such as sunlight, the environment and reliability) and outputs (such as pollution, waste products and reputation).

Because of these practical difficulties, hardly any organisation measures total productivity, preferring to use partial productivity, or single factor productivity. This relates the throughput of a supply chain to a single type of resource (Waters C.D.J.,2003:200).

Partial Productivity = total throughput / unit of a single resource used

It can be divided into three main types:

1) Partial measures being a ratio relating output to a single input, such as labour, materials or capital.
2) Total factor or value-added productivity being based on sales less bought-in goods, materials and services.
3) Total productivity measures being a ratio of total output to total input.

(Stainer, 1997:55)

Productivity is the relationship (usually a ratio or an index) between outputs (goods and/or services) produced and quantities of inputs (resources) utilized by the system to produce that output. Productivity is thus a very simple concept. If a system has clearly measurable outputs and identifiable, measurable inputs that can be matched to the appropriate outputs, productivity measurement is quite routine. However, it can be difficult and frustrating if (1) outputs are hard to measure and input utilization is difficult to match up for a given period of time, (2) input and output mix or type constantly changes, or (3) data are difficult to obtain or unavailable(Bowesox and Closs 1996:673).

Bollou (1987:389-98) and Coyle et al.(1992:500-2) list various basic logistics productivity ratios; they believe these can be used to control such elements as warehousing, transportation, inventory and customer service. Their measures are almost entirely partial and are not integrated, and consequently, they have limited application, mainly at the operational rather than the strategic level.

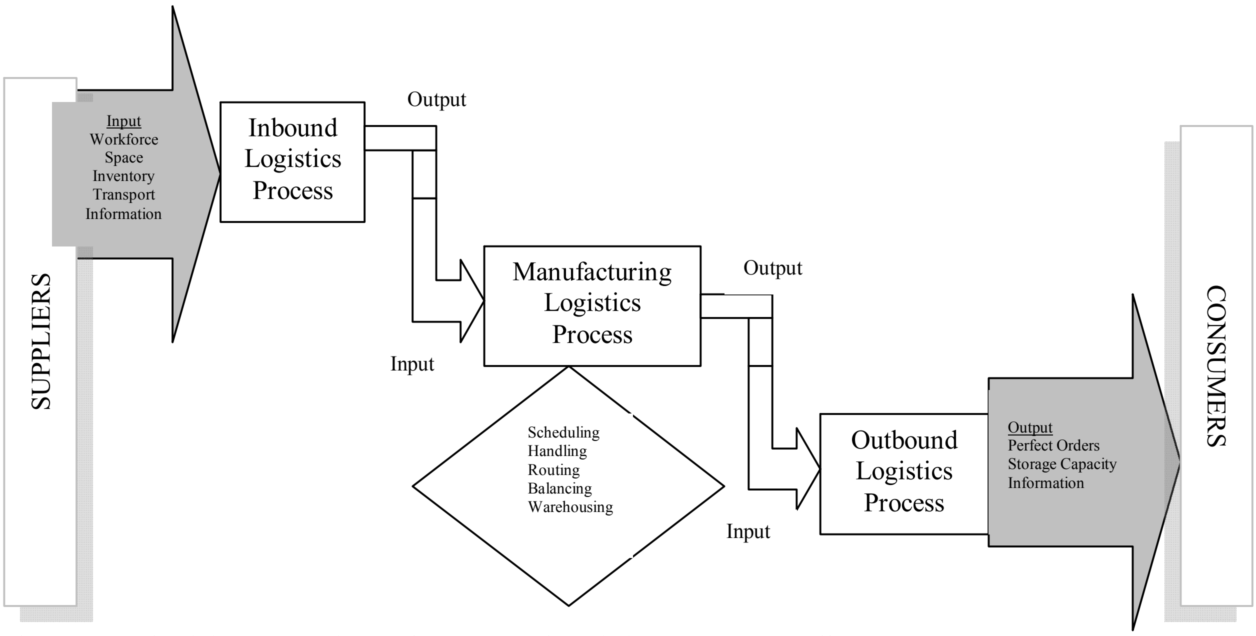


Figure 3. Productivity Perspective of the Integrated Logistics Process (Frazelle,2001)

## 4. Benchmarking and Gap Analysis

Within logistics and supply chain management, benchmarking can be used for a number of different purposes, from assessing the performance of the entire operation, through prioritizing improvements, to searching for the off-the-shelf improvement strategies in a specific area of a logistics or supply chain activity (Waters, 2003:196).

We extend the Gap Analysis concept (Frazelli, 2001) and define how to determine its factors to benchmark the overall logistics productivity of an organization to different products. The gap analysis is used in this paper as a formal way to assess the logistics productivity.

Figure 4 illustrates the logistics productivity gap analysis. Each axes represents one key logistics productivity indicator. Logistics productivity gap analysis is used to define the superiority of the efficiency of different products subject to logistics over each other.

The steps of the logistics productivity gap analysis are: (1) determine the indicators of the logistics productivity to be considered in the analysis, (2) normalize the amount of the indicators using 0-10 scale, (3) mark the value on the axes inside the gap. (4) determine the logistics productivity effort for each product.

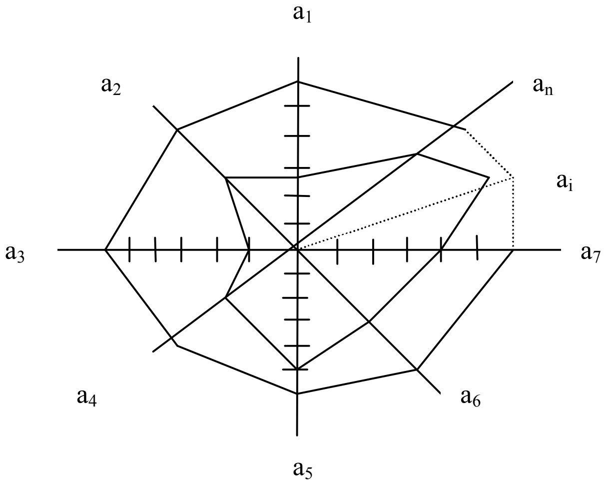


Figure 4. Gap analysis (Lakhal, Mida:2003)

The international firm taken as an example in this research is in the outbound logistics process within the context of integrated logistics process. Delivery of the goods to the customers is in question. The implementation process of the international transportation service, prepared according to the firm, can be seen in Figure 5. The firm delivers the goods to the customers without continuous inventory.

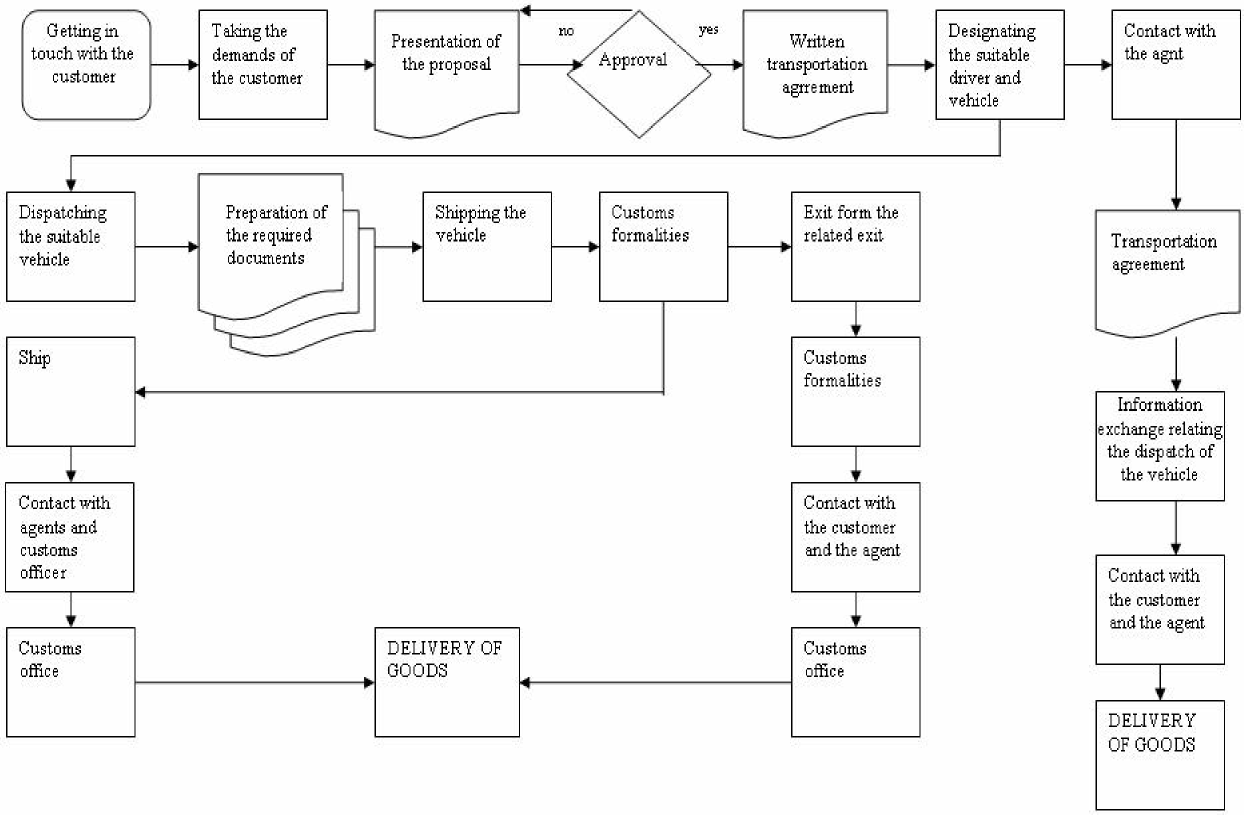


Figure 5. Implementation Process of International Transportation Service

### 4.1. Step 1. Outbound Logistics Efficiency Indicators

In order to determine the efficiency indicators of the firm, the 12 month data-set of the firm concerning transportation is examined and the data is assembled into groups in terms of goods. As a result of this grouping, the most frequently carried goods were chosen as examples. Among these goods are aluminium rim, arterven set and medical supplies imported from or exported to countries like Germany, France, Switzerland, Italy, Bulgaria and Bosnia-Herzegovina. Taking the type of goods carried into account, transportation duration, transportation amount, transportation distance and transportation fee and number of services are designated to represent the outbound logistics indicators.

$a_{.j}{}^{d}$ : indicators j for a logistics productivity d ; J = 1,2,…,n and d = 1,2,…,D ; for d=1
$a_{ij}{}^{d}$ : value of indicators of the product $c_i{}^{d}$ ; i = 1,2,…,m ;
$S_{ij}{}^{d}$ : normalized value of indicators of the product $c_i{}^{d}$ ;
$a_1$ = transportation duration
$a_{i1}$= total transportation duration of the i[th] product chosen / Total duration of the goods transported in a year
$a_2$ = transportation amount
$a_{i2}$ = total transportation amount of the i[th] product chosen / Total amount of the goods transported in a year
$a_3$ = transportation distance
$a_{i3}$= total transportation distance of the i[th] product chosen / Total distance of the goods transported in a year
$a_4$ = transportation fee
$a_{i4}$= total transportation fee of the i[th] product chosen / Total fee of the goods transported in a year
$a_5$ = number of services
$a_{i5}$= total number of services of the i[th] product chosen / Total number of services of the goods transported in a year
Indicators $a_2$ , $a_4$ and $a_5$ are to be maximized; $a_1$ and $a_3$ are to be minimized.

Table 1. Value of Indicators for each Product

| Indicator/Product | Indicators for an Outbound Logistics Productivity d | | | | |
|---|---|---|---|---|---|
| | Transportation Amount | Transportation Distance | Transportation Fee | Transportation Duration | Number of Services |
| Aluminium Rim | 0,164 | 0,264 | 0,241 | 0,369 | 0,110 |
| Arterven Set | 0,243 | 0,213 | 0,260 | 0,338 | 0,190 |
| Medical Supplies | 0,583 | 0,607 | 0,365 | 0,582 | 0,361 |
| Target Product | 0,583 | 0,213 | 0,365 | 0,338 | 0,361 |

4.2. Step 2. Normalizing the value of the Indicators

To normalize the indicators we need a reference called a Target Product ( $c_*^d$ ) for each logistics productivity d. A target product could be the product of the leader in the company that would conform to all or most of the standards of the product that the company wishes to have in the future ( a targeted objective). For each product, we evaluate the value of indicators. We get a table similar to table 1.

For each product and each indicator we calculate $S_{ij}^d$.

We consider two different cases, (1) the case where the indicator is to be maximized and (2) the case where the indicators is to be minimized.

Case where the indicator is to be maximized

$$S_{ij}^d = \frac{a_{ij}^d}{a_{*j}^d} \times 10 \qquad (1)$$

Case where the indicator is to be minimized

$$S_{ij}^d = \frac{a_{*j}^d}{a_{ij}^d} \times 10 \qquad (2)$$

The resulting matrix is displayed in table 2.

Table 2. Normalized Value of Indicators for Product

| Indicator/Product | Indicators for an Outbound Logistics Productivity d | | | | | PLE | LG |
|---|---|---|---|---|---|---|---|
| | Transp. Amount | Transp. Distance | Transp. Fee | Transp. Duration | Number of Serv. | | |
| Aluminium Rim | 2,81 | 8,06 | 6,60 | 9,16 | 3,04 | 5,934 | 4,066 |
| Arterven Set | 4,16 | 10 | 7,12 | 10 | 5,26 | 7,308 | 2,692 |
| Medical Supplies | 10 | 3,51 | 10 | 5,81 | 10 | 7,864 | 2,136 |
| Target Product | 10 | 10 | 10 | 10 | 10 | | |

4.3. Step 3. Gap Repsentation

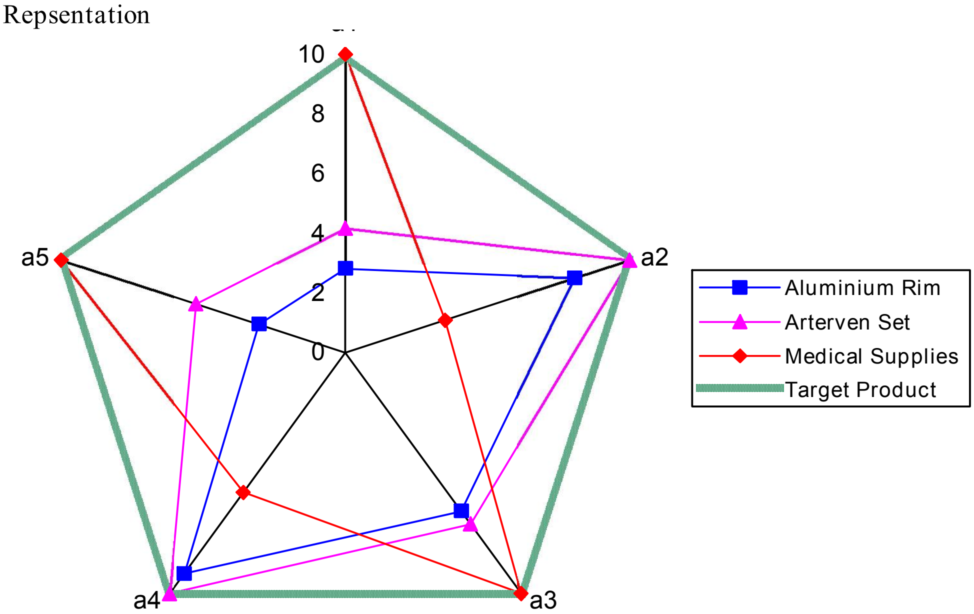


Figure 6. Gap Representation for the three-products of the example

## 4.4. Step 4. Determination of logistics productivity

If all values have the same weight, the present logistics effort (PLE) for the product is calculated by the equation (3).

$$\text{PLE}(C_i^d) = \frac{\sum_{j=1}^{n} S_{ij}^d}{n} \qquad \text{for i=1,2,…,m} \quad \text{d= 1,2,…,D} \qquad (3)$$

The logistics gab(LG) for the product is determined by equation (4).

$$\text{LG}(C_i^d) = 10 - \frac{\sum_{j=1}^{n} S_{ij}^d}{n} \qquad \text{for i=1,2,…,m} \quad \text{d= 1,2,…,D} \qquad (4)$$

The PLE and the LG for each product is presented in table 2.

On the other hand, if he following weights : $w_1$=0,2 $w_2$=0,1 $w_3$=0.3 $w_4$=0,3 $w_5$=0,1 are adopted than the weighted present logistics effort (WPLE) (5) and the weighted logistics gap (WLG) (6) and the present are calculated respectively by the equations and presented in table 3.

$$\text{WPLE}(c_i^d) = \sum_{j=1}^{n} w_j^d S_{ij}^d \qquad \text{for i=1,2,…,m} \quad \text{d= 1,2,…,D} \qquad (5)$$

$$\text{WLG(cid)} = \sum_{j=1}^{n} w_j^d a_{*j}^d - \sum_{j=1}^{n} w_j^d S_{ij}^d \qquad \text{for i=1,2,…,m} \quad \text{d= 1,2,…,D} \qquad (6)$$

Table 3. Normalized Weighed Value of Indicators for each Product

| Indicator/Product | Indicators for an Outbound Logistics Productivity d | | | | | PLE | LG |
|---|---|---|---|---|---|---|---|
| | Transp. Amount $W_1=0,2$ | Transp. Distance $W_1=0,1$ | Transp. Fee $W_1=0,3$ | Transp. Duration $W_1=0,3$ | Number of Services $W_1=0,1$ | | |
| Aluminium Rim | 0,562 | 0,806 | 1,980 | 2,748 | 0,304 | 6,40 | 3,60 |
| Arterven Set | 0,832 | 1 | 2,136 | 3 | 0,526 | 7,50 | 2,50 |
| Medical Supplies | 2 | 0,351 | 3 | 1,743 | 1 | 8,09 | 1,91 |
| Target Product | 2 | 1 | 3 | 3 | 1 | | |

## 5.Conclusion

This research is focused on calculating the efficiency of outbound logistics, one of the basic components of the integrated logistics process. A gap analysis is realized on the three main products of the logistics firm, where the research is carried out, on five basic efficiency indicators.

When the results were evaluated, it was found that there is not only one product close to the target product. While for three of the five indicators, medical supplies is close to the target product; for the other two arterven set is closer. Thus, these two products are non-dominated. Yet, aluminium rim is dominated by both. However, this product is the one least close to the target product in terms of the three indicators. These indicators will be maximized. On the other hand, among the products to be minimized, medical supplies is the farthest from the target product.

Consequently, obtaining the calculated values of the defined five efficiency indicators having a similar composition to the target product is the principal aim. The analysis carried out here forms the basis for the policy decisions that will be given to achieve this aim. Using these efficiency indicators, it can be determined which products should be improved. Therefore, it is always possible to change products or indicators, or use sectors or firms instead of products. Thus, evaluations and amendments concerning gap analysis and other dimensions of integrated logistics can be made.

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# A PROPOSITION ON LOGISTICS SERVICE PROVIDERS ORGANIZATIONAL STRUCTURES FOR SCOR

Engin Deniz Eris[1], Okan Tuna[2]

## Abstract

*The most important change that a modern business management faces is that the firms are transformed from unique competing units, to competing chains that is combined with the customers like a network. A supply chain can be defined as the whole flows of services, information and money from suppliers to customers and also to customers' customers. Combining the main processes in this chain and building business models in order to provide faster, cheaper and high quality services for the customer is named as supply chain management.*

*The Supply-Chain Operations Reference (SCOR) which is developed by the Supply Chain Council (SCC) to assist firms in increasing the effectiveness of their supply chains, and to provide a process-based approach to supply chain management (SCM). SCOR is a standard supply chain process reference model designed to embrace all industries. It includes a methodology that enables companies to analyze and improve their supply chain operations by helping them communicate supply chain information across the enterprise, measure performance objectively, and identify supply chain performance gaps and improvement objectives with twelve measurement criteria in four steps.*

*Logistics service providers should adapt and improve themselves according to the changing and developing needs of the industries. In this study some propositions are given for an organizational structure for SCOR model.*

Keywords: Logistics, Supply Chain Management, SCOR

## 1. Logistic Systems in Business Organizations

In today's business organizations there are five tightly connected business systems that are management systems, engineering systems, marketing systems, manufacturing systems and logistics systems (Muckstadt et al, 2001: 428). As we are now in service age, logistic systems are separated from the firms and logistics service providers are become a part of new economy.

A simple definition of logistics is the flow of service, material, information, and money between consumers and suppliers. From the year 1950's to 1990's, logistics evaluation can be classified in five steps (workplace logistics, facility logistics, corporate logistics, supply chain logistics, global logistics). Nowadays we are talking about the next generation of logistics, collaborative logistics, virtual logistics and fourth-party logistics (Frazelle, 2002: 5-11) in firms and logistics service providers.

## 2. Supply Chain Management as the Success Factor for Logistic Systems

As we thing the logistics and supply chain together, we can say that logistics is a part of supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customer' requirements (Ballou, 2004: 4). To take a competitive advantage, firms should organize their logistics systems properly for supply chain. As a good supply chain management there are five principles that must guide the developments of these effective supply chains (Know the customer, construct a lean supply chain organization that eliminates waste, variability and uncertainty, build tightly coupled information infrastructures, build tightly coupled business processes, construct tightly coupled decision support systems) (Muckstadt et al, 2001: 430-432).

A supply chain is the set of value-adding activities that connects a firm's suppliers to the firm's customers (Harrison, 2001: 413). Supply-Chain Council (SCC) uses the definition: "The supply chain -a term increasingly used by logistics professionals- encompasses every effort involved in producing and delivering a final product, from the supplier's supplier to the customer's customer. Four basic processes –plan, source, make, deliver- broadly define these efforts, which include managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, and delivery to costumers" (Lummus, Vokurka, 1999: 11). Supply chain management (SCM) is the process of planning, organizing, and controlling the flow of materials and services from suppliers to end users/customers (Bloomberg, LeMay, Hanna, 2002; 1).

The concept of SCM can be traced back to just before the 1960s. Increased study of the field began with 1980s, with a dramatic increase in the publication rate since 1990 (Huan, Sheoran, & Wang, 2004: 23). Firms are using SCM to reduce their operational costs and build solid customer relations (Ferguson 2000 in Lockamy,

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McCormack, 2004b: 1192). SCM is a philosophy that based on the belief that each firm in the supply chain directly and indirectly affects the performance of all the other supply chain members (integration), as well as ultimately, overall supply chain performance (Cooper 1997 in Lockamy, McCormack, 2004b: 1192). The integration of supply chain processes can provide effective means by which costs can be reduced and customer service levels improved. The formula for integration, however, is not a simple one. Organizations that aim to become part of an extended, integrated supply network can also expect that this will require an infrastructure enabling effective information flows and streamlined logistics. A key component of this infrastructure will be based on robust and durable collaborative arrangements with trading partners. The most effective of these networks will be those that are able to get the mix of information requirements, physical logistics and collaboration right, providing shared benefits to a majority of partner organizations (Power, 2005). The basis of integration can therefore be characterized by cooperation, collaboration, information sharing, trust, partnerships, shared technology and a fundamental shift away from managing individual functional processes, to managing integrated chains of processes. Effective application of information technology to the integration of supply chain activities has the effect of reducing levels of complexity.

Basic SCM which emphasizes getting the most out of current manufacturing resource planning or enterprise resource planning tools and combining them with the effective use of SCM best practices, such as supplier partnerships and vendor managed inventory. On the other hand, sophisticated SCM, which focuses on the newer information technology (IT), tools are for SCM optimization (IOMA, 2002: 729).

In literature there are lots of supply chain models for a sophisticated SCM such as MRP models, Mathematical programming-based models, Inventory models (Muckstadt et al., 2001: 440-442) or RosettaNet Standarts, software reference models (Kirchmer, 2004: 29). And from 1996 some commercial and academic diagnostic tools developed for the SCM. One of the useful self-diagnostic tool for SCM is Supply-Chain Operations Reference Model (SCOR model) (Monroe, 2004: 832). As the need of today's logistics approach, SCOR model describes supply chain in five dimensions: reliability, responsiveness, flexibility, cost and efficiency in asset utilization (Stephens, 2001: 473).

Although this model offers many benefits for the manufacturers in all aspects of the supply chain management, the contribution/relation of the logistics service providers have not been reviewed in literature and practice. Considering this fact, this study attempts to give a proposition on logistics service providers' organizational structures for SCOR model.

## 3. Supply-Chain Operations Reference Model for Effective Supply Chain Management

Supply-Chain Operations Reference Model (SCOR model) is the first cross-industry framework for evaluating and improving enterprise-wide supply-chain performance and management. SCOR model was developed in 1997 by the SCC to assist firms in increasing the effectiveness of their supply chains, and to provide a process-based approach to SCM. SCOR is designed to enable companies to communicate, compare and develop new or improved supply-chain practices from companies both within and outside of their industry segment. When applying SCOR, users will typically consider two supply-chain improvement perspectives: internal and external (Stewart, 1997: 63-64).

SCOR is currently being used to identify and implement supply chain improvements, evaluate and select off-the-shelf software, select and manage consulting and system integration services, promote and manage change within organizations, and provide a basis for education and training in the area of supply chain. It is endorsed by more than 750 member companies of the SCC (Hoole, 2005: 3) and now being successfully applied to improve business operations in North America, Latin America, Europe, Asia and Australia/New Zealand. Practitioners have generated significant returns on their supply chain investments through usage of the Model. And this model was originally conceived as a standard reference that could be used by organizations in any industry segment for sharing information with supply chain partners (Stephens, 2001: 471-474).

SCOR Model views the supply chain as a processes chain. The models are purposefully designed to be configurable by accommodating flexible combinations of hierarchical processes (Li, Kumar, & Lim, 2002: 551). SCOR is a business process reference model that links process description and definition with metrics, best practice and technology (Stephens, 2001: 472). To make the supply chain performance better business process orientation and process maturity models can be used. And in this context, the SCOR framework conceptualizes the supply chain management maturity model with its process orientation (Lockamy, McCormack: 2004a).

## 4. Logistics Service Providers Organizational Structures for Supply-Chain Operations Reference Model

Organizational structure about logistics and supply chain was weak at the 1970's (Stage I). At the 1980's (Stage II) organizations were directed at formal structures, where a top level executive was placed in charge of the relevant logistics activities, usually those of physical supply or physical distribution but not both. At Stage III, organizational structures referred to the full integration of logistics activities, spanning both physical supply and physical distribution. Total integration of logistics activities, and the organizational structure of the scope to coordinate them, increased in popularity. At Stage IV organizations did have new complex structure: all logistics activities took place between their raw materials sources throughout production and final customers. At Stage V, organizational structures can be envisioned as follows: logistics activities will be managed between firms in the supply channel that are separate legal entities. At this point managerial attention and organizational structure must be available for control and responsibility of the firm (Ballou, 2004: 696-7).

SCOR is a management tool. It is a process reference model for logistics & supply-chain management, spanning from the supplier's supplier to the customer's customer. The SCOR-model has been developed to describe the business activities associated with all phases of satisfying a customer's demand. By describing supply chains using process building blocks, the model can be used to describe supply chains that are very simple or very complex using a common set of definitions. The model has been able to successfully describe and provide a basis for supply chain improvement for global projects as well as site-specific projects. For this model organizations have to redesign themselves.

As seen in figure 1, the process description based SCOR model includes 5 processes: Plan-Source-Make-Deliver-Return. The essence of SCM is integrated planning (Functional integration, Geographical integration, Intertemporal integration) and in the SCOR Model every activity is based on planning. These processes are held within 4 levels. At level 1, the supply chain's performance can be tied directly to the business objectives of the organization. On level 2 and 3 process elements are used to describe more detailed activities to provide greater insight into the operation of the supply chain. Because this model is a cross-industry model and each organization's operations are unique, a fourth level is needed. Level 4, called the implementation level, defines practices to achieve competitive advantages and to adapt to changing business conditions (Shapiro, 2001; Stephens, 2001; Huan, Sheoran, Wang, 2004; Kirchmer, 2004).

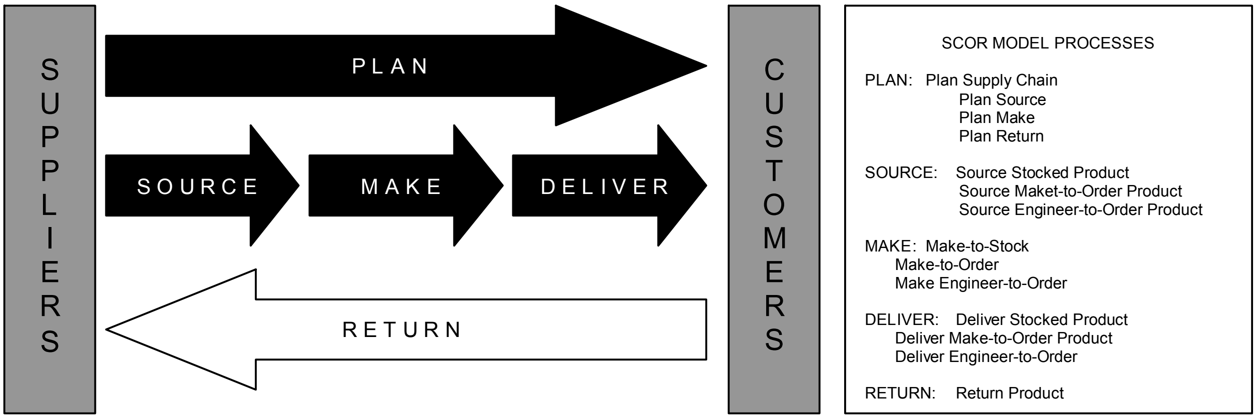


Figure 1. SCOR Model Processes

Sources: Adapted from Lockamy, McCormick, 2004b; Huan, Sheron, Wang, 2004; Stephens, 2001.

For today's logistics service providers to be competitive and suitable for SCM, organizational processes must have been structured within the framework of 5 processes of SCOR that are mentioned below (Stewart, 1997; Youngdahl, Loomba, 2000; Lockamy, McCormack, 2004b; Sinha, Whitman, Malzahn, 2004; Hoole, 2005).

Planning Process is in charge of planning the balance between supply and demand requirements in order to optimize the logistics and production resources with regard to requirements. It also includes the spreading of the plans to all chain members to coordinate and update the other processes. This process covers management of business rules, supply chain performance, data collection, inventory capital assets, transportation, planning configuration and regulatory requirements and compliance. This stage involves managing the planning infrastructure. Infrastructural planning includes make/buy decisions, supply-planning, product phase-in/product phase-out, manufacturing ramp-up, end-of-life management and product-line management.

Sourcing Process includes the processes to procure goods and services to meet actual or planned demand. This is in charge of evaluating and selecting providers according to the established criteria and authorizes future payments to them. In the same way, it contains the programming of the periodic delivery of raw material in order to keep optimal stock levels. This process also deals with the supplier performance, supplier network and supplier agreements.

Making Process includes processes to transform goods to a finished state to meet planned or actual demand. It is used to schedule the logistic and production activities, including design and product tests, as well as packing and production rules.

Delivering Process includes processes to provide finished goods and services to meet planned or actual demand. Transport routes are selected, the warehouses are managed as well as the required activities for merchandising, installing and following customer satisfaction.

Returning Process contains the management activities regarding the return of exceeding or defective raw material, verification of its status, return schedule or repair.

Current key trend in logistics for application in the near future include e-business supported supply chain management (Skjoett-Larsen, 2000). And today, the effective and technological based SCM needs a high capacity and new technological background. As we look the functional roles technologies in SCM, we see three parts; transaction execution, collaboration and coordination, decision support. IT is identified that it is expected to have a pivotal role in managing supply chains, now and in the future (Auramo, Kauremaa, & Tanskanen, 2005). As a newly tool SCOR is a real useful model for using IT in SCM.

Typically the goals for SCM are to increase productivity by reducing total inventory level and cycle time for orders. To achieve these objectives business processes pertaining to material handling, information processing and capital control need to be optimized in relation to the limited resources. And in this view supply chains software applications can be used (they are classified in two classes: transactional and analytical) (Helo, Szekely, 2005: 5-6).

As an IT tool SCOR model enables companies to communicate supply chain issues, measure their performance improvement objectively, identify performance improvement objectives, and influence future SCM software development (Wang, Huang, & Dismukes, 2004: 6). It contains (Huan, Sheoran, & Wang, 2004: 24);

- Standard descriptions of management processes
- A framework of relationships among the standard process performance
- Management practices that produce best in class performance
- Standard alignment to software features and functionality.

Implementation is a key factor in IT. Hammant and Fischer (1997) give critical success factors for implementation (Power, 2005: 258). Firms and firms are especially based on technology like logistics firms should do these:

- A committed organizations, from board to down
- Effective program management
- Consistent, pre-emptive communications
- Positive action to identify and manage key risks before they become issues
- A well-defined and managed programmed baseline, changed as necessary
- A succession of manageable delivery milestones to maintain momentum and confidence
- An actionable, owned, manageable and measurable set of business benefits.

In these contexts to be effective and productive and suitable for a SC, it can say that SCOR model is an efficient tool for logistics service providers. And to be suitable for SCOR model, logistics service providers should upgrade their organizational designs. An organizational design that suitable for SCOR contains;

- Operational processes and flows
- Technology based organization structure
- Lean management thinking
- Less hierarchy
- Integrated processes
- A technological platform between the logistics firm, customers and suppliers
- Integrated planning
- Information and communication flow

These factors are just a proposition for the logistics service providers. And this study just aims to explain the SCOR model and give a framework about its use in logistics provider organizations.

## 5. Conclusion

In the era of service, logistics is a flourishing sector worldwide. Logistics activities now are outsourced from the firms to logistics service providers. As a result of this, SC importance gets more.

Performance measurement, productive and effectiveness are one the main problems in SCM. To solve these main problems lots of models are developed and one the latest and continuously updating model is SCOR. SCOR model is a systematic model that contains process. The core of this model is processes. To be effective in usage of SCOR, logistics service providers have to reorganize their organization structure. SCOR model strategy makes the organizational structure be compatible with the dynamics of change.

In this study it is mentioned about the processes of this model and organizational dimensions to be needed. The next step of this study is to find the answer to the question that “Do the logistics service providers have an organizational structure that fits the SCOR model?”. Delphi technique will be used and the sample of the work will be chosen from the top-level managers that are working in Turkey and have variety of skills related with their expertise. The results will present a starting view about the organizational structures of the logistics service providers and their suitability to the SCOR model.

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# IDENTIFICATION, EVALUATION AND MEASURING OF AUTONOMOUS COOPERATION IN SUPPLY NETWORKS AND OTHER LOGISTIC SYSTEMS

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## Abstract

*The implementation of autonomous cooperation in logistic systems seems to be an appropriate method to cope with the increased requirements on competitive enterprises caused by highly dynamic and complex environments. In order to manage autonomous cooperating logistic processes efficiently, its measurement and evaluation are essential preconditions. The objective of this paper is to introduce the concept of autonomous cooperation in logistic processes and to answer the questions on how autonomous cooperation could be measured and evaluated. To obtain a comprehensive and multi-perspective picture of autonomous cooperation, the several steps of analysis are divided into two sequenced parts. The first sequence of examination contains a general perspective, which is exemplified by supply networks. The second sequence represents a specified engineering perspective of autonomous cooperation in a production logistic system.*

*Keywords: Autonomous Cooperation, Supply Networks, Production Logistics, Measurement, Evaluation*

## 1. Introduction

Recent changes like short product life cycles as well as a decreasing number of lots with a simultaneously rising number of product variants and higher product complexity lead to an increase of complexity of production systems. Therefore competitive enterprises have to develop new planning and control methods for their supply networks and their production systems in order to cope with these requirements. To achieve an ability to adapt on these new challenges the approach of decentralized planning and control by intelligent logistic objects in autonomously controlled production systems – called autonomous cooperation – seems to be an appropriate method.

In order to prove in which case autonomously cooperating processes are more advantageous than conventionally managed processes it is essential to specify what is exactly meant with autonomous cooperation, how does it differ from conventional control and how achievement of logistic and economic objectives in autonomously cooperating systems can be estimated and compared to achievement of objectives in conventionally controlled systems. The necessity for an operationalization of the idealistic concept of autonomous cooperation will be outlined in this paper, as it is a basic requirement for every single logistics company to decide if and to what extent autonomous cooperation should be implemented. Through the utilization of a measurement tool, logistics management has the opportunity to evaluate potentials of the concept and concretize measures for a shift from a mostly centralized to a more decentralized planning on the decision-making level (e.g. formation of autonomous working groups), information and communication technology level (e.g. use of RFID) as well as for the goods level (e.g. intelligent freight units). Furthermore, it is essential to develop an adequate evaluation system out of general business and engineering perspective in order to prove that the implementation of autonomous cooperation in production systems is of advantage in relation to conventionally managed systems. The evaluation of autonomous cooperation contains relations between a specific degree of autonomous cooperation and targeted objectives, which can be logistic objectives or financial objectives, for example. Therefore both the level of autonomous cooperation and the degree of the achievement of considered objectives (e.g. logistic, financial) must be measurable.

For this purpose, this paper introduces in the second chapter a general definition of autonomous cooperation exemplified by a supply network. Additionally, a specified definition in the context of engineering science and its meaning in the context of production logistics will be given to obtain a common understanding of the term autonomous cooperation. The third chapter deals with the evaluation of autonomous cooperation. Therefore, at first a general measuring concept, which is based on a scoring model, is introduced to give an insight into essential conditions of measuring ideas of autonomous cooperation of logistic systems. Later a specified measuring approach based on the engineering understanding of autonomous cooperation will represent an example on how a measuring

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concept of autonomous cooperation in production logistics system could look like. Based on those measuring methods, two evaluation concepts for autonomous cooperation will be introduced. One represents the general business perspective, which contains an evaluation of real-options resulting from autonomous cooperation. The other one stands for the engineering perspective in order to accomplish a comprehensive evaluation system for a production logistics system. A conclusion and further research tasks can be found in chapter four.

## 2. Understanding of Autonomous Cooperation

The vision of autonomous cooperating logistics processes emphasizes the transfer of qualified capabilities on logistic objects as explained above. According to the system theory, there is a shift of capabilities from the total system to its system elements (Krallmann 2004). By using new technologies and methods, logistic objects are enabled to render decisions by themselves in a complex and dynamically changing environment.

### 2.1 General Definition of Autonomous Cooperation

The source of the idea of autonomous cooperation is derived from different concepts of self-organization (e.g. cybernetics (von Foerster 1960), dissipative structures (Prigogine & Glansdorff 1971), synergetics (Haken 1973), autopoiesis (Maturana & Varela 1980), and chaos theory (Peitgen & Richter 1986). The focus of study is the autonomous evolution of ordered structures in complex systems. To specify the term 'autonomous cooperation' for the following analysis, a working definition, which was established in the work of the CRC 637, is presented. In this paper, autonomous cooperation describes processes of decentralized decision-making in flat organized structures of logistic processes. It requires that interacting elements in non-deterministic systems possess the capability and the possibility of making decisions independently. The implementation of autonomous cooperation aims at an increased robustness and positive emergence of the complete system through distributed and flexible coping with dynamics as well as complexity (Hülsmann & Windt 2006). Consequently, autonomous cooperation is based on the idea that systems cannot only be regulated by an external force, but also within the system as an internal force.

In supply networks for example, this concept means leaving operative decision-making in its sub-systems, sub-units, and sub-elements which are part of the network, while the individual system components operate independently from centralized decision-making structures. Due to the existence of various sub-systems in a supply network, the surface of the total system expands and allows more complex processing. Through independently operating sub-systems a higher degree of flexibility is assumed, which raises the capability to compensate complexity and dynamics caused by unexpected changes and to fulfill the long-term strategic goals of the major supply network actors (Hülsmann & Grapp 2005).

### 2.2 Specified Definition in the Context of Engineering Science

The general definition for the term autonomous cooperation provides the basis for the development of a definition in the context of engineering science, which is focused on the main tasks of logistic objects in autonomously controlled logistics systems:

"Autonomous control in logistics systems is characterized by the ability of logistic objects to process information, to render and to execute decisions on their own." (Hülsmann & Windt 2006)

In the context of engineering science this comprehension of autonomous cooperation is used in the following chapter to present an evaluation system that allows examination of the ability of autonomously controlled systems to cope with increasing complexity through better accomplishment of logistic objectives. In order to identify autonomous cooperating logistic objects, dissociation from conventionally managed logistic objects is necessary. The definition of autonomous cooperation explained earlier, describes the maximum level of imaginable autonomous cooperation. Thus, all system-elements in an absolutely autonomous controlled system are able to interact with other system-elements and to render decisions on the basis of a self decentralized target system in combination with suited evaluation methods. In general, logistics systems probably contain conventionally managed as well as autonomously controlled elements and sub-systems, respectively. Thus it can be declared, that there are different levels of autonomous cooperation which is called level of autonomous control. For example, one part of a production lot could be able to coordinate each production stage of the lot which represents a high level of autonomy; meanwhile other parts only allocate data regarding their processing states. Consequently, the latter mentioned case shows a lower level of autonomy.

## 3. Multi-perspective Measurement and Evaluation Concepts of Autonomous Cooperation

To apply and manage autonomous cooperation in logistic business processes efficiently, a continuous monitoring system is needed. Before the management can evaluate whether autonomous cooperation helps gaining company's goals or not, it has to be informed about the current degree of autonomous cooperation within their processes. Consequently, for an adequate establishment of this conceptualization, its contributions will only be manageable if they are measurable (Drucker 1954). On the basis of the measured degree, an evaluation of autonomous cooperation can take place regarding its influences on general objectives like financial and logistic objectives, and if a higher or lower degree of autonomous cooperation in the logistic process is more useful.

This chapter will focus on the measuring and evaluation of autonomous cooperation. Based on two different measurement concepts for autonomous cooperation, two different concepts will be introduced. The general evaluation concept evaluates autonomous cooperation out of an economic perspective, which has a high relevance until the concept of autonomous cooperation will be implemented in logistic processes as its cost-value ratio is transparent and its possible profits are traceable. The second evaluation concept deals with the impact of autonomous cooperation on logistic objectives. Together with the measurement of the level of autonomous cooperation it allows an investigation of the coherence between the level of autonomous cooperation and the performance of production systems.

### 3.1 Measurement of Autonomous Cooperation

In the following, first a general measurement concept of autonomous cooperation is presented which introduces the measurement problem of autonomous cooperation and that is adaptable to different logistics scenarios, like a supply network. Later a more specified measurement concept of autonomous cooperation shall also be exemplified in the field of production logistics which will give a more detailed insight into a possible measuring approach.

#### 3.1.1 General Measurement Approach of Autonomous Cooperation

Previous research has focused on abstract contributions of the concept of autonomous cooperation (e.g. Hülsmann & Grapp 2005, Hülsmann & Wycisk 2005a, b). Before introducing a general measurement approach of autonomous cooperation, it is necessary to define its basic requirements that determine its design. Based on measurement theory there is a need for validity or reliability regarding the used indicators and their key operators (Kromrey 2000). On the one hand they shall allow deduction of the degree of autonomous cooperation. On the other hand it is necessary to design a measurement system that integrates economic indicators in order to identify contributions to the objectives of autonomous cooperation (Hülsmann & Grapp 2006). Besides the basic requirement of measuring, an instrument should be able to visualize the results and it should support to interpret them (Bronner 1989). Due to existing dynamics of a logistic system and its processes that are quite evident through phenomena as real-time economy, there is not just a static optimum of autonomous cooperation. It can be assumed, that the degree of autonomous cooperation varies over time. A continuous monitoring system for the degree of autonomous cooperation is needed on all levels of logistic processes (Hülsmann & Grapp 2006).

A first step in developing a measurement concept for autonomous cooperation is defining its scope of application. To capture an entire logistic system while keeping a manageable degree of description, a trichomoty of logistics is used. It consists of the decision system (management), information system (information and communication) and execution system (material and goods flow) (Scholz-Reiter et al. 2004). A second step is to choose an appropriate basic measurement method. The chosen basic method of measuring the degree of autonomous cooperation is a scoring model. The third step of developing a measurement concept contains defining the constitutive objects of measuring. In this scoring model the constitutive characteristics of the general definition of autonomous cooperation (decentralized-decision-making, autonomy, non-determinism, interaction, heterarchy) (Hülsmann & Windt 2006) shall represent autonomous cooperation. They are transferred and specified in each case into indicators and key operators for each level of a logistic system (Hülsmann & Grapp 2006). The selection of characteristics and indicators depends on the field of application. A measurement concept which measures the degree of autonomous cooperation in a supply network could differ from a measurement concept of production logistics.

Figure 1 illustrates a general process of measurement of autonomous cooperation by the characteristic of "decentralized decision-making" at the executive level of a logistic system, which could be specified as local disposition.

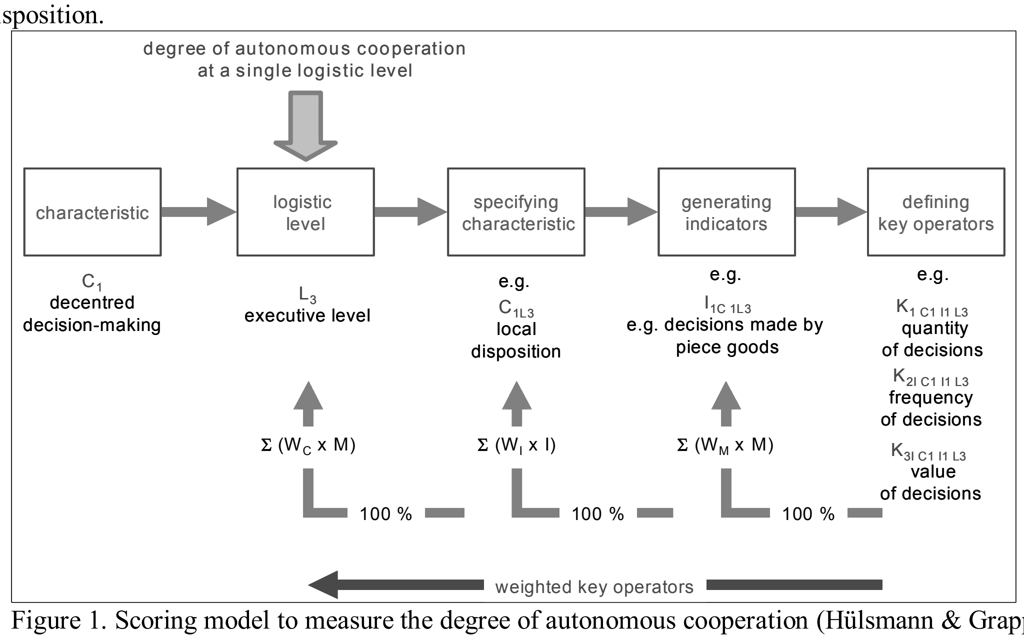



Figure 1. Scoring model to measure the degree of autonomous cooperation (Hülsmann & Grapp 2006)

The specified characteristic local disposition will be transferred into indicators e.g. "decisions made by piece goods". Key operators enable to measure each indicator (Orth 1974) such as in the example: quantity, frequency or value of decisions. The amount of all weighted key figures assigns the value of the particular indicator. Finally, the sum of all weighted indicators composes the weighted score of specific characteristic for a particular level of the production logistic system. To apply the scoring model in practice one possible tool could be a software-based question sheet (Hülsmann & Grapp 2006).

To fulfill the requirement of visualization of the developed measurement instrument, the measured degree of autonomous cooperation can be charted on a polarization graph (Hülsmann & Grapp 2006). The polarization graph represents the measured degree of autonomous cooperation based on its constitutive characteristics, which are in a general understanding decentralized-decision-making, autonomy, non-determinism, interaction and heterarchy (see figure 2). The measured results of each characteristic of autonomous cooperation can be pictured on a scale form from 0 to 100%, while a higher percentage indicates relatively higher degree of autonomous cooperation and a lower percentage indication stands for a relatively higher degree of centralized coordination. Additionally a comparison of the different logistic levels of a logistic system (decision system, information system and executive system) is assumed to be possible regarding their individual degrees of autonomous cooperation (Hülsmann & Grapp 2006).

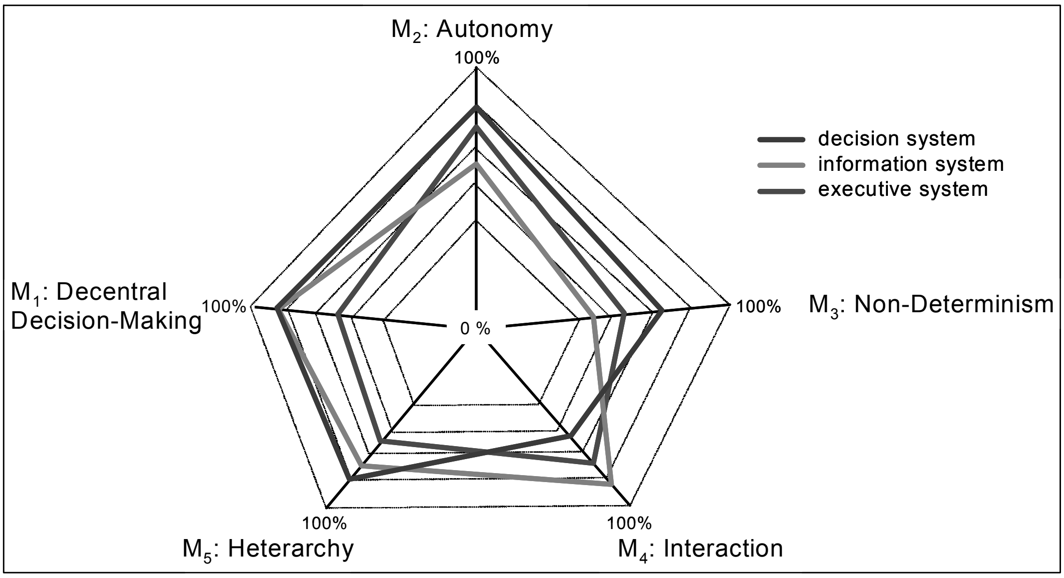



Figure 2. Polarization graph as a possibility to visualize and compare the degree of autonomous cooperation in the different logistics levels (Hülsmann & Grapp 2006)

For a context based interpretation of the gained results not only the measured quantitative degree of autonomous cooperation is significant but its combination with a temporal and spatial analysis (Hülsmann & Grapp 2006). Even if the degree of autonomous cooperation is equal for certain characteristics in different logistic systems, the relevance of the respective value differs with an increasing spatial and temporal validity. The score of the measured degree of autonomous cooperation of the scoring model cannot be used to gain perceptions about the quantity of autonomous cooperating elements. Consequently, it just represents a tendency of more or less autonomous cooperation within a logistic system. Furthermore, due to the logistics systems immanent dynamics it is assumed that the calculated values of the scoring model cannot be considered as absolute. Consequently, the degree of autonomous cooperation should be measured or monitored at different phases in a logistic process (Hülsmann & Grapp 2006).

3.1.2 Specified Measurement Approach of Autonomous Cooperation in the Context of Engineering Science

The main characteristics of the definition of autonomous cooperation in the context of engineering science are the ability of logistic objects to process information and to render and execute decisions. These characteristics can be assigned to different layers of work in an enterprise. In accordance with Ropohl (Ropohl 1979), different layers of work can be classified in organization and management, informatics methods and I&C technologies as well as in flow of material and logistics, each concerning decision and information and execution system.

The decision system is characterized by the decision-making ability. As mentioned before in autonomous controlled production systems decision functions are shifted to logistic objects, which are aligned in a flat organizational structure. These functions contain planning and control tasks and enable logistic objects to assign their progression. The decision-making process includes the identification and evaluation of decision alternatives on the basis of a self, decentralized objective system, the selection, instruction and control of the best rated alternative as well as possible adjustments. The basis for decision-making is the information processing ability on the information system layer. In autonomous controlled production systems logistic objects must be able to interact with each other as well as to store and to process data. The execution system layer is characterized by the decision execution ability of logistic objects. Autonomous logistic objects are able to measure their current state and react flexibly to unforeseeable, dynamic influencing variables. Mobility and high flexibility of the resources are other main criteria of autonomous cooperation in production systems.

In the following a catalogue of criteria is derived, that contains the main criteria of autonomous cooperation described above as well as their properties, which describe the different levels of autonomous cooperation in a logistic production system. The catalogue of criteria is illustrated in form of a morphologic scheme in figure 3.

| System layer | Criteria | Properties | | | |
|---|---|---|---|---|---|
| Decision system | Time behaviour of objective system | static | mostly static | mostly dynamic | dynamic |
| | Organisational structure | hierarchical | mostly hierarchical | mostly heterarchical | heterarchical |
| | Number of alter-native decisions | none | some | many | unlimited |
| | Type of decision making | static | rule-based | | learning |
| | Location of decision making | system layer | subsystem layer | | system-element layer |
| | System behaviour | elements and system deterministic | elements non-/ system deterministic | system non-/ elements deterministic | elements and system non-deterministic |
| Information system | Location of data storage | central | mostly central | mostly decentralised | decentralised |
| | Location of data processing | central | mostly central | mostly decentralised | decentralised |
| | Interaction ability | none | data allocation | communication | coordination |
| Execution system | Resource flexibility | inflexible | less flexible | flexible | highly flexible |
| | Identification ability | no elements identifiable | some elements identifiable | many elements identifiable | all elements identifiable |
| | Measuring ability | none | others | self | self and others |
| | Mobility | immobile | less mobile | mobile | highly mobile |

increasing level of autonomous control →

Figure 3. Extract of catalogue of criteria for autonomously controlled systems (Windt et al. 2005)

The transferring of qualified capabilities (e.g. decision-making, data processing, measuring) from the total system to the system elements, i.e. autonomous logistic objects is the vision of autonomous cooperation. Therefore the visualized system layers relate both to the total system and the system elements. Each criterion has a series of properties, with an increasing level of autonomous cooperation in their order from left to right. For example, a logistic system rendering centralized decisions has a lower level of autonomous cooperation than a system with decentralized decision-making by its elements.

The grey marked properties in Figure 3 show exemplary, how a considered production system could be represented in the catalogue of criteria. This example is described in the form of an exemplary production logistics scenario with the individual criteria and their marked properties following (figure 4).

Each criterion characterizes the behavior of logistic objects and is assigned to different system layer, i.e. decision-making system, information system and execution system. The first production stage contains the manufacturing of a part on two alternative machines (Mij). The raw materials that are needed for production are provided by the source (So). In the second production stage, the assembly of the parts that were produced in the first stage is done alternatively on two machines (Aij). The manufactured items leave the material flow net at the sink (Si) (Windt et al. 2005).

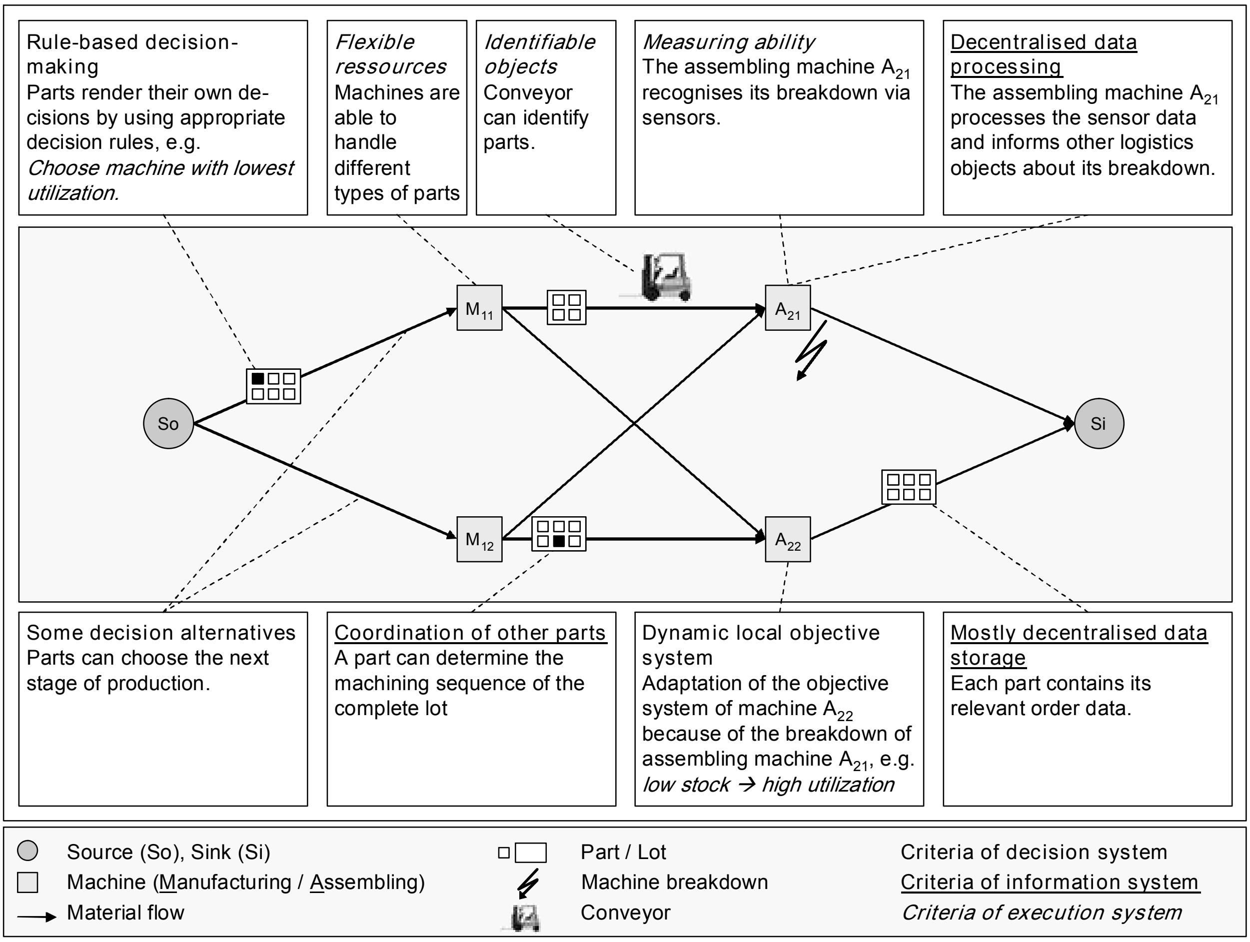


Figure 4. Autonomously controlled production logistic scenario (Windt et al. 2005)

### 3.2 Evaluation of Autonomous Cooperation

In the following, first a general evaluation concept of autonomous cooperation out of financial perspective is presented which is based on the real-options theory. Secondly out of engineering perspective a more specified evaluation concept in the field of production logistics is introduced which allows a concrete determination of the level of logistic objective achievement.

#### 3.2.1 General Evaluation Approach of Autonomous Cooperation

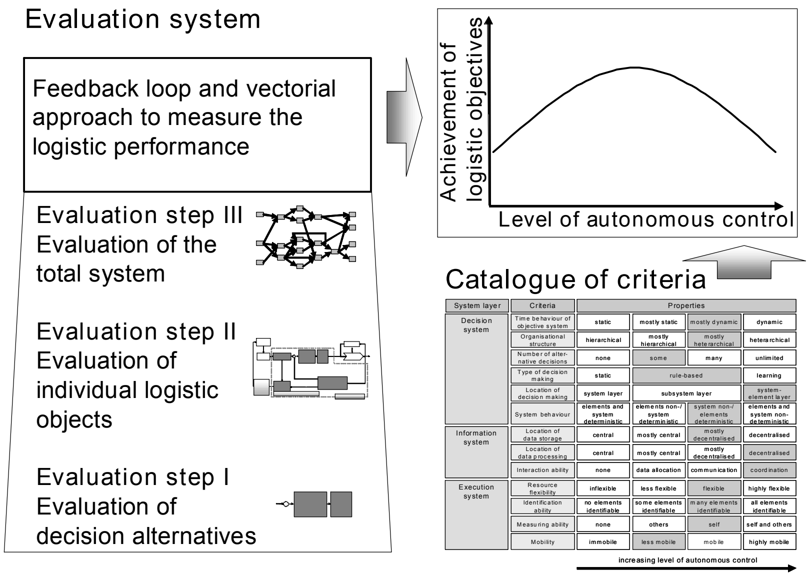
Through the appliance of autonomous cooperation a higher degree of flexibility in the system structure is assumed (Hülsmann & Windt 2006). More precisely, autonomous cooperation feed the logistic system with more acting alternatives to adapt to changing environmental demands. The question that arises is what values those additional options have for acting out of an economical perspective for the firm? To evaluate autonomous cooperation in this context, the real-options-approach could be an appropriate base. This approach differs from other financial evaluation concepts in considering the value of flexibility (in terms of options of acting) explicitly (Trigeorgis 1996). Objectives of a real-options-based evaluation are to identify and to assess options of acting as a result of autonomous cooperation in logistic processes.

The Real-Options-Approach belongs to the research field of investments and finance. Current methods of dynamic investment analysis are the Net-Present-Value-Approach, the Dynamic Amortization Calculation and the Method of Internal Rate of Return (Hommel & Pritsch 1999), whereas the Real-Options-Approach represents an extension of the Net-Present-Value-Approach. Starting point of evaluation is defining the net present value of the considered system (Nowak 2003). The next step of evaluation is the assessment of the options of acting resulting from autonomous cooperation. Different kinds of real-options resulting from autonomous cooperation could be identified, like options to wait/defer, options to expand, options to innovate and switching options. There are several methods to calculate the value of the different kinds of real-options, but what they all have in common is the analogy to financial options (Hommel & Pritsch 1999).

However, the general applicability of the real-options-approach for evaluating autonomous cooperation is not completely proved yet. At first, the process of calculation of the options-values are said to be complicated. The risk of false calculations and mistakes is not marginal. Furthermore, the value of a real-option is hard to forecast due to uncertain future developments of influencing factors. The calculation of volatility is based on foretime information, whose validity is not guaranteed or on objects of comparison. Using objects of comparison could lead to over- or underestimation and thus lead to mistakes in the calculating process of real-options. In the end the life expectancy of real-options is not scheduled as financial options are. This also could lead to false results in the real-options-analysis (Arnold 2005; Hommel & Pritsch 1999). Overall, the real-options-approach seems to be established in theory and practice due to its ability to evaluate options of acting in their flexibility. If it is the right method to evaluate autonomous cooperation it will be further examined in research.

3.2.2 Specified Evaluation Approach of Autonomous Cooperation in the Context of Engineering Science

In order to prove whether the implementation of autonomous logistic processes is useful, an adequate evaluation system is needed. In production logistic systems an adequate evaluation system reflects the degree of logistic objective achievement related to the level of autonomous cooperation. Consequently the degree of the logistic objective achievement as well as the level of autonomous cooperation must be measurable. The level of autonomous cooperation of logistics systems can be determined with an adequate operationalization based on a catalogue of criteria as described before. Furthermore, the logistic objective achievement can be ascertained through comparison of target and actual logistic performance figures related to the objectives low work in process, high utilization, low throughput time and high due date reliability.




| System layer | Criteria | Properties | | | |
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| | Number of alternative decisions | none | some | many | unlimited |
| | Type of decision making | static | rule-based | | learning |
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| Execution system | Resource flexibility | inflexible | less flexible | flexible | highly flexible |
| | Identification ability | no elements identifiable | some elements identifiable | many elements identifiable | all elements identifiable |
| | Measuring ability | none | others | self | self and others |
| | Mobility | immobile | less mobile | mobile | highly mobile |

Figure 5. Logistic objective achievement vs. level of autonomous cooperation (engineering science) (Philipp et al. 2006)

Simulation studies showed that a low level of autonomous cooperation in conventional controlled logistics systems leads to a sub-optimal achievement of logistic objectives (Scholz-Reiter et al. 2006). An increase of the level of autonomous cooperation e.g. by decentralization of decision-making functions to the logistic objects causes a rise of the achievement of logistic objectives (comp. upper curve (right) in figure 5). However at a certain level of autonomous cooperation a decrease in the achievement of logistic objectives can probably be noticed caused by chaotic system behavior. By means of simulation studies the limits of autonomous cooperation shall be detected. Therefore it is possible to specify in which cases an increase of autonomous cooperation does lead to higher performance of the system.

The logistic measurement and evaluation from engineering point of view is bases on a feedback control approach for individual logistic objects as shown in figure 6.

The controlled process is a production process with two logistic objects (an order object as well as a resource object) involved. Starting from a global system of objectives, target values for varying object classes are deduced. This enables for example from an order's point of view a differentiation between customer order and storage order with different target weights for delivery reliability and throughput time of an individual order. Local objectives for individual logistic objects arise based on the object classes' objectives. These local objectives act as reference value for the feedback control approach for autonomously controlled processes. Eventual changes during the production process can immediately be realized through a feedback loop by measuring simultaneously the relevant logistic performance figures. Based on this feedback loop suitable solutions to react on process changes can be found by the evaluation of possible alternatives (Scholz-Reiter et al. 2006).

The deviations of production process from locally desired values are analyzed within the controller (figure 6). All possible alternatives to react on the process deviation will be taken into consideration and are evaluated regarding its forecasted logistic performance. This first evaluation step (figure 5) provides the basis for the following operation procedures of a logistic object through the production floor.

The evaluation-based decision will subsequently be executed by the actuator. For example this might be the transport to a different machine if the object decides to change the manufacturing system because of a higher potential of the degree of logistic objective achievement. At the end of a production order the actual logistic performance figures are compared with the target performance figures (normative-actual value comparison). On this basis the degree of logistic objective achievement of an individual object is calculated. This determination represents the second step of the evaluation system. By taking all objects within the entire system into account and in combination with weights of different objects it is possible to determine the degree of logistic objective achievement for the overall system. The weighting of individual objects or object classes allows to emphasize the importance e.g. of bottleneck machines or specific customer orders. This consideration of the overall system represents the third step of the evaluation system. The target values as well as the actual values are expressed in the form of a vector. This enables a mathematical description and a calculation of the different objective achievements. Through the decentralized feedback control of individual objects an opportunity is given to react on eventual changes or disturbances near real time and thus to increase the logistic performance of the overall system while measuring the individual degree of logistic objective achievement (Philipp et al. 2006).

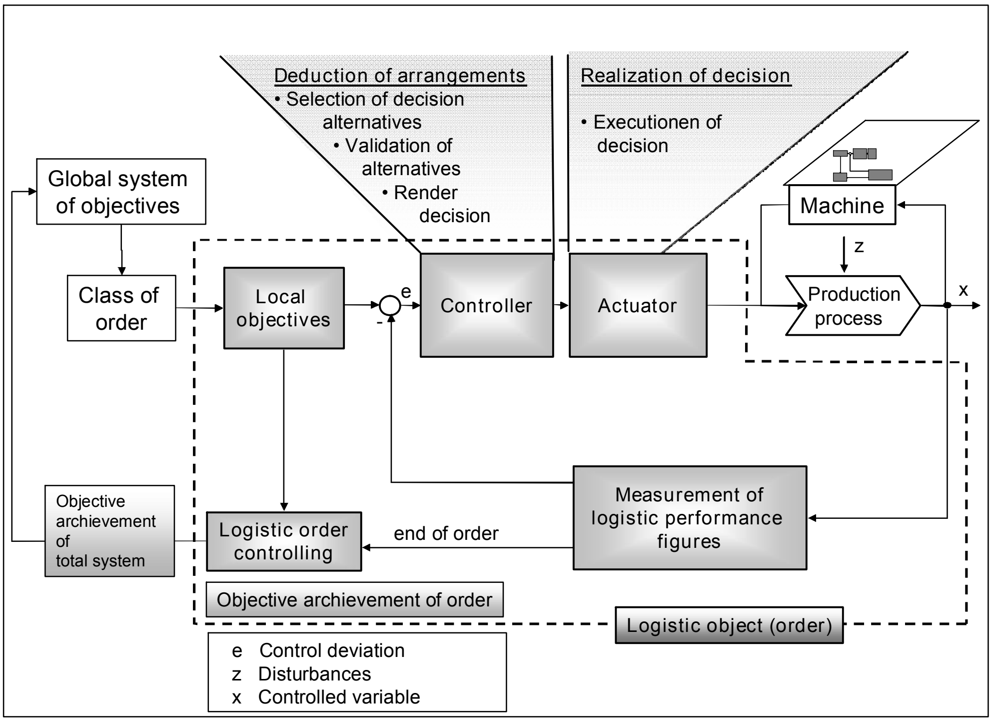


Figure 6. Feedback loop of autonomous cooperation (Philipp et al. 2006) adapted from Wiendahl (Wiendahl 2005)

## 4. Conclusion

Within this paper autonomous cooperation as a new planning and control approach to cope with challenges caused by increasing complexity and dynamics of today's logistics was introduced. To achieve a common understanding a general definition of autonomous cooperation exemplified by a supply network as well as a definition in the context of engineering science was presented. To manage autonomous cooperation efficiently, it has to be measurable and appraisable concerning its relation to central steering objectives like logistics or financial objectives.

Therefore, at first general requirements for measuring autonomous cooperation as well as a measuring concept, which is based on a scoring model, was introduced. Afterwards a specified measuring approach based on the engineering understanding of autonomous cooperation was presented. To ensure the identification of autonomous cooperating processes in production logistic systems and their distinction to conventionally controlled processes a catalogue of criteria was developed. To demonstrate this catalogue, its criteria, the concerning properties were explained by means of an exemplary shop-floor scenario. For the purpose of evaluation of autonomous cooperating processes two concepts were introduced to consider different perspectives of evaluation. One represents the business perspective and the other one the engineering perspective in order to accomplish a comprehensive evaluation system.

Further research is necessary concerning the development of the presented measurement and evaluation concepts of autonomous cooperation. The general scoring model approach has to be enhanced regarding the spatial and temporal analysis of the level of autonomous cooperation. In order to obtain a concrete number for the level of autonomous cooperation from an engineering point of view the catalogue of criteria needs to be operationalized. Furthermore the development of additional criteria and properties is planned in the near future. The evaluation concepts from business perspective and engineering perspective need further research regarding the definition of specific performance indicators for autonomous processes. By usage of simulation studies these evaluation concepts can be validated as a preparation for the implementation in real logistic systems. These simulation studies will also allow the identification of an optimal level of autonomous cooperation in a specific system. The coherence between the level of autonomous cooperation and the logistic performance is dependent on the system's complexity. For this reason it is necessary to do further research on the characterization of complexity in production system as an additional component of the evaluation system.

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# AN ANT COLONY OPTIMIZATION APPROACH FOR SOLVING CONCAVE COST TRANSPORTATION PROBLEMS

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## Abstract

*Transportation problem (TP) is one of the most popular network problems because of the theoretical and practical importance. TP reflects the situation of transporting amounts of a single commodity from a set of suppliers to a set of customers. If the transportation cost linearly depends on the transported amount of the commodity, then the TP is solvable in polynomial time with linear programming methods. However, in real world, the transportation costs are generally nonlinear, especially concave where the unit costs decrease while amount of transporting amount increasing. Since concave cost transportation problems (ccTP) are NP-hard, solving large-scale problems is time-consuming. Therefore, metaheuristics such as simulated annealing (SA), tabu search (TS), genetic algorithms (GA), and ant colony optimization (ACO) have gained considerable attention to solve complex optimization problems. In this study, we propose a new algorithm based on the ACO approach, which is inspired from foraging behavior of real ants, to solve the ccTP. The effectiveness and efficiency of the developed algorithm have been investigated on different size transportation problems using SA linear threshold acceptance (LTA), an adaptive tabu-SA (ATSA) algorithm proposed in literature for the ccTP.*

Keywords: Transportation problem, concave cost, metaheuristics, ant colony optimization

## 1. Introduction

Supply Chain Management (SCM) describes the discipline of optimizing the delivery of goods, services and information from supplier to customer. Typical supply chain management goals include transportation network design, plant/DC location, production schedule streamlining, and efforts to improve order response time. Transportation network design is one of the most important fields of SCM. It offers great potential to reduce costs and to improve service quality. For the planning of large-scale regular service networks, small daily savings of a few percent can imply substantial overall savings caused by the regular repetition of transportation processes. The transportation problem (TP) is well-known basic network problem which was originally proposed by Hitchcock (1941).TP reflects the situation of transporting amounts of a single commodity from a set of suppliers to a set of customers. The capacities of the suppliers and the demands of the customers are known a priori, and a feasible transportation plan must obey these restrictions. The goal is to minimize the overall shipping cost with the transportation cost between suppliers and customers. If the transportation cost linearly depends on the transported amount of the commodity, then TP is solvable in polynomial time with linear programming methods (Ahuja et al., 1993). However, in practice, the transportation costs are generally nonlinear, especially concave where the unit costs decrease while amount of transporting product increasing. The fare structure for freight transportation can be given an example to concave transportation cost (Yan and Luo, 1999).

Since concave cost transportation problems are NP-hard, solving large-scale problems is time-consuming. Recently, meta-heuristic optimization methods such as simulated annealing (SA), tabu search (TS), genetic algorithms (GA) have been successfully applied to solve different TP problems. For example, Michalewicz *et* al (1991) were the first researches that discussed the use of GA for solving nonlinear TP. They showed that the GA was able to produce high-quality solutions on most of the nonlinear TPs when compared with a gradient-based method. Gen and Li (1998, 1999) have applied the GA for solving bicriteria fixed charged and bicriteria fuzzy TPs. Syarif and Gen (2003) have used the GA for nonlinear and exclusionary side constraint TPs. The heuristic approaches based on TS for nonlinear side constraint, fixed-charged, and exclusionary side constraint TPs have been proposed by Cao and Uebe (1995), Sun *et al* (1998) and Sun (1998), respectively. Yan and Luo (1999) have developed new heuristics based on SA and threshold acceptance (TA) for solving ccTP. Altiparmak and Karaoglan (2006) have also proposed an adaptive tabu-SA approach for the ccTP.

The ant colony optimization (ACO) method has emerged recently as a new meta-heuristic for hard combinatorial optimization problems. ACO algorithms have been inspired by the capability of real ants to find the shortest path from a food source to their nest. Due to the attractiveness about ant behaviors and simplicity in implementation, ACO has been gaining more and more research attention during last decade. It has been successfully applied to solve the traveling salesman problem (Dorigo, Maniezzo and Colorni, 1991; Dorigo and Gambardella, 1997a; 1997b), graph coloring problem (Costa and Hertz, 1997), quadratic assignment problem (Maniezzo, 1998),

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generalized minimal spanning tree problem (Shyu et al., 2003), scheduling problems (Jayaraman et al. 2000; Shyu et al. 2001), stenier tree problem (Hu et al., 2006), and degree constraint minimum spanning tree problem (Bau et al., 2005). In this paper, a new heuristic approach based on the one of the versions of ACO algorithms, called MAX MIN Ant System (MMAS), is developed to find approximate solution to the ccTP and its effectiveness is comparatively investigated on different size problems using heuristic approaches proposed in the literature.

This paper is organized as follows: the concave cost transportation problem is given in the Section 2. While the Section 3 includes brief information about ACO, our ACO approach for the ccTP is described in the Section 4. The Section 5 gives computational results and conclusion follows in the Section 6.

## 2. The Concave Cost Transportation Problem

The general TP is formulated as a bipartite network, $G = (N, A, M)$, where $N$ is the set of all supply nodes (facilities, distribution centers, etc.), $M$ the set of all demand nodes (customers, warehouses, etc.), and $A$ the set of all arcs. Arc $(i, j)$ denotes the arc from supply node $i$ to demand node $j$. Let $a_i$ be the capacity of supplier $i$, $i\in N$, and $b_j$ the demand of the customer $j$, $j\in M$ (Ahuja et al., 1993). In ccTP, cost for each arc in $A$ is concave function of transporting units on $(i, j)$. Due to the nature of the TP, numerous nonlinear cost functions can be considered. As in the Yan and Luo's (1999) study, we consider $f(x_{ij}) = c_{ij}\sqrt{x_{ij}}$ for arc $(i, j)$ as nonlinear cost function, where $x_{ij}$ and $c_{ij}$ denote the amount of product transported (i.e. flow) and the per unit variable cost corresponding to $(i, j)$, respectively. The objective of the ccTP is to find the route satisfying all demands from the supply nodes to demand nodes. The ccTP can be formulated as follows:

$$\text{Minimize} \quad f(x) = \sum_i \sum_j c_{ij} \sqrt{x_{ij}} \qquad (1)$$

$$\text{Subject to:} \quad \sum_j x_{ij} \le a_i \quad \forall i \in N \qquad (2)$$

$$\sum_i x_{ij} \ge b_j \quad \forall j \in M \qquad (3)$$

$$x_{ij} \ge 0, \text{int} \quad (i, j) \in A \qquad (4)$$

In this model, constraint (2) is the capacity constraint. Constraint (3) guarantees that all demands are met. In this problem, one must determine the amount of the product to be transported from supply node $i$ to each demand node $j$ so that all constraints are satisfied and the total transportation cost can be minimized. In the ccTP, we assume the balance equation is satisfied since we can convert an unbalanced problem into a balanced problem by introducing dummy supply center or dummy customer. If there exists an arc from each supply node to each demand node, the network is called as fully connected, i.e. there are $|N|*|M|$ arcs in the network.

## 3. Ant Colony Optimization

Ant colony optimization (ACO) system, namely, the ant system (AS) was proposed by Dorigo (1992) to solve hard combinatorial optimization problems. Several variants or extended versions of the AS, such as MAX MIN AS (MMAS), approximate nondeterministic tree search (ANTS), ant colony systems (ACS), etc. have been successfully applied to the well known NP-hard problems, such as the traveling salesman problem, graph coloring problem, quadratic assignment problem, generalized minimal spanning tree problem, scheduling problems, stenier tree problem, and degree constraint minimum spanning tree problem. The ACO is inspired by the behaviors of real ants. Ethnologists find that ants could manage to construct the shortest path from their colony to the feeding source through the use of pheromone trails. An ant leaves some quantity of pheromone on the ground when it travels and marks the path by a trail of this substance. The pheromone would evaporate at a certain rate as time goes on. The next ant will sense the pheromone remained on different paths and choose the one with a probability proportional to the amount of pheromone. Then the ant follows the path and leaves its own pheromone. This is an autocatalytic process. The path in where more previous ants have traveled is favored by this process. This kind of path finding process can be considered as knowledge sharing with collaborative efforts. Therefore, the main idea in ACO is based on communication via pheromone between ants.

The ACO simulates the behavior of real ants to cope with hard optimization problems. Initially, it distributes a population of ant-like agents (for simplicity, called ants) on a graph which is transformed from the underlying problem. Then, the ants walk on the graph to obtain a tour according to the pheromone intensities on the edges. When a tour is completed, an extra pheromone is added to the edges into the tour based on the quality of the tour. The process is repeated until predefined stopping criterion is met. The attractiveness of the ACO comes

```
represent the problem with a connected weighted graph
set the initial pheromone for each edge.
while stopping criterion not met do
        for each ant do
            randomly select a starting node
            while a tour is not completed do
                  move to the next node according to the node transition rule
             end while
        end for
        for each edge do
           update the pheromone intensity using the pheromone updating rule
        end for
end while
Output the global best tour
```

Figure 1. Basic structure of the ACO

from the fact that it uses natural metaphor, positive feedback and stochastic process, and can be implemented in parallel (Dorigo and Stützle, 2004). The basic structure of the ACO algorithm is given in Figure 1.

The best tour reported by the ACO algorithm is a path in the graph that reflects the attempt to optimize the objective of the problem under the set of constraints. Dorigo et al (1996) has pointed out some difficulties encountered when the ACO algorithm is applied to solve any problem. These are:

- Finding an appropriate graphical representation for the underlying problem
- Finding a greedy heuristic algorithm for the node transition rule.

In this paper, ccTP is considered. The objective of the ccTP is to find the route, i.e. transportation tree, satisfying all demands from the supply nodes to demand nodes. When a tree optimization problem is considered, finding an appropriate tree construction strategy for the problem is another difficulty encountered. Since the transportation tree is a special type of spanning tree, its construction by an ant during the search process is an important part of the proposed ACO algorithm.

## The Proposed ACO Approach for the ccTP

The proposed ACO approach for the ccTP, called TP-ACO, is based on MMAS since it has several advantages according to the AS. Dorigo and Stutzle (2004) summarize them as follows: First, it strongly exploits the best tour found that is either iteration best or global best solution to deposit pheromone. However, this strategy can lead to premature convergence because of the excessive growth of pheromone values on the arcs of the best solution. To prevent this disadvantage, a second modification introduced by MMAS is that it limits the possible limit range of pheromone trial values to the interval $[\tau_{\min}, \tau_{\max}]$. Third, to explore the solution space at the beginning of the algorithm, all pheromone values are initialized to $\tau_{\max}$ together with small evaporation rate. Lastly, pheromone trails are reinitialized when the system converges to a solution or no improvement has been obtained for a certain number of successive iteration.

In this section, we introduce the tree construction heuristic, local improvement procedure, pheromone updating rule and stopping criterion for the TP-ACO.

### Tree Construction Heuristic

As mentioned before, the transportation tree is a special type of the spanning trees. Therefore, the method of tree construction for the TP by an ant is different from the approaches proposed in the literature which are used to obtain spanning tree for the problems such as generalized minimum spanning tree, degree constraint minimum spanning tree, Steiner tree, etc.( Shyu et al, 2003; Bau et al., 2005; Hu et al., 2006). Tree building in TP-ACO is an iterative procedure where a population of ants works in parallel to generate feasible solutions. For an ccTP instance with $|N|$ supply nodes and $|M|$ demand nodes, each ant is allowed $|N|+|M|-1$ steps to generate a feasible transportation tree. Let $T$ be the transportation tree, $T_{r-1}$ the ($r$-1) cardinality tree, $N$ and $M$ the set of unvisited supply and demand nodes, respectively, $A'$ the set of arcs between unvisited supply and demand nodes, and defined as below:

$$A' = \{(i, j) \mid i \in N' \text{ and } j \in M'\} \qquad (5)$$

Initially, $A'$, $N$ and $M$ are set to $A$, $N$ and $M$, respectively. To build a solution, an ant starts from a randomly chosen arc, i.e. $(i, j) \in A$ . At each step of the tree construction, an arc $(i, j) \in A$ is added to the $T_{r-1}$. When an arc ($i$, $j$) is selected, the amount of product transported between supply node $i$ and demand node $j$ is determined as $x_{ij} = \min\{a_i, b_j\}$, and the availability of corresponding nodes are updated as $a_i = a_i - x_{ij}$ and $b_j = b_j - x_{ij}$. If $a_i$ is zero, then supply node $i$ is eliminated from the $N$, otherwise $M$ is updated by discarding the demand node $j$ from it. The choice of the next edge to be added depends on the underlying pheromone model. This model includes a pheromone trail parameter $T_{ij}$ with pheromone trial value $\tau_{ij}$ for every arc $(i, j) \in A$. Therefore, the number of pheromone trail parameters is equal to number of arcs in the transportation network. Given the set $A'$, the next arc is chosen with a random proportional scheme. This scheme assigns the probability to each arc in the $A'$ which will be selected by ant $k$ as given equation (6):

$$p_{ij}^{k} = \begin{cases} 1, & \text{if } q < q_0 \text{ and (i, j)} = \arg\max\{(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta} \mid (i,j) \in A'\} \\ \dfrac{(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}{\sum_{(i,j)\in A}(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}} & \text{if } q \geq q_0 \end{cases} \quad (6)$$

where $\alpha$ and $\beta$ are the parameters that control the relative importance of global and local preferences, and $\eta_{ij}$ is the visibility value (i.e. heuristic information) on the arc $(i, j)$ and it is determined as $\eta_{ij} = 1/r_{ij}$ where $r_{ij} = c_{ij}/\sqrt{x_{ij}}$ that gives the unit transportation cost. As a result, $\eta_{ij}$ is defined as the inverse of the unit transportation cost. As seen in equation (6), ant $k$ selects the best desirable arc with probability $q_0$ according to learned pheromone knowledge and heuristic information (exploitation), and with probability (1- $q_0$) it selects an arc according to random proportional rule (exploration). It is important to note that the size of $A'$, i.e. the number of arcs which can be added to tree, increases enormously with the problem size. For example, in a transportation network with 100 supply nodes and 100 demand nodes, there are 10000 arcs in the first step of tree construction. Although this value gradually decreases in the later steps of tree constructions, selection of an arc from $A'$ is very time consuming process in the earlier steps of this process. To save computation time for tree construction process, the candidate list strategy is used. In the preliminary experiments, it is seen that arcs which are in optimal solution, are in the first 20% of the list of arcs which are sorted non-decreasing order in terms of unit transportation cost. Therefore, at each iteration of construction phase, all available arcs sorted in non-decreasing order according to unit variable cost and the first 20% of them are selected for the $A'$. Figure 2 gives the overall procedure to construct transportation tree.

Local Improvement Procedure

To accelerate the convergence of the TP-ACO, a local improvement has been implemented to the iteration best solution ($S^{ib}$) after all ants in an iteration have constructed a solution. A simple hill-climbing (HC) approach is used as local improvement procedure. In the HC, a new solution ($S_n$) is obtained from $S^{ib}$ using a moving strategy defined below. If $f(S_n) < f(S^{ib})$, then $S_n$ is considered as $S^{ib}$ and this procedure is repeated till no further improvement is possible.

*Moving Strategy*: A move is defined to be a transition from one feasible solution to another. For the ccTP, simplex method on graph is used to obtain a move. Hence, a move is equivalent to one iteration or one pivot in the simplex method on graph. Let $S$ be a spanning tree representing the basis of the transportation network. Since there are $|N| + |M| - 1$ arcs in $S$, the number of candidate arcs for entering to $S$ is $|N|*|M|-(|N|+|M|-1)$. At the current basic feasible solution, any $(i, j) \notin S$ is replaced with $(k, l) \in S$ to transit from the current basic feasible solution to an adjacent basic feasible solution and each such transition is a candidate for the next move. The neighborhood of a given basic feasible solution is composed of all basic feasible solutions that can be reached within one move. Suppose $(i, j) \notin S$ is considered for introducing to spanning tree in the next move. Entering this arc to $S$ forms a circuit. The leaving arc from $S$ is selected from this circuit. To determine the leaving arc, a path, $P \subset S$, from node $j$ to node $i$ is constructed. As in the network flow simplex algorithms, the leaving arc $(k, l) \in P$ is determined by the following test to maintain primal feasibility:

$$\delta = \min\{x_{kl} \mid (k,l) \in P\} \quad (7)$$

where $x_{kl}$ is the shipment amount of product from supply node $k$ to demand node $l$. The leaving arc $(k, l)$ is one

set $N' \leftarrow N,\ M' \leftarrow M,\ A' \leftarrow A,$

determine the $A'$ using candidate list strategy

choose an edge $(i, j) \in A'$ with probability $p_{ij} = \dfrac{(\tau_{ij})^{\alpha} (\eta_{ij})^{\beta}}{\sum_{(i,j) \in A'} (\tau_{ij})^{\alpha} (\tau_{ij})\beta}$

$A(T_1) \leftarrow \{i, j\}$,

$N(T_1) \leftarrow \{i\}$,

$M(T_1) \leftarrow \{j\}$,

assign available amount of units to $x_{ij} = \min\{a_i, b_j\}$

update the availability of corresponding supply and demand nodes $a_i = a_i - x_{ij}$ and $b_j = b_j - x_{ij}$

if $a_i = 0$ then $N' \leftarrow N' - \{i\}$,

if $b_i = 0$ then $M' \leftarrow M' - \{j\}$,

for $r = 2$ to $|N|+|M|-1$ do

determine the $A'$ using candidate list strategy

generate a random number q ~U(0,1)

if $q < q_0$ then choose an edge $(i, j) \in A'$ with deterministically:

$$(\text{i, j}) \leftarrow \arg\max\{(\tau_{ij})^{\alpha} (\eta_{ij})^{\beta} \mid (i, j) \in A'\}$$

else choose an edge $(i, j) \in A'$ with probabilistically:

$$p_{ij}^{k} = \frac{(\tau_{ij})^{\alpha} (\eta_{ij})^{\beta}}{\sum_{(i,j) \in A} (\tau_{ij})^{\alpha} (\eta_{ij})^{\beta}}$$

$A(T_r) \leftarrow \{i, j\}$,

$N(T_r) \leftarrow \{i\}$,

$M(T_r) \leftarrow \{j\}$,

assign available amount of units to $x_{ij} = \min\{a_i, b_j\}$

update the availability corresponding supply and demand nodes $a_i = a_i - x_{ij}$ and $b_j = b_j - x_{ij}$

if $a_i = 0$ then $N' \leftarrow N' - \{i\}$,

if $b_i = 0$ then $M' \leftarrow M' - \{j\}$,

end for

Figure 2. Procedure to construct transportation tree

such arc for which the value of δ is obtained. After determining the leaving arc, the shipment amount of arcs in $P$ are adjusted and cost of the new transportation spanning tree is calculated.

Pheromone Trial Limits and Pheromone Trial Updating Rule

In TP-ACO, all pheromone trail values are initialized to $\tau_{\max}$ , and during the search process these values are restricted in the interval of $[\tau_{\min}, \tau_{\max}]$ to avoid search stagnation. There are two ways for estimating $\tau_{\max}$. Firstly, $\tau_{\max}$ is set to a high value and adjusted according to best solution of first iteration. Secondly and most preferable, a solution, which is obtained by randomly or a heuristic approach developed for the underlying problem, can be used to determine the value of $\tau_{\max}$. In this paper, a heuristic approach developed by Yan and Luo (1999) is used to obtain an initial solution ($S^{in}$) for the ccTP, and lower and upper limits of the pheromone trial values are determined with the objective function value of $S^{in}$. Therefore, while $\tau_{\max}$ is set to $1/[f(S^{in})\rho]$, $\tau_{\min}$ is set to $\tau_{\max}/a$ in where $0 < \rho \le 1$ is the pheromone evaporation rate and $a$ is a parameters.

After all ants in an iteration have constructed a solution and a local improvement has performed for the iteration best solution $(S^{ib})$, pheromone trail values of all arcs in transportation network are decreased as follows:

$$\tau_{ij} = (1-\rho)\tau_{ij}, \quad (i, j) \in A \tag{8}$$

where $0 < \rho \le 1$ is the pheromone evaporation rate. This rate is used to avoid unlimited accumulation of the pheromone trail on the arcs. After evaporation, pheromone trail values of the arcs in $S^{ib}$ are updated as in equation (9):

$$\tau_{ij} = \tau_{ij} + \Delta\tau_{ij}^{ib}, \quad (i, j) \in S^{ib} \tag{9}$$

where $\Delta\tau_{ij}^{ib} = 1/ f(S^{ib})$ . It is important to note that when $\tau_{ij} < \tau_{\min}$ or $\tau_{ij} > \tau_{\max}$ , this value is set to closest bound value.

Stopping Criterion

The stopping criterion of the ACO algorithm can be defined by the number of solutions searched, CPU time limit, or a given number of consecutive iterations within which no improvement on solutions is attained. In this paper, the number of solutions searched is considered as stopping criterion to obtain quality solutions in a reasonable time.

## 5. Experimental Study

To test the performance of the TP-ACO, three heuristic approaches given in the literature for the ccTP are considered. The first two approaches developed by Yan and Luo (1999) are based on SA and LTA. The last heuristic proposed by by Altiparmak and Karaoglan (2006) is a hybridization of SA and TS, and it is called adaptive tabu-simulated annealing (ATSA). All algorithms; TP-ACO, SA, TA and ATSA were coded in C++ programming language and run on Pentium 4, 2.8 GHz clock pulse with 512 MB memory.

The comparative experiments were conducted on two sets of test problems. The first set includes three small-size networks in which the number of supply and demand nodes varies between 4 and 6. Optimal solution for each small-size network was obtained by an exhaustive enumeration method (EEM). The second set consists of seven medium-size networks that are not solved optimally and the number of supply and demand nodes on the network varies from 10 to 50. Table 1 gives test instances and their total supply (demand) for networks. Each test instance is fully connected, i.e. there is an arc between every supply and demand nodes. The supply and demand for all nodes are randomly determined. To ensure that the flows are balanced at all nodes, the sum of all node supply is equal to that of all node demand. The arc costs in all test problems were randomly generated between 3 and 8.

Table 1. Total supply (demand) for test problems

| Problems | Network size ($\|N\|$ x $\|M\|$) | Total Supply |
|---|---|---|
| Small-size networks | 4x4 | 1600 |
| | 5x5 | 2500 |
| | 6x4 | 2400 |
| Medium-size networks | 10 x 10 | 10000 |
| | 12 x 12 | 14400 |
| | 20 x 20 | 40000 |
| | 25 x 25 | 62500 |
| | 30 x 30 | 90000 |
| | 40 x 40 | 160000 |
| | 50 x 50 | 250000 |

The parameters of the TP-ACO are set to the following values: $\alpha = 1$, $\beta = 5$, and $\rho = 0.02$. The number of ants depends on the network size and it is set to $|N|+|M|$ for each test instance. While $q_0$ is taken as 0.25 if $|N|+|M| \leq 50$, it is set to 0.50 for the other test instances.

Since the heuristic approaches are stochastic search algorithms, five runs of each algorithm were made using different random number seeds for each test instances. To make fair comparison between heuristics, the maximum number of solutions searched was considered as a stopping criterion and is set to ($|N|\cdot|M|\cdot 100$).

Table 2 gives the best costs within 10 runs and average solution time of EEM, SA, LTA, ATSA and TP-ACO for small-size networks. The 'best cost' columns in the table show that each heuristic reaches optimum solution in a very small time when compared to time of the EEM. It is also important to note that each heuristic finds the optimum solution on each run. Table 3 summarizes the comparative results of TP-ACO with those of SA, LTA and ATSA. As it is seen from this table, while all heuristics reach the same best solution for the first problem, ATSA and TP-ACO obtain better solution than SA and LTA for the second problem. For the remaining problems, TP-ACO outperforms the heuristics with respect to best, average and worst costs. Figure 3 shows the convergence behavior of the heuristics during the search process. It is clearly shown in this figure that TP-ACO gives better convergence than that of the other heuristics.

Table 2. Computational results of small-size networks

| | EEM | | SA | | LTA | | ATSA | | TP-ACO | |
|---|---|---|---|---|---|---|---|---|---|---|
| Network ($\|N\|$ x $\|M\|$) | Optimum | Time (sec.) | Best Cost | Time (sec.) | Best Cost | Time (sec.) | Best Cost | Time (sec.) | Best Cost | Time (sec.) |
| 4x4 | 455 | 0.66 | 455 | 0.06 | 455 | 0.06 | 455 | 0.06 | 455 | 0.08 |
| 5x5 | 622 | 197.09 | 622 | 0.08 | 622 | 0.08 | 622 | 0.08 | 622 | 0.08 |
| 6x4 | 582 | 104.09 | 582 | 0.09 | 582 | 0.09 | 582 | 0.09 | 582 | 0.09 |

Table 3. Computational results of medium-size networks

| Network | SA | | | LTA | | | ATSA | | | TP-ACO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Best Cost | Average Cost | Worst Cost | Best Cost | Average Cost | Worst Cost | Best Cost | Average Cost | Worst Cost | Best Cost | Average Cost | Worst Cost |
| 10 x 10 | 1345 | 1350 | 1357 | 1345 | 1355 | 1357 | 1345 | 1345 | 1345 | 1345 | 1345 | 1345 |
| 12 x 12 | 1829 | 1831 | 1835 | 1829 | 1867 | 1893 | 1798 | 1817 | 1829 | 1798 | 1801 | 1816 |
| 20 x 20 | 3689 | 3733 | 3825 | 3566 | 3652 | 3685 | 3542 | 3603 | 3674 | 3490 | 3500 | 3525 |
| 25 x 25 | 4687 | 4711 | 4741 | 4642 | 4673 | 4698 | 4566 | 4664 | 4705 | 4526 | 4539 | 4573 |
| 30 x 30 | 6379 | 6414 | 6501 | 6310 | 6484 | 6542 | 6265 | 6302 | 6337 | 5943 | 6001 | 6059 |
| 40 x 40 | 9277 | 9327 | 9405 | 9208 | 9273 | 9305 | 9195 | 9212 | 9237 | 9056 | 9095 | 9133 |
| 50 x 50 | 12613 | 12675 | 12723 | 12675 | 12715 | 12749 | 12563 | 12626 | 12668 | 12425 | 12473 | 12537 |

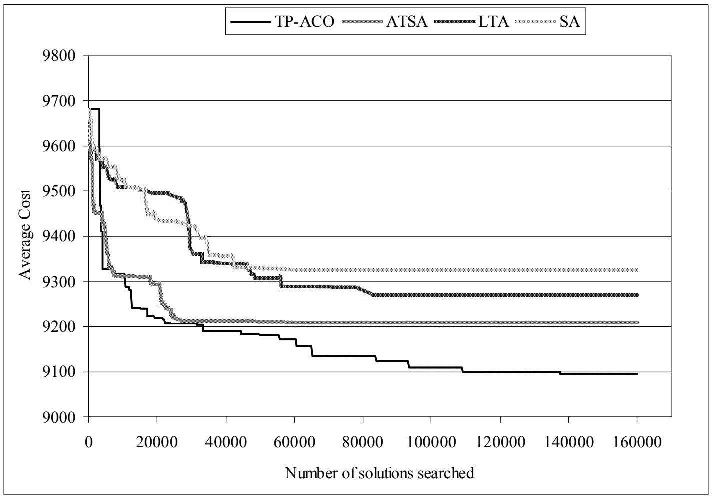

Figure 3. Comparison of the convergence of the TP-ACO, ATSA, SA and LTA

## 6. Conclusion

In this paper, we proposed an implementation of ant colony optimization approach, called TP-ACO, to solve the concave cost transportation problem (ccTP). To demonstrate its effectiveness and efficiency, we have carried out an experimental study on small and medium-size networks. The experimental study shows that although all heuristics exhibit similar performance on small-size networks, TP-ACO outperforms the other heuristic approaches with respect to solution quality and its convergency to good solutions when the network size increases. Further research may be performed to investigate the effectiveness of proposed algorithm on fixed-charged, exclusionary side constraint and multiobjective transportation problems which are faced in real world.

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# APPLICATION OF CONTROL THEORY MODELING TO STUDY THE IMPACT OF CAPACITY EXPANSION DECISIONS IN SUPPLY CHAINS

Jalal Ashayeri[1], Xumei Yuan [2]

## Abstract

*The importance of capacity expansion decisions to lift constraints in parts of supply chains has increased significantly in recent years due to general ever-increasing performance requirements. Within a supply chain, insufficient capacity gradually leads to deteriorating delivery performance, and as a consequence, lowers revenue and market share. However, supply chain capacity expansion decisions are rather complex, and must take into account not only the resources requirements, but also the structure of the chain with its three main flows: goods, information, and financial flows. Furthermore, for financial reasons, usually only limited investments can be made to expand capacities of a supply chain at one time. Therefore, it is critical to systemically address this decision by identifying the main (and mostly inter-dependent) factors affecting such a decision. This research proposes an approach to combine system dynamics loops and control theory simulations to thereby study and analyze the impacts of various factors on capacity expansion strategies within a supply chain. Our study shows that capacity expansion decision requires a careful investment tradeoff for reducing the three flows' delays, and that cannot be achieved without changes in the structure of supply chain or adjusting policies employed.*

*Keywords: Supply chains, capacity expansion, control theory, system dynamics*

## 1. Introduction

Effective capacity design has been increasingly emphasized because of the proven financial benefits that are gained from efficient customer response. Akkermans et al. (2003) consider capacity design as a one time decision, however for many companies in a supply chain, it's inevitable to face demand for capacity expansion as an on-going decision, owing to technological developments, decreasing product life cycles, and a greater reliance on outsourcing. For financial reasons, only limited investments can be made in expanding the capacities of a supply chain at a time. Therefore, a balanced strategy is required to consider the proper rate of investment for capacity increases as opposed to other major investment decisions, such as increasing sales efforts to expand markets. The proper timing of these investment decisions impacts the revenue, the level of service provided, and the business growth. Accurate timing in expanding capacities will enhance the reliability of supply and delivery by independent business units within a chain. Therefore, supply chain main actors must urgently resolve the tension between capacity deficit and economic profit, while ensuring sustainable business growth.

System dynamics modeling has a major role to play in supply chain design and analysis, especially at the aggregate level. Such modeling can help detect the missing feedback loops. In this paper, alternative supply chain modeling which in Control Engineering terms sometimes proved to be superior to system dynamics namely, Control Theory is used. Our own experience with "live" supply chains such as fast-moving consumer goods and electronics (Ashayeri & Keij, 1998, Ashayeri & Lemmes, 2006), whilst confirming the likelihood of demand amplification as reasons for many undesirable results in supply chain, it suggests some causes related to system structure, some to operating details or new technological developments, and yet others to policies and human interference. For many of these reasons neither historical data is available nor can be collected. Control Theory use can highlight areas of performance improvement, especially when combined with transfer function analysis for the areas with limited data or no data. This research proposes a framework for combining the system dynamics loops and control theory simulation to study and analyze the impacts of capacity expansion strategy systematically and quantitatively in a supply chain. A block diagram in which the sources of amplification may be diagnosed can replace the process of modeling of systems dynamics loops and sensitivity analysis will allow measuring the impact of alternative solutions.

The purpose of the paper is twofold. The primary objective is to investigate the impact of capacity expansion decisions in supply chain and to increase the understanding of the effects of and interrelationships among the critical factors. A second objective is to show the use of control theory as a method to be applied to this type of problem.

This paper is organized as follows. First, we review briefly the main contributions relating to systems dynamics, control theory as simulation tools to study supply chain management problems. In section 3, we develop block diagram and transfer function description of an enhanced version of Sterman's High-Tech Growth Firms' model. The new model includes additional casual loops affecting capacity expansion process in real-life. In section 4

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presents a sensitivity analysis of the enhanced model. Using orthogonal experimental design, the impact of each parameter is analyzed and the results are discussed. Finally, section 5 presents the conclusions.

## 2. Literature Review

Simulation is used to model efficiently a wide variety of systems that are important to managers. One particularly fast-growing area of simulation applications lies in experiential games, nowadays referred to as "Board-Room Games". During the last decade simulation has been recognized as an important tool for modeling and analyzing supply chains, so much that all leading SCM software suites offer dynamic simulation module.

Simulation has been used as an effective means for analyzing dynamically changing internal supply chain variables to support the quantification of the benefits resulting from supply chain management (SCM) (Terzi & Cavalieri, 2004). Supply chain simulations can incorporate feedback processes and demonstrate the impact of supply chain dynamics, and then lead to insights into players' behavior, decisions making, and supply chain dynamics. Also, simulation makes it possible to deploy holistic improvements through the supply chain.

In order to understand the dynamic behavior of complex systems, based on information feedback and delays System Dynamics (SD) simulation has been applied to a wide range of problem domains, including supply chain management (Angerhofer & Angelides, 2000). Over the last two decades, the use of SD modeling in supply chain has been very limited but recently given complexity in supply chains has gained increased popularity. A typical objective in these SD models includes studying the bullwhip and information sharing effects, forecasting, and inventory policy development. Given the limited space available, here only very few papers are referenced. For a more recent overview of literature see (Ashayeri & Lemmes, 2006) and (Akkermans & Dellaert, 2005).

Control theory (CT) is another approach to the deeper understanding of dynamic behavior of systems. Classical control theory advocates a wide range of attributes and measures for proper design, such as stability, tracking ability and noise rejection and has developed various methods for describing and analyzing such systems.

As (Towill, 1982) mentioned, Simon (1952) first introduced control theory for the analysis of inventory and order-based production scheduling systems using the Laplace transform concepts to a single loop continuous time system, and after that, many authors followed. For a historical overview on control theory applications in production and inventory control management, we refer to (Disney & Towill, 2002). We also draw attention to (Wikner et al., 1991), (Grubbstrom, 1996, 2000), (Disney & Towill, 2003), (Disney et al., 2004), (Dejonckheere et al., 2002,2003,2004), and (Lalwani et al., 2006) for their contributions on replenishment rules and inventory fluctuations using transform techniques. The literature shows that there is an increased interest in the use of CT in supply chain environment in recent years. It also suggests that the Laplace transform use is more frequently reported than the z-transform. (Disney et al., 2006) demonstrates that the management insights gained from both the continuous and discrete time approaches are very similar, and conclude that for practical purposes either time domain can be used in an analysis.

## 3. Control Theory simulation model of High-Tech Growth Firms

The methodology used in this paper is control system engineering. In control systems engineering, the transfer function of a system represents the relationship describing the dynamics of the system under consideration. It algebraically relates a system's output to its input, which is easier to analyze and design. (Disney & Towill, 2002) provide an excellent summary of motives to use this particularly powerful method of systems analysis in supply chain, such as: (1) the use of standard forms simplifies benchmarking and promulgation of models describing best practice; (2) the judicious integration of transfer function techniques with simulation enables added insight into system design; (3) there exists a number of techniques for transferring problems from one domain into another domain in order to gain insight from situations that have already been met and solved elsewhere. We also refer to (Nise, 1995) for a useful tutorial on constructing the transfer function of a system.

An enhanced version of Sterman's model (see chapter 15) of High-Tech Growth Firms is used for our study. We use a transfer function approach to model the complex interactions between different parts of the firms' supply chain. For every control rule, a transfer function is developed that completely represents the dynamics of this particular rule. We first replicate Sterman's original model using transfer function techniques and conducted a simulation using Simulink in MATLAB. In order to validate the approach, using the same input and settings a control theory simulation study was made. The results were the same as those of system dynamics model used by Sterman, confirming the approach.

### 3.1 Enhanced model logic---causal loop structure

In SD, the simplest possible model is always used to capture the key decision rules of the top executives. Figure 1-a shows that the High-Tech firm system consists of three sectors, each representing a different organizational subunit: sales, order fulfillment and capacity acquisition. Figure 1-b shows the causal loop of the enhanced model under study, in which the bold texts indicate the changes made in the original Sterman's model.

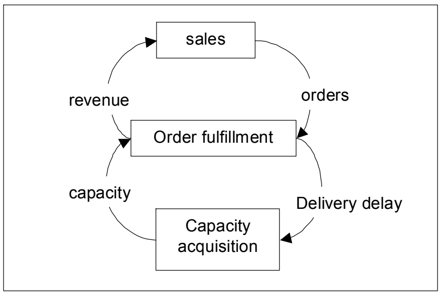


Figure 1-a. Sectors of the Model

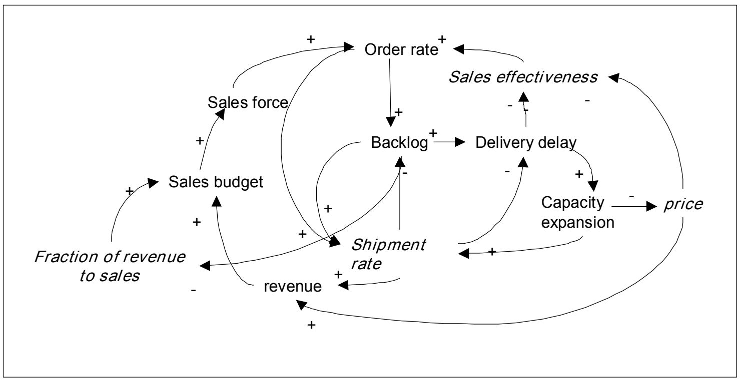


Figure 1-b. The causal loop of the enhanced Sterman's model

3.2 Block diagram and transfer function description of the system

It is useful at this stage to describe the individual building blocks of the model. Later, we will describe how these blocks are assembled together. In order to facilitate understanding we will only present the highlights.

3.2.1 Order fulfillment

In Sterman's model, it is assumed that the firm manufactures a complex high-tech product and operates a build-to-order system, like a semi-conductor company. Orders are accumulated in a backlog until they could be produced and shipped .The actual average delay in delivering orders (the mean residence time of orders in the backlog) is given by the ratio of the backlog to the current shipment rate. The difference equations required to capture backlog levels and delivery delay are shown in Eqs. (1)~(2).

$$backlog(t) = backlog(t-1) + order\_rate(t) - shipmen\_rate(t) \quad (1)$$

$$delivery\_delay(t) = backlog(t) / shipment\_rate(t) \quad (2)$$

The two rates, say, order_rate and shipment_rate, are converted into backlog levels in the $s$ domain by the integration term, $1/s$.

For the $shipment\_rate$, we use the same policy as classical beer game, in which shipment rate is decided considering the capacity of the firm and the sum of order rate and backlog. If the sum of order rate and backlog is larger than the capacity of the firm, the firm will produce products at full capacity, and the shipment rate equals to the capacity. Otherwise, the shipment rate equals to the sum of order rate and backlog. This is shown in Eq. (3).

$$shipment\_rate(t) = \min[capacity(t), order\_rate(t) + backlog(t-1)] \quad (3)$$

3.2.2 Capacity acquisition

Investments in capacity are expensive and largely irreversible. Senior managers are reluctant to invest until there is a clear evidence of need and until they could be sure that any new capacity would not go unutilized. Capacity is assumed to adjust to the desired level of capacity with a third-order delay, which is shown in Eq. (4).

$$capacity(t) = smooth3[desired\_capacity(t), capacity\_aquisition\_delay] \quad (4)$$

This can be realized in $s$ domain by a third-order lags as Eq. (5).

$$G_1(s) = \left(\frac{1}{1+T_{ca}s}\right)^3 \quad (5)$$

Where, $T_{ca}$ is *1/3* of the capacity acquisition delay. The desired capacity is formed by anchoring on current capacity, then adjusting it up or down on various pressures which are measured by the firm's perceived ability to deliver compared to its goal. The causal loop of capacity expansion is shown in Figure 2.

$$desired\_capacity(t) = capacity(t-1) * effect\_of\_\exp ansion\_pressure\_on\_desired\_capacity(t) \quad (6)$$

$$effect\_of\_expansion\_pressure\_on\_desired\_capacity(t) = f[pressure\_to\_expand\_capacity(t)] \quad (7)$$

$$pressure\_to\_expand\_capacity(t) = \frac{delivery\_delay\_perceived\_by\_company(t)}{company\_goal\_for\_delivery\_delay} \quad (8)$$

$$delivery\_delay\_perceived\_by\_company(t) = delivery\_delay\_perceived\_by\_company(t-1) + \frac{[delivery\_delay(t) - delivery\_delay\_perceived\_by\_company(t-1)]}{time\_for\_company\_to\_perceive\_delivery\_delay} \quad (9)$$

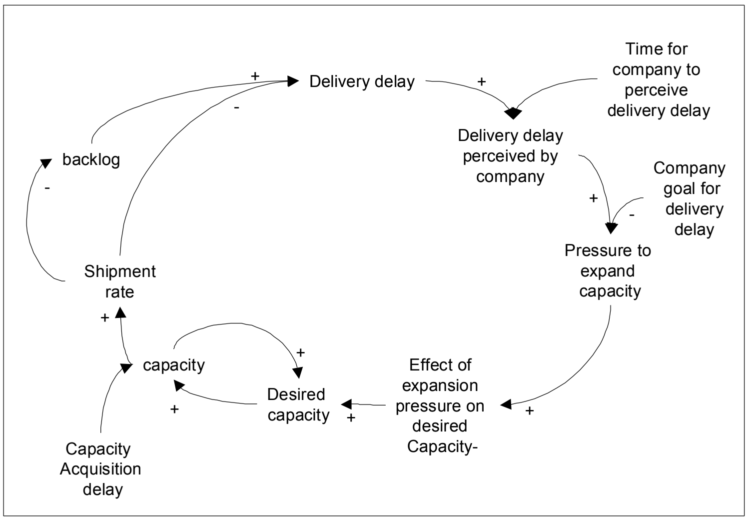


Figure 2. Details of capacity expansion causal loop

The pressure to expand capacity has a nonlinear effect on desired capacity, as shown in Figure 3. Once the capacity is acquired, it cannot be discarded or reduced, unless an outsourcing option is used and even then some penalties are involved for immediate exit from the contracts. Therefore, expansion pressure would not have immediate impact on the desired capacity as shown in Figure 3. The capacity available is always utilized fully before expanding, and as such the lower bound of the effect of expansion pressure on capacity should be one.

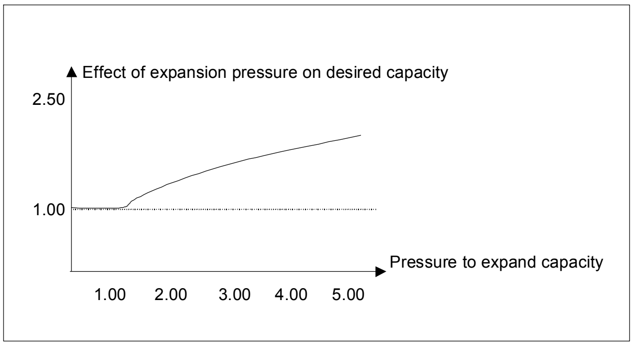


Figure 3. Effect of expansion pressure on desired capacity

Eq. (9) can be realized in $s$ domain using first-order lag, which is shown in Eq. (10).

$$G_2(s) = (\frac{1}{1+T_c s}) \qquad (10)$$

Where, $T_c$ is the time for company to perceive delivery delay.

3.2.3 The sales force

A part of the revenue of the firm is invested in the sales force. Shipment and price of the product determine the revenue. Sales budget is based on expected revenues, which are regularly updated and are modeled by smoothing actual revenue with a revenue reporting delay.

$$revenue(t) = price * shipment\_rate(t) \qquad (11)$$

$$expected\_revenue(t) = expected\_revenue(t-1) + \frac{[revenue(t) - expected\_revenue(t-1)]}{revenue\_reporting\_delay} \qquad (12)$$

Eq. (12) can be realized in $s$ domain by first-order lags as Eq. (13).

$$G_3(s) = (\frac{1}{1+T_r s}) \qquad (13)$$

Where, $T_r$ is the revenue reporting delay.

$$sales\_budget(t) = fraction\_of\_revenue\_to\_sales * expected\_revenue(t) \qquad (14)$$

The target sales force, that is, the number of sales representatives the sales organization can support, is determined by the sales budget and the average cost of a sales representative.

$$target\_sales\_force(t) = \frac{sales\_budget(t)}{cost\_per\_sales\_representative} \quad (15)$$

The actual sales force adjusts to the target sales force through the net hiring rate.

$$sales\_force(t) = sales\_force(t-1) + \frac{[target\_sales\_force(t) - sales\_force(t-1)]}{sales\_force\_adjustment\_time} \quad (16)$$

Eq. (16) can be realized in $s$ domain by first-order lags.

$$G_4(s) = \frac{1}{1+T_s} \quad (17)$$

Where, $T_s$ is sales force adjustment time.

## Price=f(capacity,backlog)

In Sterman's model, the price of the product is assumed to be constant, but in fact, with larger capacity, the quantity of products produced will be higher. According to the theory of economics, the price of the product will be then lower. That means, the price is a function of capacity as shown in Figure 4-a. (Berends & Romme, 2001) also shows this relationship. Furthermore, the level backlog has also an effect on the price of product, which can be shown in Figure 4-b. This hints when the backlog is larger than provisioned quantity during the normal deliver delay, or the loner the waiting, the higher the price.

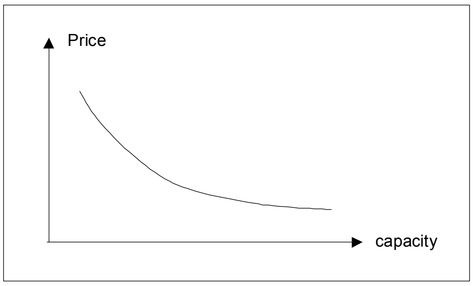


Figure 4-a. The relationship between price and capacity

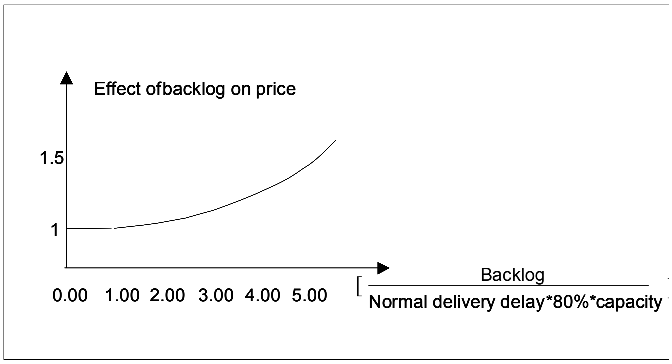


Figure 4-b. The effect of backlog on price

$$price(t) = f[capacity(t), backlog(t)]$$

$$= f_1[capacity(t)] \times f_2[\frac{backlog(t)}{normal\_delivery\_delay * 80\% * capacity(t)}] \quad (18)$$

## Sales force investment policy

The policy for investment in sales force is a very important factor for the stability of the backlog in the system. If we use fixed value investment policy, as considered in the original model by setting the fraction of revenue to sales force to be 20%, then the backlog is always out of control. For some cases, it is more than 5 times of the capacity. When the backlog is higher than we expect, investment should not be put into sales force. The backlog should have an effect on sales force, as shown in Figure 5.

$$fraction\_of\_revenue\_to\_sales\_force(t) =$$

$$f[\frac{backlog(t)}{normal\_delivery\_delay * 80\% * capacity(t)}] \quad (19)$$

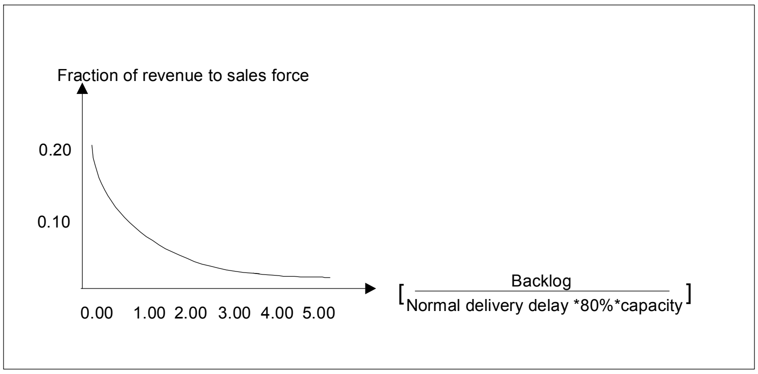


Figure 5. The effect of backlog on sales force investment

3.2.4 The market

The order rate depends on sales force and their effectiveness as measured by orders booked per person per month:

$$order\_rate(t) = sales\_force(t) * sales\_effectiveness(t) \quad (20)$$

Sales effectives depends on the attractiveness of the product, which depends on a host of attributes, including availability, price, financing terms, quality, support and service, and so on. For simplicity, the original model assumes attractiveness depends only on the availability of the product, which is measured by delivery delay. Note, if there is a substitute supply source, the order size will indeed decrease, otherwise it will not. The latter case is explained well in the literature on Bullwhip effect, called "Customer Gaming", which suggests when the delivery performance decreases customers tend to order larger quantities to guarantee their requirements and therefore even the best efforts placed for improving sales effectiveness (increasing investment in personnel or better forecasting) will not produce better situation.

In this enhanced model we assume substitution is feasible and in addition to the availability of the product, the sales effectiveness also depends on the price of the product, that means Sales effectiveness=f(delivery delay, price). Through sales effectiveness, the price can influence the order rate.

Then, the sales effectiveness is as follow:

$$\begin{aligned} &sales\_effectiveness(t) = normal\_sales\_effectiveness * \\ &[w_1 * effect\_of\_availability\_on\_sales\_effectiveness(t) + \\ &w_2 * effect\_of\_price\_on\_sales\_effectiveness(t)] \end{aligned} \quad (21)$$

Where, $w_1$ and $w_2$ are weights, which satisfy $w_1 + w_2 = 1$ .

Effect of availability on sales effectiveness

The availability of product is measured by the ratio of delivery delay perceived by market to market target delivery delay and has an nonlinear effect on sales effectiveness, as shown in Figure 6.

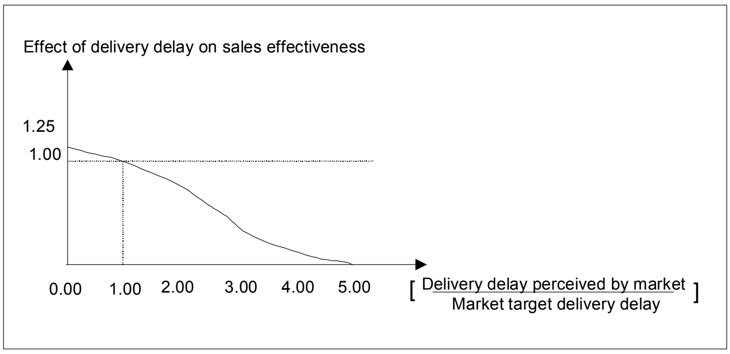

Figure 6. Effect of delivery delay on sales effectiveness

$$\begin{aligned} &effect\_of\_availability\_on\_sales\_effectiveness(t) = \\ &f\left(\frac{delivery\_delay\_perceived\_by\_market(t)}{market\_target\_delivery\_delay}\right) \end{aligned} \quad (22)$$

$$\begin{aligned} &delivery\_delay\_perceived\_by\_market(t) = \\ &delivery\_delay\_perceived\_by\_market(t-1) + \\ &\frac{[delivery\_delay\_perceived\_by\_company(t) - delivery\_delay\_perceived\_by\_market}{time\_for\_market\_to\_perceive\_delivery\_delay} \end{aligned} \quad (23)$$

Eq. (23) can be realized in $s$ domain using first-order lag, which is shown in Eq. (24).

$$G_5(s) = \frac{1}{1 + T_m s} \quad (24)$$

Where, $T_m$ is the time for market to perceive delivery delay.

Effect of price on sales effectiveness

The price has a non-linear effect on sales effectiveness as shown in Figure 7.

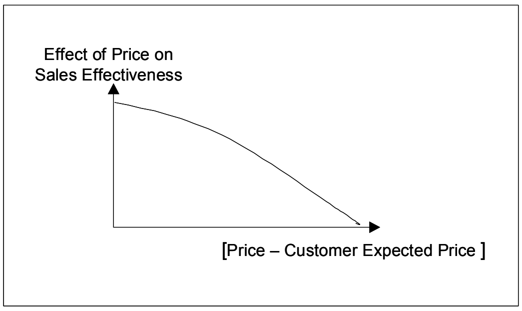


Figure 7. The effect of price on sales effectiveness

### 3.2.5 The block diagram of the full system

The block diagram of the whole system is shown in Figure 8. It describes, in a structured pictorial form, how the individual policies described earlier fit together to form the whole firm's operating environment. Of particular interests in the block diagram are the backlog, capacity and revenue signals.

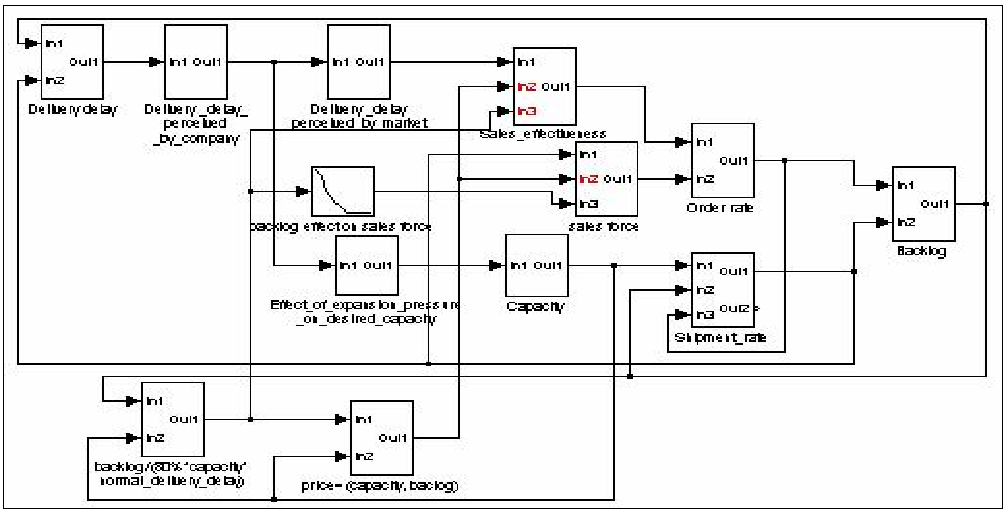


Figure 8. The block diagram of the whole system

## 4. Experiments

In this section, we present an experimental set of scenario runs to test the impacts of factors on capacity expansion decisions.

### 4.1 Experiments design based on fractional factorial orthogonal arrays

The fractional factorial orthogonal array is a method of setting up experiments that only requires a fraction of the full factorial combinations. The term array simply refers to a mathematically derived matrix arrangement that constrains the way all the parameter set points are set up prior to running the experiment. An orthogonal array imposes an order on the way the matrix of experiments is carried out; orthogonal refers to the balance between the various combinations of parameters so that no one parameter is given more or less opportunity to express its effect on the response in the experiment than any of the other parameters. Orthogonal also refers to the fact that the effect of each parameter can be mathematically assessed independent of the effects of the other parameters.

We perform an analysis of the behavior of capacity, backlog and revenue for different values of some factors. The choice of factors is rather a complicated process with an abundance literature, each suggesting a numbers of factors relating to their environment setting. This research investigates the capacity expansion decisions in supply chains. We choose eight factors namely, time for company to perceive delivery delay (P1), time for market to perceive delivery delay (P2), customer expected price (P3), importance weights for product availability impact and for price impact on the sales effectiveness (P4), capacity acquisition delay (P5), revenue reporting delay (P6), sales force adjustment time (P7), and normal delivery delay (P8). By changing the value of these eight factors, this study seeks to investigate the relationship between the factors and the severity of their effects on the capacity expansion decisions.

### 4.2 Experiment design

A factorial arrangement with the 8 factors we choose each at 3 levels is proposed, as shown in Table 1, and a complete factorial experiment requires $3^8 = 6561$ runs. But since the number of runs required is so large that it is not economical to carry out the complete factorial experiment, fractional factorial is used. Using the Principle of orthogonal design, we choose the orthogonal form of $L_{27}(3^{13})$ and get Table 2.

Table 1. Three levels of the eight factors

| Levels | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 12 | 10000 | (0.5,0.5) | 18 | 3 | 18 | 1 |
| 2 | 2 | 9 | 9000 | (0.9,0.1) | 12 | 2 | 12 | 2 |
| 3 | 1 | 6 | 8000 | (0.1,0.9) | 6 | 1 | 6 | 3 |

Table 2. Orthogonal forms

| Runs | Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
| 1 | 3 | 12 | 9000 | (0.5,0.5) | 18 | 3 | 18 | 1 |
| 2 | 3 | 12 | 9000 | (0.5,0.5) | 12 | 2 | 12 | 2 |
| 3 | 3 | 12 | 9000 | (0.5,0.5) | 6 | 1 | 6 | 3 |
| 4 | 3 | 9 | 10000 | (0.9,0.1) | 18 | 3 | 12 | 2 |
| 5 | 3 | 9 | 10000 | (0.9,0.1) | 12 | 2 | 6 | 3 |
| 6 | 3 | 9 | 10000 | (0.9,0.1) | 6 | 1 | 18 | 1 |
| 7 | 3 | 6 | 8000 | (0.1,0.9) | 18 | 3 | 6 | 3 |
| 8 | 3 | 6 | 8000 | (0.1,0.9) | 12 | 2 | 18 | 1 |
| 9 | 3 | 6 | 8000 | (0.1,0.9) | 6 | 1 | 12 | 2 |
| 10 | 2 | 12 | 10000 | (0.1,0.9) | 18 | 2 | 18 | 2 |
| 11 | 2 | 12 | 10000 | (0.1,0.9) | 12 | 1 | 12 | 3 |
| 12 | 2 | 12 | 10000 | (0.1,0.9) | 6 | 3 | 6 | 1 |
| 13 | 2 | 9 | 8000 | (0.5,0.5) | 18 | 2 | 12 | 3 |
| 14 | 2 | 9 | 8000 | (0.5,0.5) | 12 | 1 | 6 | 1 |
| 15 | 2 | 9 | 8000 | (0.5,0.5) | 6 | 3 | 18 | 2 |
| 16 | 2 | 6 | 9000 | (0.9,0.1) | 18 | 2 | 6 | 1 |
| 17 | 2 | 6 | 9000 | (0.9,0.1) | 12 | 1 | 18 | 2 |
| 18 | 2 | 6 | 9000 | (0.9,0.1) | 6 | 3 | 12 | 3 |
| 19 | 1 | 12 | 8000 | (0.9,0.1) | 18 | 1 | 18 | 3 |
| 20 | 1 | 12 | 8000 | (0.9,0.1) | 12 | 3 | 12 | 1 |
| 21 | 1 | 12 | 8000 | (0.9,0.1) | 6 | 2 | 6 | 2 |
| 22 | 1 | 9 | 9000 | (0.1,0.9) | 18 | 1 | 12 | 1 |
| 23 | 1 | 9 | 9000 | (0.1,0.9) | 12 | 3 | 6 | 2 |
| 24 | 1 | 9 | 9000 | (0.1,0.9) | 6 | 2 | 18 | 3 |
| 25 | 1 | 6 | 10000 | (0.5,0.5) | 18 | 1 | 6 | 2 |
| 26 | 1 | 6 | 10000 | (0.5,0.5) | 12 | 3 | 18 | 3 |
| 27 | 1 | 6 | 10000 | (0.5,0.5) | 6 | 2 | 12 | 1 |

4.3 Experiment analysis

After running the 27 experiments and comparing the results, from the revenue point of view, run-6, run-11, run-12 and run-27 are considered outperforming runs. Figures 9 to 12 show the results of these four runs.

By comparing run-12 with run-27, we can see that delay in revenue-reporting compensates or impacts sales adjustment time. Comparing revenue-reporting delay with normal delivery delay, we can see revenue-reporting delay can compensate normal delivery delay. In other words, that financial reporting delays can put off capacity expansion decisions, signifying they are as important as delivery lead-time and can position supply chain in distress (hug backlogs).

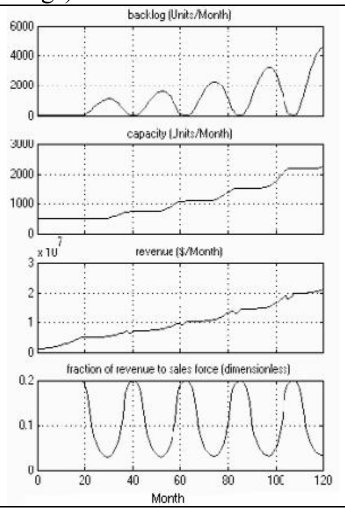

Figure 9. Run 6

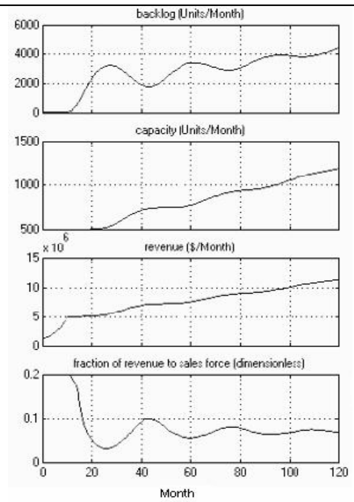

Figure 10. Run 11

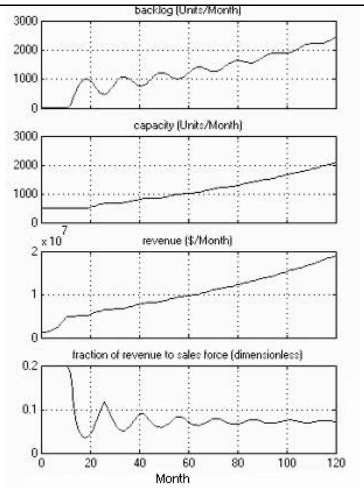


Figure 11. Run 12

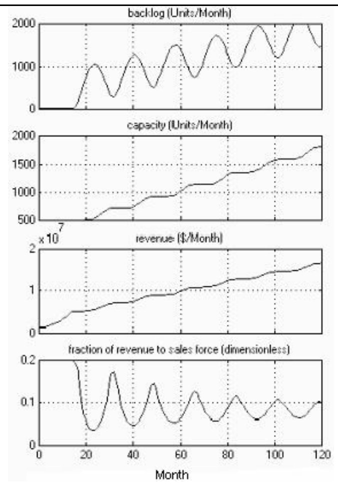


Figure 12. Run 27

Using a monthly discount rate of 0.1%, the NPV (Net Present Value) for all runs are calculated. The NPV of run-6, run-11, run-12 and run-27 are shown in Table 3.

Table 3. The NPV of outperformed runs

| Runs | Run-6 | Run-11 | Run-12 | Run-27 |
|---|---|---|---|---|
| NPV | 628,157,289.79 | 507,831,026.68 | 653,074,686.81 | 620,756,836.28 |

### 4.4 Experiments on Run12

Table 3 shows that the NPV of run-12 is the largest. For this run by changing each factor at a time, we can get the effect of each factor to the level of sensitivity. The results are:

Changing P1 (time for company to perceive delivery delay) and P2 (time for market to perceive delivery delay) respectively, we can see both of them have no obvious impacts on the stability of the backlog. Bringing down P1 or bringing up P2 increases the NPV. The impact of P1 is relatively bigger than P2.

Bringing down P3 (the customer expected price), NPV becomes much lower.

By changing P4 importance weights, we can see that when the price of the product gets a more important weight than the availability of the product impact on sales effectiveness, the NPV of the system is much higher (in other words, the sales effectiveness is more sensitive to the price of the product). This experiment shows that when sales effectiveness is more impacted by price (through more weight, P4), the capacity expansion decisions are taken earlier, creating more room to produce and bringing the product price down, which in turn increases the total revenue.

Decreasing P5 (the capacity acquisition delay) dramatically increases the NPV because of the quick acquisition of the capacity.

P6 (revenue-reporting delay) is responsible for the reaction times in capacity change, the shorter the delay, the faster is reaction to capacity expansion need, which is quite logical. Moreover, the shorter revenue reporting delay results in a larger NPV. This all suggest that financial reporting delay which is typically rooted in sorting out the Account Receivable (AR) and Account Payable (AP) can put supply chain in trouble, necessitating speeding up this process. A recent surge in SCM software solutions integrating financial flows is a witness to this conclusion (SAP, March 2006).

P7 (sales force adjustment time) is very responsible for the trend and the amplitude of backlog, bringing it down decreases the oscillation of the backlog but with the cost of NPV. The shorter this period, the shorter on average backlog stays at zero status. We can also see this from Run-6. Comparing with other runs, Run-6 has very high NPV, but oscillation of the backlog is huge. Changing the sales force adjustment to 12 and 6 respectively, the performance gets better.

P8 (Normal delivery delay) means goal of the delivery delay, or expected lead-time, the longer it is, the lower is the NPV.

## 5. Summary and Conclusions

In moving towards lean and agile supply chain, the capacity expansion decision is more critical than ever before. In designing the accurate capacity at right time, it is not only important to take into account the resources but also the structure of the chain, considering three flows: goods, information, and funds. Therefore, it is essential to address capacity expansion systemically by identifying the main (and mostly inter-dependent) factors affecting such decisions. The hierarchies of capacity expansion can be seen as changes needed in: a) structures, systems and roles, b) resources (like machines, staff, etc.), and c) operating rules. Emphasizing on systemic capacity expansion would improve identification of shortcomings in specific parts of supply chain design and monitoring, and would lead to more effective use of resources.

Based on the enhanced Sterman's High-Tech Growth model, we designed a set of control theory simulation experiments to identify the factors that play a key role in supply chain capacity expansion decisions. Among the highlighted results, the study clearly shows a strong correlation between supply chain goods, information, and financial flows delays. It suggests that an increase in financial flow delays (like reporting) diminish the effectiveness of goods flow improvement. In other words, capacity expansion or improving physical resources will not be as effective. Among other interesting results, the study shows that information delays (like sales force adjustment time) is very responsible for the trend of the amplitude of backlog, bringing it down would decrease the oscillation of the backlog in the chain. This means that sales efforts and related investment should be made in light of backlog or capacity available -- not totally independent.

According to our study, a balanced approach is needed to expand capacity for economic growth. We can further conclude that without sufficient capacity or proper utilization capacity rates, the supply chain will not grow. The success of the supply chain is highly dependent on capacity availability and inter-company cooperation, shown by structural delays in the simulation model. In addition, the model shows that supply chains need to assess their entire system assumptions and roles more closely if they want to minimize unexpected policy outcomes. Simple investment in resources for improving goods flow will not be sufficient and may have negative effects.

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# RISK MANAGEMENT IN LOGISTICS

Arzu Karaman[1] and İsmail Duymaz[2]

## Abstract

*Every business function is associated with opportunities and threats because of the uncertainties about future developments. Logistics chain is also affected by this dynamic medium. In every ring of the chain, there is a serious threat potential due to the internal and external supplier or customer. The problem is the uncontrollable nature of risks in product/information flow and the inability of managing risks.*

*Because logistics is cross functional when compared with other basic functions, the emergence of logistics risks can range from the first supply source to point of sales (PoS) that covers all areas, processes and actors. The emerging risks can originate from inside or outside the firm. When classifying the risks in logistics, speculative (emerging from management behaviors) risks should also be taken into account as well as real risks (damage/harm), risk of loss, and risk of not to take advantage of opportunities.*

*Another classification of risks can be made by the risk's importance and weight as being minor/harmless or as being major risks that threaten the survival of the firm. Risks in logistics systems can be input, transformation and output risks; or can be strategic, tactic, and operational risks. Logistics management is responsible for the management of these risks per se.*

*Keywords: Risk Management, Logistics, Supply Chain Management*

## 1. Introduction

Both as a business function and an industry, the importance of logistics is continuously increasing. But parallel to this increase, logistics security is becoming to be a more critical and important competition parameter for all actors (companies) within the logistics chain (Pfohl, 2003: 49). There are many benefits of being in a logistics chain, but it can also bring some risks to the companies (Hallikas, Virolainen &Tuominen, 2002: 45). The increasing expectations and requirements of customers force both the parties who are responsible for logistics function and the logistic service providers to be more provident against the possible risks. Also there is an increasing pressure derived from laws. For example, the 9/11 terrorist attack is a milestone for the firms and they learned a lot from it (Guinipero & Eltantawy, 2004: 698; Pfohl, 2003: 49). After the attack, the prevention of terrorism act directly influences the material flow processes in national and international scale, and thereby, with these new and radical legal measures taken, the cost of logistics security has increased. All parties within the logistics chain have turned out to be vulnerable to such pressures of cost, and are forced to undertake new and additional responsibilities.

On the other side, changes increase uncertainties. The risks emerging from the uncertainties in the decisions of management have increased and it will possibly increase in the future, because the gap between being ready for the risks and the ability to overcome these risks is increasing from day to day. This is a result of increasing dynamism and complexity of markets. While the logistics risks globalize and become more various, the logistics costs will increase because of this globalization and variety. In this paper, the sources of risks that are related to logistics risk management, types of risks, the steps of logistics risk management, and new measures employed in preventing the risks will be discussed (Pfohl, 2003: 49).

## 2. Risks and Risk Sources in Logistics

Logistics firms are confronting with various risks today. These risks can either emanate from the firm or the environment in which the firm operates. World is changing and these changes create new risk sources (Guinipero & Eltantawy, 2004: 698). In this part risks and risk sources in logistics will be discussed.

### 2.1 Risks and Uncertainty

The concepts of uncertainty and risk seem close, but they suggest different weights for decision makers. Both have threats and dangers, which may possibly create loss or damage and threaten the firm to attain its objectives. Where there is an uncertainty, there are also unforeseen events and one must constantly act with a certain security margin. All uncertainties create risks and therefore hide certain threat potentials.

If there is an impossibility to guess the realization or results of any event that is related to the business, this situation is named as an uncertainty. Uncertainty exists due to factors like changes in markets, technology, competitors, political issues, and governmental regulations (Wu, Blackhurst & Chidambaram, 2006: 350; Pfohl, 2003: 49). As for the risks, decision makers may either know about the possible results of the event or guess the

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possibility of realization of the results. Uncertainties cannot be managed but risks can be managed and controlled by means of preliminary measures. By using preliminary measures, it is possible to avoid risks or protect oneself against risk and thereby minimize or control the damages caused by the risk. By fastening the seat belt or using an airbag, it is possible to avoid injuries, or limit the effects of any risk by having insured against a possible damage. The risks against which no precaution has been taken or which are not insured always do have a cost. From that point of view, controlling risks is a must for controlling costs.

The gap between the market dynamics and business decisions, and the skills to response such dynamics in a short time is increasing. This requires the expansion of the management and control systems and their development. Thereby, it is assumed that the threats and opportunities in the business environment can be seen. For limiting the risks in long-term, the tool of "controlling" is used. In spite of this, the uncertainties in the business decisions have not been eliminated yet. Therefore, special importance should be given to the ability to respond changes in their environment in a short time, in other words the flexibility (Pfohl, 2003: 49).

### 2.2 Logistics Risks and Risk Sources

Each firm intends to maximize its benefits in an environment with a certain level of risks. In other words, it wants to create a certain level of benefit with minimum level of risks. Risks generally impose costs, and therefore, each firm is forced to make risk-benefit analyses. This fact is also valid for the logistics industry. Uncertainty and insecurity have always created risks for businesses. In theory and practice, it is not just a coincidence that researchers have focused on the procurement risks in supply. At the point we have arrived today, the radical changes of the global conditions as well as the dynamism in the markets, the logistics risks are not only considered from the point of businesses, but rather on supply chains or within logistics networks.

Logistic risks are facts (results) related to the scope and magnitude of the loss that would be caused by threat factor(s) depending on the considered perception of threat. In many cases, the magnitude of the loss that could be caused by the logistics risk factors and the probability of loss can only be guessed. The probability of emergence of a loss may be derived from frequency and time period of the threat, and the probabilities and possibilities of avoiding or limiting the loss. For that purpose, threat analyses and risk evaluations are carried out.

### 2.3 Classification of Logistics Risks

Businesses may deviate from planned results in various functions (finance, human resources, production, supply, and sales) and as well as in the logistics function due to various internal and external factors. These deviations could either be a real risk (risk of damage/loss) or a speculative risk (the risk emerging from business behaviors). From the narrower point of view, risk always contains the threat of damage or loss.

The risks in logistics function could be categorized according to various criteria (Essig, 2004: 444; Heil, 2004: 5-13; Schulte, 2005: 691; Farny, 1996: 1798-1806). Depending on the degree of risks in the field of logistics, they could be minor or major or tiny, medium level risks, or the ones threatening the existence of the business. The risks in logistics can be strategic, tactical or operational (loss of employees, IT security, financial) depending on the level of decision and time perspective. These risks may emerge from within or outside the business. Risks can also be divided into two: insurable ones, and uninsurable ones.

The risks in logistics are input (labor, machinery & equipment, capital, material, energy, information etc.) risks, transformation risks or output risks.

The most important risks in logistics are the flow risks in the sub-system of logistics transformation. The efficiency of the flows depends particularly on transportation, transshipment, warehousing, material handling, packaging/labeling, as well as the production volume and speed in the order finishing processes. The technical infrastructure and standardization does have a critical role.

Flow risks could be listed as

- information risks,
- commodity risks,
- financial risks, and
- legal risks.

In the logistics chain, the material/information flow should be uninterrupted or should be handled with minimum interruption. Therefore, the flow risks should be given special importance. To minimize the flow risks, the processes should be established and operated in a transparent manner, and the number of interfaces in the process should be minimized.

The risks in logistics could be listed depending on the business functions. Accordingly, the economic and ecologic risks in the reverse logistics should be taken into account as much as the risks in inbound, production and outbound logistics. The risk factors in input and transformation sub-systems will in turn threat or even damage the outputs of the logistics system (i.e. service level, service quality etc.).

A distinction could also be made between macro and micro logistics risks. While natural and political/legal risks, conjuncture fluctuations or shocks are macro risks; the others could be seen as micro risks. But as far as the concept of supply chain in logistics is considered, in fact, it could be said that the risks in logistics are meta-logistics risks, because no business in logistics is alone and independent from others and they cooperate with other businesses (supplier or customer) to aim at a joint target, and realize their decisions and behaviors in a coordinated manner.

Schulte classifies the risk fields and subjects in logistics as given in Table 1 (Schulte, 2005: 692);

Table 1 Logistic Risk Fields and Risk Subjects

| Risk Field | Subject of The Risks |
|---|---|
| Market / Client | Sales losses due to failing to deliver products on time to customer,<br>Damage in corporate image: The customer's refusal to buy products/services in the future,<br>Disruption of the customer's manufacturing process due to delayed deliveries |
| Supply / Provision in Manufacture | Slowing down/stopping of manufacturing due to failure to provide materials timely<br>Interruptions in transportation of mass products/liquid products |
| Ecology | Threats caused by accidents/damages that make a negative impact on environment<br>The risks caused by failure to comply with rules/regulations/standards in transportation, warehousing or transshipment |
| Foreign Trade Legislations and International Norms (Incoterms) | Failing to comply with social - economic - technical or legal standards<br>Foreign trade losses due to violating the foreign trade rules, country image loss, monetary penalties, loss of customers, embargoes etc. |

All risk fields and subjects of the risks can in turn emerge for any firm. Particularly the rule violations or negligence in food and medicine sector can cause fatalities.

## 3. Risk Management in Logistics

### 3.1 Risk Management's Field of Interest

Risk Management is interested in systematic evaluation and domination of risks. Risk management has a vital role for each business because each business faces many internal and external risks. A successful risk management assists in making more rational decisions, reduces and controls total risks, supports a successful existence of a business and in turn, increases the market value of the business.

The contributions of logistics risk management on the business success could be summarized as follows:

1) It is possible to avoid serious control weaknesses and prevent damages.
2) Financial losses, economic weaknesses and image weaknesses are limited.
3) Business targets are supported and facilitated.
4) "Shareholder Value" is increased.
5) The existence of the business is warranted in the long term.

Because logistics chain is always vulnerable to external and internal risks, the basic duty of logistics management is directly related to management of such risks. Logistics chain optimization is governing the potential logistic risks by

- organization of consistent processes,
- use of efficient information techniques,
- efficient / effective cooperation with suppliers, customers and logistics companies (Schulte, 2005: 691).

Logistics risk management is a system including decisions or behaviors that determines logistic risks and investigates their influences on functions for the purpose of prevention/protection. Its final purpose is developing alternative action ways to minimize the risks against internal and external threats so that the business survives in a reliable environment. Risk management in fact is a multi-disciplinary area. Operational Risk Management covers the processes from packaging to shipment of a fixed or mobile product, selection of a suitable transportation type and vehicles, and defining a suitable route or speed.

### 3.2 The Targets of Risk Management in Logistics

By making a successful risk management, the businesses can avoid and reduce risks, and have a better control on this, while managing to live with the -remaining- risks. Preventing or limiting the risks or minimizing the damages caused by them always imposes cost. With the increasing level of security, the cost of damage/loss increase, and, in turn, the higher preventive measures increase the total cost.

The targets of risk management can be summarized as follows (Schulte, 2005: 693):

1) Provision of compliance of the business to the legal, cultural, economic and technical standards in relation with its control and transparency,
2) Determination and finding out of risk bearing developments timely and systematically, avoiding from/protecting against them.
3) Increasing inner business transparency and improving the consciousness of risk for all employees
4) Preventing avoidance of managers against business targets and potential responsibilities

3.3 Potential Risk Fields in Logistics

The potential risk fields in logistics form a very large spectrum. Here, the construction of facilities (factories and warehouses), technical equipment, vehicles/containers as well as operation and workpower risks or the weak/vulnerable areas in the IT systems can be named as potential risk factors. With the modern follow-up and monitoring systems employed today, logistics security services are in an enormous pace of development.

The risk factors may come out both from within or outside the business. With today's supply chain concept, logistic risks are not based on business/company and don't consist of many parts, but are considered as a risk management system beyond businesses, and people try to control the risks within a monitorable and transparent environment with the help of modern information technologies.

From the point of the supply chain approach, the risk factors in logistics generally emerge from outside of the control area of business, but from the network or chain where the business belongs (Corsten, & Gössinger, 2001: 51-55). Because of this, the sources of risk should not only be taken into account on the business basis, but also they should be analyzed from the point of chain/network. In order to minimize the space, time, quantity, and quality deviations in the logistics system, the space-time coordination at the beyond business level becomes the most critical function. In management and coordination of the chains and networks, the most significant factor is the information flow. One can make use of information/communication technologies in providing the coordination beyond businesses, and EDI finds its applications in various fields under varying norms. The global EDIFACT Standard on industrial basis, EANCOM in consumables industry, ELFE, in telecommunication, ODETTE and VDA in automobile industry and the SWIFT in banking industry are the fields of application.

According to supply chain approach, logistic risks should be considered not on the basis of business/company but on the basis of supply chain, and solutions should be created accordingly. The most important risks in a supply chain emerge due to

- instability between demand and supply,
- lack of information in information flow,
- lack of adjustment of time/space, and
- lack of coordination and all in return, expose stopping/waiting time in the interfaces and reduce the total performance of supply chain.

The proper product cannot be at proper quantity and at proper place because of the risk factors caused by these facts and these factors create instability between supply and demand. If supply is greater than demand, inventory risks are unavoidable. On contrary, if supply is less than demand, unsatisfied customers and opportunity costs would emerge. Disarrangement of time and place using incorrect/missing information would have a negative impact on the outputs of the logistics system (i.e. service level, service quality etc) and would decrease the satisfaction of customers.

Possible technical/communication based risks in management of logistics operations or economical risks can be more easily managed. But all logistics operations are related to moving materials, human and information. The object in movement (flow) always encounter to higher risks than the stopping ones. It is more difficult to protect moving objects against potential threats and keep it under control. The specifications of moving objects and containers, and transportation vehicles and their compliance with norms/standards are important as to the risk potential and possibility. The tanker loaded with clean water and the one loaded with LPG do have varying levels of risk with regard to technique and economy and ecology perspectives. From that point of view, "first security, than movement" becomes a common principle in logistics.

The most important risk for moving objects is the interruption of flow. Because the interfaces that emerge in this process are unprepared. By coordinating the material and information flow within the network/chain, it is possible to minimize the risks arising from such interfaces. Furthermore, the moving vehicles, containers, materials or information are vulnerable to outside effects. For example, the most vulnerable moments for a passenger plane is while taking off or landing where ground attacks are most effective.

3.4 The Critical Importance of Logistics Objects in Logistics Risk Assessment

The economic, physical and chemical properties of materials and products, which are the flowing objects within a logistics chain, do have a particular importance with regard to logistics risks. At this point, it is enough to think about the transportation of inflammable items, frozen foods, medicines, critical energy source procured from long distances, or the critical parts for the industry. Because of this, risk factors have always been taken into account in the process of developing business strategies. While carrying out his first supply portfolio analysis, Kraljic (1985) considered the importance of the supplied materials with regard to procuring risk and business success, and named high risk and high value products as strategic products, and named the high risk products with a relatively lower influence on success as bottleneck products (Kraljic, 1985: 9; Ehrmann, 2003: 261-262; Essig, 2004: 57-59, Fortmann, 2000: 35-38).

| | | Contribution to Business Success | |
|---|---|---|---|
| Supply Risk | | Low | High |
| | Low | Non-critical products | Leverage products |
| | High | Bottleneck products | Strategic products |

### 3.5 The Steps of Risk Management Process in Logistics

As is the case with all other business function areas, the opportunities and threats (risks) within the logistics industry should also be diagnosed and managed. The estimation and consideration of risks could be made according to the facts listed below (Schulte, 2005:692):

- The updated or futuristic data (information)
- The expectations and targets of the evaluator person / team
- Subjective evaluation criteria (being ready to risk, taking risks, avoiding risks etc.)

Risk management is considered at strategic and operational levels. How to act with risks, how to live with them, and the responsibilities of risk management are determined by risk strategy. In risk strategy, some preferences are made. These preferences are cited below:

- Avoiding risks (for example, refusing to cooperate with suppliers who are at a long distance, not using risky products, markets or customers)
- Reducing risks (Operating and using a warehouse with a supplier or customer)
- Transferring the risks (partially or entirely) to responsibilities of others (risk insurance, outsourcing)
- Assuming the risk and trying to overcome it radically.

Operational risk management is generally considered as a 4 steps process (Pfohl, 2004: 135-136; Schulte, 2005: 693-694)

*1. Risk Identification*

In this step, the definition, type, cause of the risk, and the level of damages it can generate is specified. Risks may range from the infrastructure facilities or tools to technical quality or organized personnel or information. At this step, the security problems and undefended points should be diagnosed.

*2. Risk Analysis and Assessment*

It is necessary to measure the losses/damages caused by the risks as much objectively as possible and to estimate the cost of the new preventive/protective measures.

While specifying the risk priorities, strategic risks are of course the ones that must observed and followed because it is impossible to compensate the losses caused by strategic risks by means of a perfect operation.

*3. Reducing / limiting risks*

At this point, responsibilities and timing plan are specified (related to organization structure and investments) and decisions are made. For the purpose of a continuous improvement, the measures should also be followed up.

*4. Risk Financing*

The risks can either be financed through equities or through insurance. In order to compare the suitable financing model, it is necessary to know about the origin and frequency of losses/damages. Insuring the risks which cannot be influenced by management and have a high financial burden seems the best solution today. Insurance companies also focus on clarity of risks, their level of estimation and a premium system suiting the risk.

Risk management is generally considered as a task of operational management but isn't assigned to only one risk manager.

### 3.6 Risk Analysis in Logistics Network Strategies

In the strategies of all logistics companies a special importance should be given to strategy related risks. As for the risk factors, the trends influencing the logistics network strategies are of special importance. These trends are as follows (Pfohl, 2004: 135):

1) Effectiveness of the network: should be weighted according to the efficiency of the network;
2) Manufacturing facilities are gradually specializing;
3) Warehouse locations are becoming more central;
4) Number of suppliers is reducing;
5) Outsourcing is gradually increasing;
6) Subject to the increasing globalization, global manufacturing networks are emerging.

The coordination problem in logistics network, increasing need for coordination and increasing relations between the locations in different regions all increase the requirements and expectations from a logistics system. This in turn increases the number of potential failure/deviation sources even more. The risks emerging here are rather related to the links between the organization units within a network. The consistency of the connections may be threatened by technical or personnel negligence/weaknesses in the interfaces or insufficient organizational measures (Pfohl, 2004: 135; Rogler, 2001: 211). Negative impacts, particularly the transport risks in the international manufacturing relations and material flows, can impair the security of procurement/supply. Risk level depends on the type or distance of transportation, complexity of transportation form and the quality of the means of transport employed. The country risks also cannot be neglected. There might be risks in material, information or finance flow as well as the flow of rights. It is clear that all these risks would impair the total functioning performance of the supply chain.

### 3.7 New Measures Employed in Risk Management in Logistics

In order to avoid, reduce or control the risks in the logistics area, a number of organizational, technical, economical/commercial and IT related measures, rules and standards are required. To avoid risks as much as possible, or minimize the losses / damages caused by possible risks, first,

- measures should be taken to prevent the risks that might arise due to instability between supply and demand (flexibility and risk premium contracts with suppliers and/or manufacturers),
- simplifying complex flow processes and make them transparent ,
- following up and observing the operations with sufficient information and communication support,
- application of the security measures before or during operations without reservation, complying the norms or standards related to movement or moving material/information.

The most recent trend in logistics is the usage of Radio Frequency Identification Devices (RFID), which seems to replace barcode systems in the future (Knospe & Pohl, 2004: 39; Lin & Brown; 2006: 34). In supply chain management, RFID enhances instantaneous information about supply of inventory (quantities, locations) and demand (customer or market), while reducing the risk of theft (Lin & Brown, 2006: 34; Atkinson, 2004: 13-14). The benefits of RFID systems are the transparency across supply-chain relationships, ability to track lifecycles of inventory, higher productivity, lower levels of inventory, and improved customer service (Lin & Brown, 2006: 34). The enhanced ability to track the flow on the logistics activities reduces uncertainties and therefore risks in return.

In order to reduce, share or control the risks within the supply chain, the following risk management strategies can be emphasized (Pfohl, 2004: 138):

1) Strategy of Avoidance: A business can give up some products, geographical markets, suppliers and/or customers,
2) Management/Direction: Vertical integration; higher inventory; making use of buffer stock; additional capacities in manufacturing, storing, handling and/or transportation,
3) Cooperation: By means of joint activities like
    a. Increasing supply chain transparency,
    b. Imposing concept, depth, speed and transparency to information exchange that creates risk
    c. Developing / changing the relations in a consistent manner
4) Flexibility: Postponement; Multiple Sourcing; Local Sourcing

Decision as to which one of those risks management strategies is to be employed depends on differentiation of logistics strategies.

Companies and chains today prefer two ways to prevent or reduce strategic level risks. One of them is the use of outsourcing in logistics services; the other is logistics cooperation (meta-logistics). The risks should be prevented, restricted or estimated primarily through cooperation contracts. Several cooperation models exist for this purpose (Pfohl, 2004: 138):

The shorter the visibility in market, the narrower the visibility angle, the higher the turbulence expectation, the more is the tendency to use outsourcing in logistics. On one side, the existence of rationalization (cost saving) potential in logistics, the target to provide flow optimization, and increasing pressure of competition has improved outsourcing in the conduct of logistics services. Focusing on core capabilities, reducing the depth of manufacturing and plant investment requirements, increasing organizational plainness, organizational and economic efficiency, creating cost savings and flexibility, and outsourcing are considered as opportunities. Outsourcing provides a suitable base to transform fixed costs to variable costs and minimize logistics risks by means of assigning them to others, but at the same time, the need for a coordination of mutual trust and relations between supplier and customer increases.

## 4. Conclusion

Fast changes in the economy and technology create uncertainties and risks. The risks arising from the uncertainties in business decisions have increased, and will probably increase in the future, because the gap between the requirement to be ready to risks and the ability to bear risks is becoming larger. This fact is due to increasing dynamism and complexity of the markets. The instabilities arising in the supply chain due to various reasons, and increasing number of interfaces nurture risks in logistics activities. It is therefore necessary to act with a security margin in all decisions and applications in logistics and take various risk costs into account. The problem in fact is not taking controllable risks. The problem is the uncontrolled existence of risks in logistics and failure to have dominance over such risks. The real issue is due to the increasing distance between being ready to a risk and the ability to overcome that risk. Because of the increasing environmental dynamism and complexity, increasing scale of the business, increasing innovativeness of new manufacturing techniques/methods, and increasing distance in the commercial locations, an increase in the number of risks should be expected. While it is possible to take preventive actions against risks by taking precautions and by having an insurance policy, acting towards market risks can only be possible by specific risk management method. It seems that reducing or sharing are possible by outsourcing in logistics and by cooperating between horizontally/vertically in the logistics chain.

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# A GENETIC ALGORITHM BASED APPROACH TO THE WORKLOAD BALANCING PROBLEM

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## Abstract

*Workload balancing (generally known as assembly line balancing) problem is an assignment problem. The traditional assembly line balancing problem considers the manufacturing process of a product where production is specified in terms of a sequence of tasks that need to be assigned to workstations. Each task takes a known number of time units to complete. Also, precedence constraints exist among tasks: each task can be assigned to a station only after all its predecessors have been assigned to stations. In this paper, a Genetic Algorithm approach is represented to solve this problem. The purpose of the model developed here is to provide a solution to the decision maker for uncertainty cases of cycle time, number of stations and work load values. Algorithm is coded in Matlab 7.0 and it is tested on a simple and complex problems. The results confirm that the proposed genetic algorithm approach is useful for solving the assignment problem and it is useful for optimizing the workloads of workstations.*

Keywords: Genetic algorithms, Workload balancing, Permutation coding, transposition mutation

## 1. Introduction:

In the competitive business environment, the manufacturing facility has experienced enormous pressures to improve quality and reduce costs. In general a competitive response is an expansion of variety, or models, cross product lines in a battle for market share (Houghton and Portugal, 1991). As manufacturing companies struggle to remain competitive, one of the strategies by which gains in speed, quality and costs can be achieved is to use the resources in an efficient way. Hence, the effective usage of manufacturing systems has become a vital concern, and continual improvement in manufacturing facility delivery and cost containment is critically important. A well-designed manufacturing facility helps increase efficiency through minimizing material transfer, work-in-progress and lead times. It has been estimated that 30-75% of total manufacturing costs may be attributed to materials handling and layout (Chiang and Kouvelis, 1996). To design the facility well manufacturing manager needs to estimate the work stations operation times and balance them.

### 1.1. Workload Balancing (WLB)

Workload balancing is the process of allocating works to the stations in such a manner that all stations have roughly the same amount of work assigned to them. The operation times of the workstations will be similar and then the operation costs will decrease by allocating works equivalent to the stations. The basic aim of work load balancing is to deal the total workload equally to the work stations for reducing the time diversities between the work stations. Among many different types of balancing problems, balancing the workload among workers on the assembly line is the focus. Assembly line is defined as a manufacturing technique in which a product is carried by some form of mechanized conveyor among stations at which the various operations necessary to its assembly are performed. It is used to assemble quickly large numbers of a uniform product (The Columbia Encyclopedia, 2006). An assembly line consists of a number of workstations linked by a transport mechanism. For the effective usage of this system, all workstations operation time should be provided at the same level. There are many methods developed for this problem. In general assembly line balancing problems are classified into two groups: Type 1 and Type 2. In Type 1 the cycle time (c) is fixed and the number of workstations is minimized, in Type 2 the number of workstations is fixed and the cycle time is minimized.

Production planning for work stations has attracted much attention in the operations research literature. As this production environment becomes increasingly sovereign in many countries, there is a growing importance for an operation research analysis of its complicated planning and scheduling problems. The objective function of the balancing problems is to assign the works to the stations in such manner that provides the precedence conditions between the works, total workload time in all work stations will not be bigger than given cycle time and ensure the intended performance criteria.

In traditional workload balancing problem, a manufacturing process in which the products are formed by allocating tasks in a sequence to the different work stations is considered. The distribution of tasks within the workstations is related to the time unit needed for completing every task as well as priority constraints between tasks. Also the product can stay in the work station maximal the cycle time.

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## 2. Literature Review

There is an extensive literature on work load problems for manufacturing systems, focusing on workload balancing, movement of work between machines, and problems of machine layout. Hence there have been several research studies about the workload balancing problems since 1950's. In the literature review we found that the approaches for the workload allocation problems are grouped in two categories. The first one is the mathematical optimization models that contain the linear programming, integer linear programming, non-linear 0-1 mixed integer programming, branch-bound and 0-1 Goal Programming. Second one is the heuristic methods that find a solution close to optimal solution, genetic algorithms, simulation methods and the computer techniques. Below we listed some of the studies in the literature according to their method used for solving the work load problem.

### 2.1. Mathematical Optimization Models

Mathematical optimization models are widely used for modeling workload balancing problems. These models contain the linear programming (Purcheck, 1974), integer linear programming (Rajamani, Singh, & Aneja, 1990; Potts & Whitehead, 2001), non-linear 0-1 mixed integer programming (Steeke, 1983), branch-bound (Berrada & Stecke, 1986).

### 2.2. Heuristic Approaches

According to the structure of the balancing problems, to seek a solution with the optimal methods to these problems will bring around some difficulties as the size of the problem grows. Because of this reason in the solution of such problems to use the heuristics may be more meaningful and realistic. In collaboration without guaranteeing the optimal solution Heuristics Methods, in specific constraint, relatively provide the effective solution by using less computation. Hence, heuristic methods developed for the workload balancing problems. There are several studies related with workload balancing using heuristic approaches (Askin & Chiu, 1990; Tansel & Bilen, 1998; Xiaobo, 2001; Gonzáleza & Adenso-Diaz, 2006), genetic algorithms (Cheng & Gen, 1998; Simaria & Vilarinho, 2004), simulation methods (Shanker, Padman, & Khelton, 2001; Gökçen and Ağpak, 2004) and the computer techniques.

## 3. Mathematical Model of the WLBP

Mathematical optimization models are widely used for modeling workload balancing problems. The notation and the mathematical model of the balancing problem are given below. The target is to minimize the cycle-time given at a fixed number of stations. Precedency constraints are provided by using a penalty function.

Cycle time, $C$
A set of m stations, S = $\{ S_1, S_2, \ldots, S_m \}$
A set of n tasks, $T = \{ T_1, T_2, \ldots, T_n \}$
Durations of the tasks, $t = \{ t_1, t_2, \ldots, t_n \}$
Penalty function constant, $k$
The number of tasks which do not suit the priority of job flow, $p$

The objective function is as follows;

$$\min \left[ std\_dev\left(\sum_{i=1}^{m} \sum_{T_k \in S_i} t_{(T_k)}\right) + k \cdot p \right]$$

Subject to ,

1 ) $\sum_{T_k \in S_i} t_{(T_k)} \leq C$ for all $S_i$,

2 ) $T_{j(s_i)} < T_{j(s_k)}$ , $i < k$ and precedency constraints.

Assuming,
A task will not be assigned to more than one station
(Ajenblit & Wainwright, 1998; Rajamani et al., 1990).

## 4. Model (Simple Problem)

In this section, we give a simple job precedence diagram and we explore all the steps of the GA approach on this problem. Consider Figure 1 where there are 8 tasks which have to be assigned to 2 different stations paying attention to precedence. The processing time units and the predecessors for each task are given in the second and the third rows of the Table 1. Sum of processing times of all tasks is 47 minutes (6 + 5 + 3 + 8 + 4 + 8 + 9 + 4 = 47).

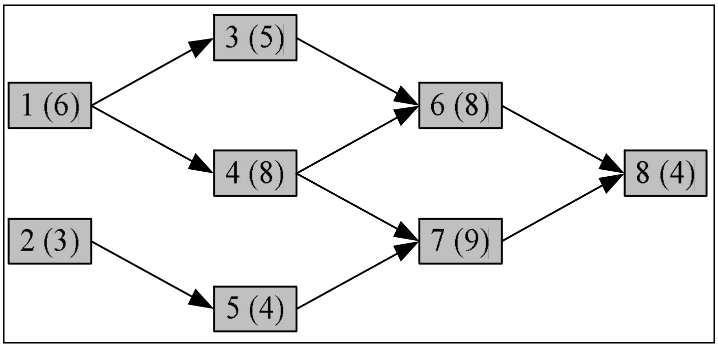


Figure 8. Precedence diagram for a simple workload balancing problem

Table 1. Names, processing times and the predecessors of the tasks

| Task $j$ | : | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Processing time $t_j$ | : | 6 | 3 | 5 | 8 | 4 | 8 | 9 | 4 |
| Predecessors | : | - | - | 1 | 1 | 2 | 3 , 4 | 4 , 5 | 6 , 7 |

We devise the lower and the upper bounds for each task in order to determine the sequence of the tasks. For example; task 3, 4 and 5 can be assigned after the task 1 and task 2. So, the lower and the upper bounds for the task 3, 4 and 5 are 3 and 5

Table 2. Priority matrix and lower and upper bounds for the tasks

| Task number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Lower limit | 1 | 1 | 3 | 3 | 3 | 6 | 6 | 8 |
| Upper limit | 2 | 2 | 5 | 5 | 5 | 7 | 7 | 8 |

## 5. Genetic Algorithm

Genetic algorithm, based on mechanism of natural selection and natural genetics, is a stochastic search and optimization technique which was proposed by Holland (Holland, 1975; Goldberg, 1989; Reeves, 1995). GA starts with an initial set of solutions called population. Each individual in the population is called a chromosome, representing a solution of the problem. A population of solutions is evolved to a next set of solutions through genetic operators such as selection, crossover and mutation. In GA, the idea is to get a new population with better desired characteristics than the previous. One of the critical problems in GA is to determine the encoding structure of the problem. The steps of GA are as follows:

*Step 1. Generation of initial population*
*Step 2. Evaluation of each individual*
*Step 3. Selection*
*Step 4. Crossover*
*Step 5. Mutation*
*Step 6. Obtaining the best solution (If stopping criteria is not met return to Step 2 and Select the best individual as a final solution.)*

### Generation of initial population

A set of initial solution is the starting point of the evolutionary process. In this study, the individuals of the initial population are formed in two parts, called string. In the first string, we use binary encoding and in the second, we use integers. Both strings indicate that which job is assigned to which station. The first string of the chromosome is randomly assigned and the other is obtained from the first string. To compose the initial population we use $m$x$n$ matrix, where $m$ shows the number of station and n shows the number of job. In our simple example, there are 8 jobs that must be assigned to 2 stations. Hence we formed 20 units (population size) of 2x8 matrixes. The structure of the initial population is shown in Figure 2.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solution 1 | Station 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 5 | 0 | 0 | 0 |
| | Station 2 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 3 | 0 | 0 | 6 | 7 | 8 |
| Solution 2 | Station 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 3 | 4 | 5 | 0 | 0 | 0 |
| | Station 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 6 | 7 | 8 |

Figure 9. The structure of the initial population

Calculating fitness function

Fitness is a criterion of the selection process. The larger the fitness is, the higher the probability of survival in the next generation. To calculate the fitness value of each individual, the durations of the tasks are placed in the second string of the chromosomes then the sum of time durations in each station are calculated (Figure 3).

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ind 1 | Station 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 0 | 8 | 4 | 0 | 0 | 0 | 17 |
| | Station 2 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 6 | 0 | 3 | 0 | 0 | 8 | 9 | 4 | 30 |
| Ind 2 | Station 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 3 | 8 | 4 | 0 | 0 | 0 | 20 |
| | Station 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 6 | 0 | 0 | 0 | 0 | 8 | 9 | 4 | 27 |

Figure 10. Binary encoding and time durations of the tasks in each station, total task durations

The next step is to obtain the sequence of the tasks in each station. Utilizing the first string, we readily obtain the sequence of the tasks and then we calculate the standard deviation using each of individual total durations of the stations. Since the sequences are randomly formed, they can produce infeasible solutions. Therefore this solution can not be a good solution of the problem. In GA approach, it can be benefited from penalty functions in order to get rid of the unfeasible solutions. When the solution 1 is controlled, two tasks are not appropriate for the precedency constraints. They are task 4 and task 1. This value is put into the objective function as the summation by multiplying constant *k*. The value of *k* is selected as 3 in our model. Figure 4 shows the task sequence and the fitness values of the Individual 1 and 2.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ind 1 | 2 | 4 | 5 | 1 | 3 | 6 | 7 | 8 | 9,1924 + 3*2 | 15,1924 |
| Ind 2 | 2 | 3 | 4 | 5 | 1 | 6 | 7 | 8 | 4,9497 + 3*2 | 10,9497 |

Figure 11. Task sequence and the fitness value for each individual

Selection mechanism

The purpose of parent selection in GA is to offer additional reproductive chances to those population members that are the fittest. One commonly used technique, the roulette-wheel-selection, is used for this proposed GA approach.

Crossover

Crossover is the most important operator in GA applications. Many different types of crossover are mentioned in the literature. The most useful ones are one point and two point crossover. In our GA approach, we use one point permutation crossover (PX) with a probability of 0,5 and 0,75 (Oliver et al., 1987). Crossover process is shown in Figure 5.

Crossover point (between positions 3 and 4)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Parent 1 | 2 | 4 | 5 | 1 | 3 | 6 | 7 | 8 |
| Parent 2 | 2 | 3 | 4 | 5 | 1 | 6 | 7 | 8 |
| Offspring 1 | 2 | 4 | 5 | 3 | 1 | 6 | 7 | 8 |
| Offspring 2 | 2 | 4 | 3 | 5 | 1 | 6 | 7 | 8 |

Figure 12. Crossover operator

Mutation

Mutation plays decidedly secondary role in the operation of GA. In artificial genetic systems the mutation operator protects against such an irrecoverable loss (Goldberg, 1989: p.14). Mutation arbitrarily alters one or more genes of a selected chromosome, by a random change with a probability equal to the mutation rate In our model transposition mutation is used with a probability of 0,20, represented in Figure 6.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 4 | 5 | 3 | 1 | 6 | 7 | 8 |
| 2 | 7 | 5 | 3 | 1 | 6 | 4 | 8 |

Figure 13. Mutation operator-single transposition mutation

Obtaining the best solution

We obtain the best and feasible solution in 10 iteration because of the simplicity of the problem.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 6 | 5 | 0 | 8 | 4 | 0 | 0 | 0 | 23 |
| Station 2 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 8 | 9 | 4 | 24 |

| | Station 1 | | | | Station 2 | | | | Fitness Value |
|---|---|---|---|---|---|---|---|---|---|
| Job Sequence | 1 | 2 | 4 | 5 | 3 | 6 | 7 | 8 | 0,7071 |

Figure 14. Best Solution

## 6. WLB Application

In this section; a larger WLB problem, which have 40 tasks and 4 stations that the precedence diagram are seen in Figure 8, is solved using GA approach. The evolutionary process is applied to this problem similarly. Matlab 7.0 is used for GA coding system. Tasks, duration of the tasks (Table 3) and are selected as the data. The upper and the lower bounds of the tasks are found from the precedence diagram.

Table 3. Number of tasks and the time durations of them

| Task Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time Duration | 7 | 8 | 12 | 5 | 9 | 6 | 10 | 8 | 10 | 7 | 12 | 10 | 6 | 9 | 3 | 10 | 11 | 4 | 12 | 8 |
| Task Number | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| Time Duration | 10 | 5 | 4 | 12 | 6 | 4 | 4 | 3 | 8 | 12 | 5 | 11 | 6 | 15 | 10 | 8 | 6 | 7 | 3 | 12 |

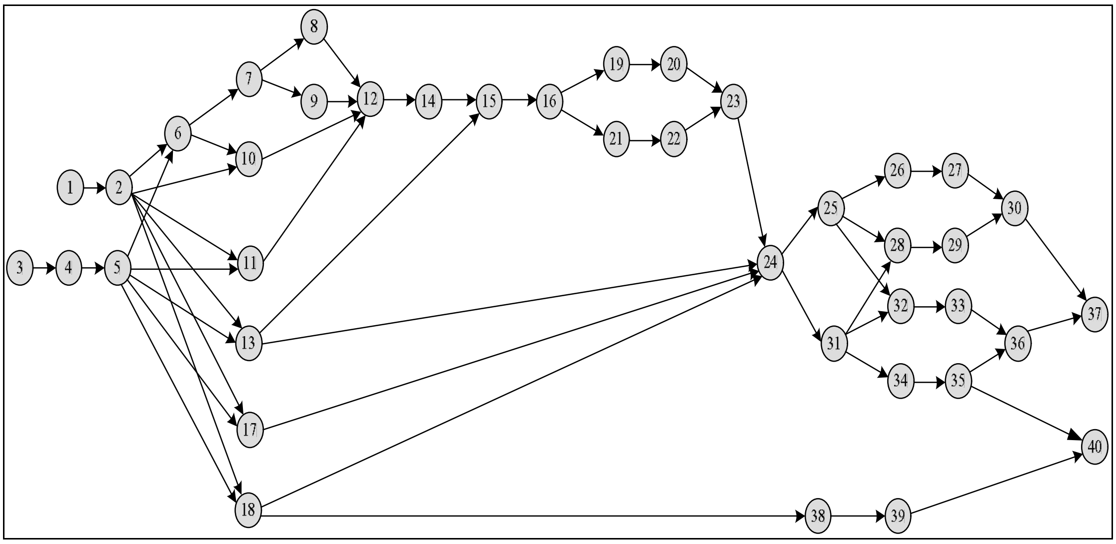


Figure 15. Precedence diagram for WLB

The GA parameters which are used in the algorithm are given in Table 4. These parameters are determined heuristically in the direction of the literature as a consequence after many trials. A specific parameter optimization study is not built. The result is generally obtained in a number of 2000 iteration. When the final solution is compared with the result that has got from specific line balancing software, we see that both of the solutions are the same. The results of our GA approach are indicated in Table 4. The cycle time and the efficiency of the line (1–total idle time/total time) with 4 stations are found as 68 min and % 99, 4.

Table 4. GA parameters, used for two trials

| First Trial | | Second trial | |
|---|---|---|---|
| Crossover rate | 0,50 | Crossover rate | 0,75 |
| Mutation rate | 0,20 | Mutation rate | 0,15 |
| Max. Number of iteration | 10000 | Max. Number of iteration | 5000 |
| Size of the population | 30 | Size of the population | 40 |
| Obtained Efficiency | % 99,37 | Obtained Efficiency | % 99,37 |

Table 5. The results (Schedule of the tasks-sequence and others)

| | | | | | | | | | | | | | Total Durations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station 1<br>Num. of Task: 10 | Task Names | 3 | 1 | 2 | 4 | 5 | 18 | 6 | 11 | 13 | 17 | | 80 min. |
| | Durations of the Tasks | 12 | 7 | 8 | 5 | 9 | 4 | 6 | 12 | 6 | 11 | | |
| Station 2<br>Num. of Task: 9 | Task Names | 10 | 7 | 9 | 8 | 12 | 14 | 15 | 16 | 19 | | | 79 min. |
| | Durations of the Tasks | 7 | 10 | 10 | 8 | 10 | 9 | 3 | 10 | 12 | | | |
| Station 3<br>Num. of Task: 11 | Task Names | 21 | 38 | 39 | 20 | 22 | 23 | 24 | 31 | 34 | 25 | 26 | 79 min. |
| | Durations of the Tasks | 10 | 7 | 3 | 8 | 5 | 4 | 12 | 5 | 15 | 6 | 4 | |
| Station 4<br>Num. of Task: 10 | Task Names | 28 | 35 | 27 | 29 | 40 | 30 | 32 | 33 | 36 | 37 | | 80 min. |
| | Durations of the Tasks | 3 | 10 | 4 | 8 | 12 | 12 | 11 | 6 | 8 | 6 | | |
| Total cycle time: 318; The fitness value: 0,577<br>Cycle time for a station: 80 min, Idle time: 2 min.<br>Line Efficiency =1-(Idle time/total time) = 1– (2/318) = 0,9937 | | | | | | | | | | | | | 318 min. |

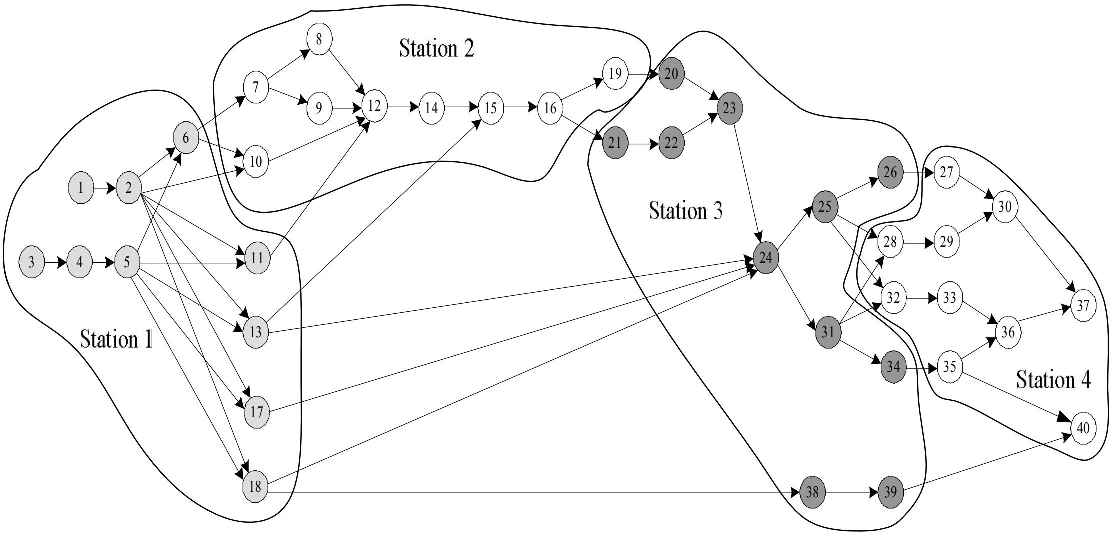


Figure 16. Schedule of the tasks to 4 stations

## 7. Conclusion

In this paper, we propose a GA approach to solve workload balancing problem which is known as Type I assembly line balancing problem. One of the main assets of this research is to explore the use of GA in workload balancing problems which has the targets of minimizing total idle time for a fixed number of stations and balancing of the workloads among stations. By using this approach, we achieve the results as good as the results obtained by specific balancing software. But, the larger the problems the higher total processing time. Results from GA approach indicate that small manufacturers can easily improve their throughput by applying the proposed approach. This approach can easily be applied to both Type II assembly line balancing and for U shaped line balancing problems, by small changes.

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# IMPACT OF EXPONENTIAL SMOOTHING FORECASTING ON THE BULLWHIP EFFECT UNDER LINEAR DEMAND WITH SEASONAL SWINGS

Erkan Bayraktar[1], and Kazım Sarı[2]

## Abstract

*The bullwhip effect as one of the highly studied areas of supply chain implies the information distortion among the supply chain members. Demand forecasting is one of the main causes of the bullwhip effect. The purpose of this study is to analyze the impact of exponential smoothing forecasts on the bullwhip effect in a linear-seasonal demand environment for a two-stage supply chain. A simulation model is developed to experiment the different scenarios of selecting right parameters for exponential smoothing forecasting technique. It is found that longer lead times and poor selection of forecasting model parameters lead to strong bullwhip effect. In contrast, increased seasonality helps to reduce the bullwhip effect. The most significant managerial implication of this study lies in the need to reduce lead times along the supply chain to mitigate the bullwhip effect. While high seasonality would reduce the forecast accuracy, it has a positive influence on the reduction of bullwhip effect. SCM managers are therefore strongly suggested to utilize exponential smoothing by selecting lower values for $\alpha$ and $\beta$ and higher value for $\gamma$ to keep the bullwhip ratio low, while at the same time to increase forecast accuracy.*

*Keywords: Bullwhip Effect, Forecasting, Exponential Smoothing, Supply chain management*

## 1. Introduction

The bullwhip effect, also known as Forrester or whiplash effect is one of the key areas of research in supply chain management (SCM). It represents the phenomenon where orders to supplier tend to have larger variance than sales to the buyer and customer demand is distorted (Lee *et al.*, 1997a, 1997b). This demand distortion also propagates upstream stages in an amplified form. In return, high inventory levels and poor customer service rates along the supply chain are typical symptoms of bullwhip effect. In addition, production and inventory holding costs as well as lead times increase, while profit margins and product availability decrease (Chopra and Meindl, 2001:363). Metters (1997) empirically showed that elimination of bullwhip effect might increase product profitability by 10-30 per cent depending on the specific business environments.

The bullwhip effect was first noticed and studied by Forrester (1961) in a series of simulation analysis. He named this problem as 'demand amplification'. He further concluded that the problem of the bullwhip effect stemmed from the system itself with its policies, organization structure and delays in material and information flow, not stemmed from the external forces. Later, Sterman (1989) studied the bullwhip effect by playing 'beer distribution game' with students. He noted that misperception of feedback loops and irrational reaction of decision makers to a complex and tacit system created the bullwhip effect. As people have difficulties to realize the impact of their ordering decisions due to complexity of the system and the time lags between ordering and receiving, Sterman (1989) suggests that operations managers be provided necessary training on the bullwhip effect. Lee *et al.* (1997a, 1997b), however, indicate that bullwhip effect is present; even if all members of the supply chain behave in optimal manner unless supply chain is redesigned with different strategic interactions. Their analytical study point outs that the bullwhip effect stems mainly from four factors: demand forecasting, order batching, price fluctuations, and rationing and shortage gaming. While supporting this view on the causes of the bullwhip effect, Miragliotta (2006) criticizes the mechanism generating the bullwhip effect. In their review of bullwhip effect, Geary *et al.* (2006) emphasize the following causes initially suggested by Jack Forrester and Jack Burbidge, twin pioneers of modern supply chain knowledge: control systems, activity times in the chain, level of information transparency, the number of echelons, synchronization, and multiplier effect.

Demand forecasting is an essential tool for production and inventory planning, capacity management, and the design of the customer service levels. Many demand-forecasting techniques rely on the historical data and assume the validity of the past demand patterns for the near future. Due to high sensitivity of the forecast values to the most recent occurrences, this approach produces high demand forecast values just after high demand periods, and low demand forecasts following low seasons. At the same time, customer demand is passed to the wholesalers, distributors, or manufacturers in the form of retailers' order, which is actually the demand for wholesaler or distributor. The need to forecast the demand at each level of the supply chain amplifies the forecast errors along the

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whole chain. This is called as double forecasting by Lee *et al.* (1997b) and thus a proper demand forecast system is required to reduce the bullwhip effect.

Demand forecasts in practice, however, are rarely accurate and they get even worse at the higher levels of supply chain. In most supply chains, individual chain members attempt to rationalize their order sizes with economical batching decisions, though this creates a distortion on the real customer demand and misleads the upper-level supply chain members on demand. Promotions and price fluctuations also contribute to demand distortion.

The purpose of this study is to analyze the impact of exponential smoothing forecasts on the bullwhip effect in a linear-seasonal demand environment. Based on a simulation model, while Chen *et al.* (2000a, 2000b) analytically examined earlier the same problem for autoregressive demand structures and linear demand, they did not consider the demand seasonality. This study therefore fills this gap considering a two-stage supply chain to analyze the impact of exponential smoothing forecasting technique on the bullwhip effect under linear demand assumption with seasonal swings. A simulation model is developed to experiment the different scenarios of selecting right parameters for exponential smoothing forecasting technique.

The remainder of this study is organized as follows. The next section reviews the previous literature related to forecasting on bullwhip effect. Section 3 explains the development of simulation model to test exponential smoothing for demand forecast. Setting of experimental design is identified in Section 4 followed by simulation results. Conclusion is provided in final section.

## 2. Literature survey

Following Lee et al. (1997a), several other researchers have also concentrated on the causes of bullwhip effect in order to understand their impacts on supply chain. Of these causes, the major emphasis has been placed on demand forecasting. Researchers relying on different methodologies have constructed various models to explore the impact of demand forecast. For example, Chen et al. (2000a, 2000b) used statistical methods; Anderson et al. (2000) adopted system-thinking methodology; Dejonckheere et al. (2003, 2004), and Disney and Towill (2003a) used control-engineering methodology. All of these studies concentrated mostly on the forecasting methods of moving average, simple exponential smoothing and double exponential smoothing. Their results indicated that the number of observations used in moving average should be high in order to lower the bullwhip effect. Moreover, lower values of smoothing parameters ($\alpha$, $\beta$) are required in exponential smoothing forecasting. While these studies offer a number of useful implications for SCM practitioners, they do not provide all the information required as none of these studies considered seasonality in their models.

For AR(1) demand process using order-up-to inventory policy, Chen et al. (2000a) quantified the bullwhip effect for moving average forecasting model in a two-level supply chain. Their findings support the significance of reducing lead times to mitigate bullwhip effect. Under the similar assumptions, Zhang (2004) derived the optimum forecasting procedure minimizing the mean-squared forecasting error (MMSE) where MMSE forecast leads to lowest inventory cost under the given conditions. Reduction of lead time has the most significant impact on the decline of bullwhip effect under MMSE forecasts when the demand autocorrelation is positive and away from zero or one. If demand correlation is negative, exponential smoothing provides the most significant impact on bullwhip effect for reduced lead times. Chen et al. (2000b) also investigated the double exponential smoothing forecasting technique for demand process with a linear trend. They emphasized the importance of selecting relatively lower values for smoothing parameters ($\alpha$, $\beta$) and reducing lead-times to diminish the bullwhip effect. They also stated that a retailer who forecasts a linear demand process faces relatively higher order variability as compared to one who forecasts a stationary demand process. This variability also does not depend on the magnitude of the linear trend. Another important finding emerging from this study is that exponential smoothing method also produces more variability compared to the moving average method.

Zhao et al. (2002) investigated the impact of forecasting models, demand patterns and capacity tightness of the supplier on the performance of the supply chain in terms of total cost and service level. Their model has included one capacitated supplier with setup and backorder costs and four retailers replenishing according to economic order quantity model. Their findings have emphasized the impact of the accuracy of forecast models on the value of information sharing. The supplier can improve its total costs and service level through information sharing in all cases, while total costs and service level for retailers may even get worse under information sharing when capacity tightness is low.

In fact, the demand forecasting is only one of the four causes of bullwhip effect according to Lee et al. (1997a); thereby using smoother forecasting policy is not a unique remedy for the bullwhip effect. There are also other proposed strategies, which can be summarized as follows:

- Sharing POS data with trading partners (Dejonckheere et al., 2004; McCullen and Towill, 2002; McCullen and Towill, 2001; Chen et al., 2000a, 2000b; Mason-Jones and Towill, 2000; Towill, 1997);
- Echelon elimination (e.g. implementing vendor managed inventory) (Disney and Towill, 2003b; Forrester, 1961);
- Lead time reduction (Forrester, 1961; Lee et al., 1997a; Machuta and Barajas, 2004; Anderson et al., 2000);
- Training decision makers for more rational decisions (Sterman, 1989);
- Designing robust systems that minimize human interactions (Disney et al., 2004).

## 3. The Supply Chain Model

This study concentrates on a two-stage supply chain consisting one manufacturer and one retailer. The manufacturer has unlimited capacity and produces a single product for the retailer, whereas the retailer fulfills the demand of the final customers. Simple order-up-to policy is used for replenishment decisions[1]. In the supply chain, the following sequences of events occur in a given period:

- At the beginning of the period, the retailer analyses the historical demand data and makes a demand forecast.
- After the demand forecast is completed, order-up-to level of that period is updated.
- The retailer observes the inventory position and places a replenishment order to the manufacturer if the inventory position is less than the updated order-up-to level.
- Final customer requirements are met by on hand inventory. Any unfilled demand, however, is backordered to be satisfied in the following periods.
- The manufacturer, on the other hand, has unlimited manufacturing capacity. Therefore, any order placed by the retailer is fully met after a fixed lead-time interval.

It is assumed that the retailer has a linear demand process with seasonal swings. In order to evaluate the impact of seasonality on the bullwhip effect, three types of demand structures representing different levels of seasonality are used: low, medium and high level of seasonality. Different demand structures for the retailer in the simulation model are generated using the following formula (1):

$$D_t = (100 + 2 \times t) \times \left( \frac{[\text{season} + \sin(\frac{2 \times \Pi}{52} \times t)]}{\text{season}} \right) + 100 \times \text{snormal}() \qquad (1)$$

where $D_t$ is the demand in period t, snormal() is a standard normal random number generator. The seasonal parameters in Eq. (1) for low, medium and high levels of demand seasonality are selected as 5, 15 and 30, respectively.

Since both linear trend and seasonality exist together in the demand model, Winter's (triple exponential smoothing) method for forecasting is employed in the simulation model. This forecasting method requires three smoothing parameters to update level, trend, and seasonal components of the demand, which are represented by alpha (α), beta (β), and gamma (γ), respectively. More detailed information on this forecasting method is provided in Abraham and Ledolter (1983:170).

## 4. Experimental Design

The purpose of the experimental design is twofold: (1) Analyze the impact of the smoothing parameters, lead-time and strength of seasonality on the bullwhip effect; (2) Examine interaction of the smoothing parameters with lead-time and seasonality. Therefore, three groups of independent factors are investigated through the experimental design. The number of levels of these factors and their values are listed in Table I. The values of alpha (α) and beta (β) parameters used in the exponential smoothing are suggested to be less than 0.5 in order to get better forecast values from Winter's forecasting model (Winston, 1993:1268). The levels of these parameters are set accordingly.

*Table 1: Independent factors of the experimental design.*

| Independent Factors | Levels | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Smoothing parameters | | | |
| Alpha *(α)* | 0.01 | 0.25 | 0.50 |
| Beta *(β)* | 0.01 | 0.25 | 0.50 |
| Gamma (γ) | 0.01 | 0.25 | 0.50 |
| Strength of Seasonality | Low | Medium | High |
| Lead Time | 1 week | 3 week | 5 week |

'The bullwhip effect' is considered as the dependent variable of the design of experiment. It indicates the ratio of variance of the orders realized by the manufacturer to the variance of the demand observed by the retailer as in Eq. (2).

$$\textit{Bullwhip Ratio} = \frac{Var(Order)}{Var(Demand)} \qquad (2)$$

[1] This policy requires placement of an order when the inventory position is less than the order-up-to level.

## 5. Simulation Output Analysis

The supply chain model above was simulated for 520 weeks. The initial parameters of the forecasting model are estimated by the first 156 weeks of simulation run. Therefore, data from the remaining 364 weeks (from week 157 to week 520) were used for simulation output analysis. In addition, ten replications for each combination of the independent variables were conducted to reduce the impact of random variations. The output from the simulation experiments was examined by ANOVA tests. The ANOVA test results are shown in Table II.

Table 2. Selected ANOVA results[1].

| SOURCE | Mean Square | F | Sig. |
|---|---|---|---|
| Alpha | 104,7684 | 44828,4067 | 0,00000 |
| Beta | 14,0638 | 6017,6438 | 0,00000 |
| Gamma | 0,4636 | 198,3575 | 0,00000 |
| Lead time | 34,7446 | 14866,5445 | 0,00000 |
| Seasonality | 12,0279 | 5146,5105 | 0,00000 |
| Alpha * Beta | 3,3380 | 1428,2830 | 0,00000 |
| Alpha * Gamma | 0,0120 | 5,1181 | 0,00042 |
| Alpha * Lead time | 8,7309 | 3735,7877 | 0,00000 |
| Alpha * Seasonality | 0,7507 | 321,2195 | 0,00000 |
| Beta * Gamma | 0,0221 | 9,4537 | 0,00000 |
| Beta * Lead time | 1,5905 | 680,5240 | 0,00000 |
| Beta * Seasonality | 0,0458 | 19,6010 | 0,00000 |
| Gamma * Lead time | 0,0038 | 1,6185 | 0,16681 |
| Gamma * Seasonality | 0,0061 | 2,6134 | 0,03370 |
| Lead time * Seasonality | 0,1378 | 58,9725 | 0,00000 |

## 6. Main Effects

ANOVA test results in Table II indicate that bullwhip effect is significantly influenced by the smoothing parameters, lead time and the seasonality ($p<0.05$). In order to understand how these factors influence the bullwhip effect, a series of multiple range tests were conducted. The test results are shown in Table III.

Table 3: Multiple range tests for each independent variable.

| VARIABLE | LEVEL | N | SUBSET | | | SIG. |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | |
| Alpha | 0.01 | 810 | 1.5278 | | | 1.00 |
| | 0.25 | 810 | | 4.7314 | | 1.00 |
| | 0.50 | 810 | | | 11.9877 | 1.00 |
| Beta | 0.01 | 810 | 3.2035 | | | 1.00 |
| | 0.25 | 810 | | 5.6520 | | 1.00 |
| | 0.50 | 810 | | | 9.3914 | 1.00 |
| Gamma | 0,25 | 810 | 5.7972 | | | 1.00 |
| | 0.50 | 810 | | 6.0406 | | 1.00 |
| | 0.01 | 810 | | | 6.4091 | 1.00 |
| Lead time | 1 week | 810 | 2.3932 | | | 1.00 |
| | 3 week | 810 | | 5.1418 | | 1.00 |
| | 5 week | 810 | | | 10.7119 | 1.00 |
| Seasonality | High | 810 | 3.7289 | | | 1.00 |
| | Medium | 810 | | 6.9463 | | 1.00 |
| | Low | 810 | | | 7.5718 | 1.00 |

Table III indicates that any increase in the values of alpha and beta parameters as well as lead-times cause an increase in bullwhip effect. On the other hand, the impacts of the gamma parameter and seasonality on bullwhip effect are only slightly different. Table III reveals that as the strength of seasonality increases, the value of the bullwhip ratio decreases. This might be explained by the fact that the forecasting method used in the model performs better for higher levels of seasonality. In other words, the variation generated by the seasonality cancels out the variability created by the bullwhip effect. When we consider the gamma parameter, however, Table III reveals that the bullwhip ratio becomes the smallest when the gamma parameter is 0.25 and largest when it is 0.01. This result

[1] Log transformation of dependent variable is conducted in order to satisfy the ANOVA assumptions.

indicates that the relationship between gamma parameter and bullwhip ratio is not unidirectional. It is most likely that there are slight decreases in the bullwhip ratio as the value of the gamma parameter increases up to a point, and then it starts to increase with the higher values of gamma parameter. The gamma parameter will be analyzed further in the following subsections.

## 7. The Interaction between Smoothing Parameters and Lead Time

The interaction effect between smoothing parameters and lead time is shown in Figure 1. Figure 1 indicates that alpha and beta parameters act very much similar on the bullwhip ratio against to lead times. When the lead time is low, there is not much difference on bullwhip ratio based on the selection of the alpha and beta parameters. However, the bullwhip ratio increases very quickly as the lead time, and the values of alpha and beta parameters increase. Therefore, the values of alpha and beta parameters in the forecasting model should be selected small enough to keep the bullwhip effect low.

When we consider the interaction of gamma parameter with lead time, Figure 1 indicates a different situation. It is apparent from Figure 1 that longer lead times always lead to huge increases in the bullwhip ratio independently from the value of gamma parameter. Therefore, we can state that gamma parameter cannot contribute much to reduce the negative impact of the longer lead times.

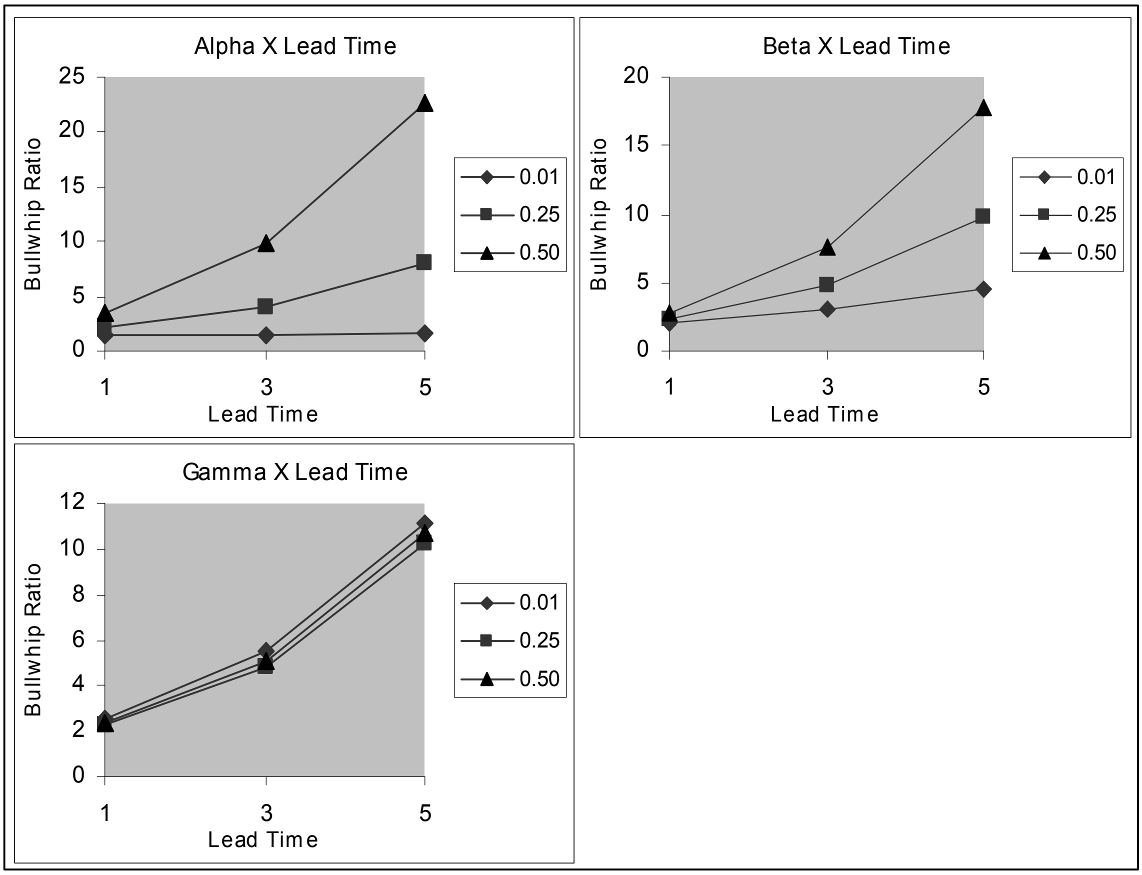


Figure 1. Interaction effect between smoothing parameters and replenishment lead time

## 8. The Interaction between Smoothing Parameters and Seasonality

The interaction effect between smoothing parameters and seasonality is shown in Figure 2. Figure 2 indicates that interactions of alpha and beta parameters with the seasonality have some similarities; selection of relatively lower values for alpha and beta parameters enables to reduce the bullwhip ratio in all demand seasonality levels. Since the bullwhip effect is lower under high seasonality levels as compared to the one under low seasonality levels, the selection of relatively lower values for alpha and beta parameters becomes much more important to be able to reduce the bullwhip ratio under low demand seasonality. On the other hand, Figure 2 reveals that selection of gamma parameter does not have much significant impact on each seasonality level individually, since the seasonality has much stronger influence on bullwhip effect.

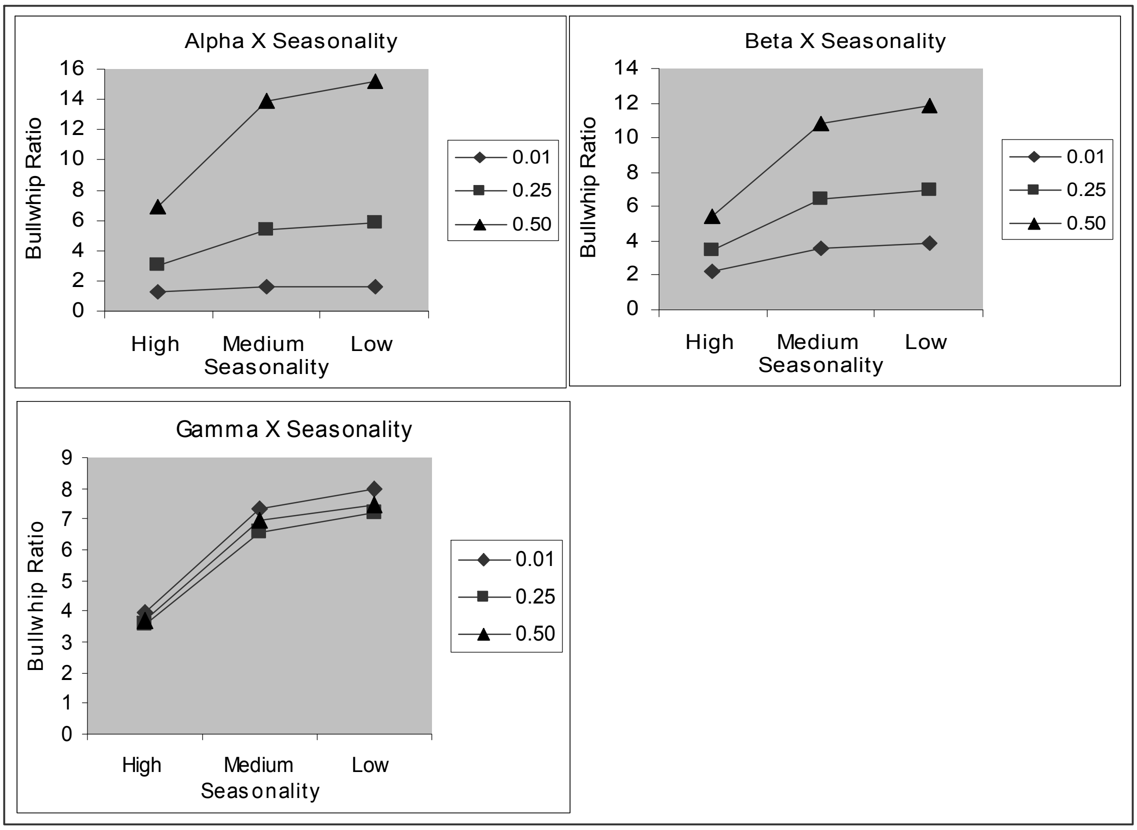


Figure 2. Interaction effect between smoothing parameters and seasonality

## 9. Further Analysis of Gamma Parameter

In order to understand better the influence of the gamma parameter on the bullwhip ratio, we further analyze gamma parameter for various levels ranging from 0.01 to 0.91 with increments of 0.10 while keeping all other parameters of the model constant. This analysis clarifies that the relationship between bullwhip effect and gamma parameter is in a quadratic form as shown in Figure 3. Hence, the value of gamma parameter should be selected in a way to minimize bullwhip effect.

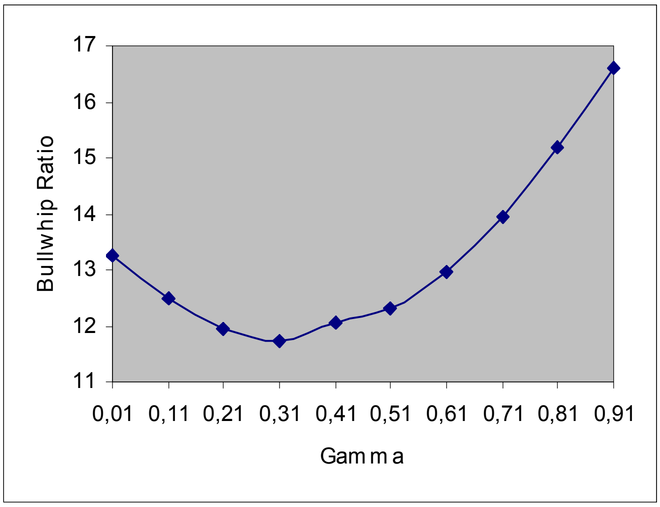


Figure 3: Bullwhip ratio for different levels of gamma parameter

## 10. Conclusion

This study has provided a detailed analysis of the impact of exponential smoothing forecasting technique on the bullwhip effect for a linear demand structure with seasonal swings. Although Chen et al. (2000a, 2000b) initially examined the same problem analytically for autoregressive demand structures and linear demand, they did not consider the demand seasonality in their study. A simulation model developed here considers linear demand process with seasonal swings in order to observe the interaction between the forecasting parameters and the bullwhip effect. Based on the simulation analysis, this study reveals a highly significant finding that high levels of seasonality have a positive impact on reducing the bullwhip effect. In other words, the bullwhip effect is compensated by the variability generated by the seasonality. As noted earlier, for some other demand structures, lead time has also a very strong impact on bullwhip effect for both linear and seasonal demand structures.

In terms of Winter's model for exponential smoothing technique, selection of smoothing parameters (α, β, γ) has significant impact on the bullwhip ratio. Of these parameters, the impact of the gamma (γ) parameter on the bullwhip ratio is relatively minor. For lower bullwhip ratio, choosing relatively lower values for alpha (α) and beta (β) parameters becomes crucially important. This is even true for the different levels of lead time and seasonality. Since the relationship between bullwhip effect and gamma parameter forms a quadratic association, the gamma (γ) parameter should be selected in a way to reduce the bullwhip effect.

The findings of Winter's model parameters to reduce the bullwhip effect have some similarities with those of Winston (1993:1268) for the selection of exponential smoothing parameters for forecast accuracy. Therefore, we may conclude that better forecasting leads to lower bullwhip effect.

As a future area of research, the analysis above can be extended in a way to assess the impact of bullwhip effect on the performance measures of the supply chain (e.g., total cost of the members, total chain cost, service level of chain members, and service level of the chain). It is well accepted that the bullwhip effect has a deteriorating impact on the performance measures of the whole chain, but the magnitude of direct relationship between the bullwhip effect and the performance measures of supply chain and its members is still an interesting research question to investigate.

While in practice there are many different forms of demand processes as well as many forecasting techniques to predict these demands, this study focuses on forecasting of linear seasonal demand through exponential smoothing. Therefore, our findings on seasonality are limited to only exponential smoothing forecasting, which constitutes a limitation of this study. Investigation of other techniques of time series analysis for seasonality would also prove useful for future research.

The most significant managerial implication of this study lies in the need to reduce lead times along the supply chain to mitigate the bullwhip effect. While high seasonality would reduce the forecast accuracy, it has a positive influence on the reduction of bullwhip effect. SCM managers are therefore strongly suggested to utilize exponential smoothing by selecting lower values for α and β and higher value for γ to keep the bullwhip ratio low, while at the same time to increase forecast accuracy.

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# FACTORS TO CONSIDER FOR OUTSOURCING DECISIONS IN SUPPLY CHAIN MANAGEMENT

Ali Kuzu[1], Erman Coşkun[2], Turan Çakır[3]

## Abstract

*Outsourcing is one of the most discussed and also widely applied methods in today's business world. Outsourcing strategy has found effective applications especially in the information technology and the logistics (supply chain management) areas. The basic factors that cause "outsourcing" being widely preferred by managers are the cost advantage, insufficient expertise in different specialty areas, desire to focus on core activities, and desire to increase efficiency. Although the general aptitude emphasizes the advantages of outsourcing, there are some researchers against it because of the disadvantages and risks that it contains.*

*The logistics outsourcing, which is also named as "third party logistics – 3PL" in literature, includes the functions of the supply chain management (such as warehousing, transportation, and inventory management), being performed by a specialized logistics firm, outside of the company. This study examines the advantages and disadvantages of outsourcing in supply chains especially in logistics sector and aims to come up with a list of factors and their importance order required for successful outsourcing decisions, besides the risks and possible problems that could be faced during the application of it.*

*Keywords: Outsourcing, Supply chain management, Outsourcing Logistics, 3rd Party Logistics, 3PL*

## 1. Introduction

The general purpose of the supply chain management can be described as maintaining the right products and/or resources at the right place at the right time, in order to support the general target of profit maximization. Especially after the 1990s, as a result of the fast development in information technologies, companies concentrated on increasing their efficiencies (Siems, 2005). At the same time, the increasing globalization effect forces companies to gain competitive advantage in speed, flexibility and cost, in order to survive in this intensified competitive environment. Besides the customers' increasing demands, the increasing global economic crisis cause increase in the risks of companies that they are faced with. As a result of these factors, companies began to make radical changes in their production, marketing and management structures. In order to adapt to the changes, to be less-affected from the fluctuations, and to benefit from the newest and updated technology and knowledge, companies tend to outsource some functions (Mersin, 2004).

If we are to make a definition, the main concept of outsourcing is quite clear: It is the assignment of a "third-party" supplier (either a person or a company) to perform a task or a function, on behalf of the mother company. Although outsourcing has been used (and especially preferred for the operations, which are not directly related with the core businesses of the companies), the discussions about the advantages and disadvantages of this application have also been continued.

## 2. Outsourcing

Outsourcing simply refers to the operations and functions which are performed by third parties, out from the company, that are not the workers of the company. When we look at the definitions in the literature; Outsourcing is the transfer of operations about some business processes to a service provider outside of the company, or fulfillment of some operations by authorized third-parties (Polhill, 2004). On the other side, outsourcing, which is the use of suppliers out of the company during the design, production, transportation and service phases, should not be confused with the contract manufacturing (Reese, 2005). Outsourced functions are generally the ones which are not directly related with the core-business of the company. The main reason for this situation is that, companies do not want to invest their scarce resources (such as the capital, human resources, technology and facilities) into the areas that are not directly related with their core businesses (Craig, 2005).

The services supplied by the third-parties generally divided into two categories: Supportive services related with technology and information systems, and services related with business processes. The first group contains the services such as electronic commerce, network infrastructure, software and its applications; telecommunications web site preparation and hosting. The business processes in the second group includes the customer relationship management (CRM), finance and accounting, human resources management, procurement, logistics and supply chain management, and security services (Polhill, 2004).

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2.1. Why outsourcing?

The increasing competitive environment in today's business world caused the companies to turn their attention to increase their competitive advantage in their core business areas. "Core competency" term is used to identify the ability of a company which differs itself from its competitors and which provides a competitive advantage. Honda's specialization in motor production or Sony's capability of making very small equipments can be given as examples for this definition.

As the companies design all the targets and processes so as to support and develop their core competencies, they will operate more efficiently (Mersin, 2004). According to this approach, all the business processes which are not directly related with the core business of the company, or all the processes which can cause to loose the core competency, can be outsourced.

By outsourcing the functions related with the non-core business, companies strategically focus on their core competency areas and main business functions. By doing so, they can increase efficiency in the indirect functions where they do not have competitive advantage, they become able to take precautions to decrease costs, they can fulfill the required specialists and other human resources, and also can fulfill the required legal procedures, and finally, they can restructure the business processes. Besides the above advantages, in order to operate more elastically, to decrease the labor costs and to make less investment in the plants and equipments, companies started to use outsourcing more and more. In the United States, the suppliers' share in the cost of goods sold is expected to increase up to 43% from 37%, within two years (Reese, 2005).

3. Outsourcing the supply chain management:

Logistics services are either fulfilled by in-house providers of the company or by outsourcing to the third-party logistics companies. In-house logistics solutions are usually asset-based (i.e. established by the company's own resources) and operates as a department or a division of the company, to carry out the transportation, forwarding, warehousing, inventory management and the necessary information technology required for these functions. Third-party logistics company (3PL) is an independent stand-alone entity apart from the company, which has its own facilities and transportation fleet, in order to maintain logistics services to other companies.

Outsourcing in logistics means to have a specialized 3PL company to make transportation, inventory management, order processing, information systems management, packaging and managing all the sub-systems related with these functions. Logistics services are witnessing a considerable expansion of 3PLs, primarily because companies, including e-merchants, prefer to outsource logistics functions. In today's business world, companies heavily concentrate on their core competencies, in order to survive under the global competition. As a result of this incline, more and more companies start to outsource the secondary functions, so as to serve their customers with the best logistics support services. The third party logistics services providers are said to be "… *interested in investing in assets, dedicating capacity and personnel, customizing information systems and communications in order to improve the productivity and customer satisfaction of their manufacturing and distributing clients*" (Sink, Langley & Gibson, 1996).

According to the United States E-Commerce and Development Report (2001), the remarkable growth of logistics outsourcing has been attributed to a number of factors:

1) Many companies have installed various types of applications to optimize their in-house logistics functions, and these applications are tending to become increasingly sophisticated and complex. Some companies are unable to cope with the changes and have responded by outsourcing the provision of the applications to specialized technology companies. In other cases, companies have simply not yet installed any logistics applications and outsourcing has been a convenient short cut.
2) A second factor is companies' desire to concentrate their resources and competencies on their core businesses.
3) A third factor is the avoidance of sunk costs and risks, since outsourcing eliminates the need to incur costs on training logistics staff and acquiring warehouses, equipment and hardware.
4) Fourth, for a start-up company or a company that is expanding quickly, outsourcing allows it to expand the volume of its business quickly with minimum investments, simply by relying on third-party facilities and services.
5) Fifth, by providing services to several firms, 3PLs are in a position to develop large databases and other information that an outsourcing firm can access at lower cost than if it were to collect the same data itself.

In today's business world, all the supply chain functions, including the management function, could be outsourced. According to a research, which was performed by the Accenture Consulting firm, the number of companies outsourcing the logistic functions to 3PL companies, doubled between the years 1991 and 2001 (Sanders & Locke, 2005).

In United States in 1995, there were "so many trucks but very few job", which means that there was excess capacity, in other words the capacity usage ratio was quite low. On the other side, when we came to the year 2005, the capacity usage ratio of the logistics companies fairly increased. This situation is explained by the logistics outsourcing because, as the companies closed their own in-house logistics departments and outsource their logistics functions, the productivity and capacity usage ratios of the 3PL logistics companies increased. Similarly, the decrease in the supply chain and logistics expenses share in the gross domestic product (GDP) from 10.4% to 8.6% during this period (1995-2005) was also explained by this productivity increase (3PL Annual Study, 2005).

The above mentioned study also identifies the factors that influence the logistics executives' business. According to the executives, the major factors affecting their businesses are: pressure to reduce cost, pressure to enhance customer service, the globalization effect, and developments in information technologies.

Despite the promising benefits of outsourcing, companies need to carry out a proper assessment of the scope and timing of outsourcing and also the choice of 3PL firm that they are going to choose. An "outsourcing model" chosen for today's needs may become insufficient against the new and developing requirements of tomorrow. Because of this, the outsourcing contacts should be clearly understood and evaluated according to the company's targets. Consequently, a company must compare the costs and advantages of providing logistics functions in-house with those of outsourcing.

3.1. Outsourcing Strategy:

Although there are lots of successful examples of outsourcing, there is not a "one size that fits all" strategy in this area. The chosen strategy should be dynamic and flexible so as to meet the current and future needs of the company. Besides this, different strategies could be required for different functions, operations and processes of the company.

The most important and the basic point in an outsourcing strategy is the level of authorization of the 3PL firm, in other words, determining the duties and responsibilities assigned to the logistics company. Looking from the reverse angle, it is the identification of which processes are in the scope of "core business" concept that should be solved within the company using its own resources. Sanders and Locke (2005) grouped outsourcing arrangements into four categories, according to the scope of the outsourced functions: "*At one extreme, outsourcing can involve only one of the many tasks that comprise an entire operation or process… At another extreme, it can involve outsourcing development, implementation, management, and even strategic direction of the entire operation or process*". According to the level of the responsibilities assigned to the 3PL company, the four groups are as below, from least to most vendor responsibility:

1) Out-tasking: This is the assignment of a specific task to an outside logistics company. The scope is limited with the specified task and the responsibility of the 3PL company is limited only with that task. A simple example might be a manufacturing company hiring a trucking firm for transportation purposes.
2) Co-Managed Services: Although the scope of the outsourced operation or process is greater, the overall operation and function still remains under the direct control of the company. The company (customer) and the vendor (3PL company) share responsibility of the operation and they work in collaboration, but the vendor generally have less strategic significance. An example might be the inventory management, being carried by the vendor: The 3PL company usually observes and monitors the inventory levels and might procure the required product or the raw material. On the other hand the customer still controls the inventory plans. Risks associated with the poor vendor performance are still small, since the vendor is operating the less strategic tasks.
3) Managed Services: The 3PL company is responsible for design, implementation and management of an end-to-end solution of a complete function, including the equipment, facilities, staffing, software, implementation, management and the improvement of the system. In this type of outsourcing, companies generally expect the vendors to have deep industry knowledge and to meet the necessary rulings and standards. This kind of agreement not only enables a company to focus on its core business, but also to benefit from the vendor's unique skills and experience in that operation. On the other side, this kind of relationship includes greater business risks because of the dependence to the vendor.
4) Full Outsourcing / Business Process Outsourcing-BPO: In this kind of relationship, the customer assigns all the responsibility of design, implementation, management and even the strategic direction of a function, to the third party logistics company. This relationship includes and requires a customization at high levels. Not only the daily operations, but also the ongoing development of the business process is under the responsibility of the vendor. Although this kind of relationship can maintain benefits (competitive advantage) through process transformation and strategic differantion, it also contains higher risks since both the operational and strategic control is out of the company. Also this situation sometimes can cause problems in mergers, which was the latest fashion among the business world.

The main characteristic that differentiates the four types of outsourcing strategies, mentioned above, from each other is the scope of the outsourcing contract. Apart from this, another differentiating characteristic of outsourcing strategies is the *strategic importance level* of the function which is going to be outsourced. In case of "Business Process Outsourcing", it is evaluated as a *strategic* step whereas the "Out-Tasking" is only a *tactical* situation.

Another difference between outsourcing strategies is the customer and vendor (the company and the 3PL side) relationship. If the vendor is performing only a specific task of a function, relations are poor and limited, since it contains only the completion of the task according to the contract. As the scope of the outsourcing contract broadens, the relations (collaboration and co-operation) between the customer and the vendor increase and intensify.

Consequently, in order to determine the right strategy of outsourcing, the company targets, goals and the expected benefits from the outsourcing contract should be clearly stated and put forward. The outsourcing agreement signed today should be dynamic and flexible enough to meet the company's probable requirements tomorrow. As the company grows, the agreement also should be adoptable to meet the new requirements. Many companies in today's business world take outsourcing decisions without thinking about how it is related with their goals and objectives. They only imitate their competitors and they take outsourcing decisions only because other companies in the industry do so! Therefore, the result is going to be a disaster in terms of the costs and miss-directed resources. (Sanders ve Locke, 2005).

A last remarkable point might be that, a responsible person, who is going to continue and direct the relations with the third party logistics firm, should be determined. This is also vitally important for successful operations. This person monitors the performance of the 3PL firm, sustain the relationship and determine the measures for performance evaluation (Atkinson, 2006).

### 3.2. Factor to consider in choosing a 3PL firm

While selecting the third-party logistics company which is going to be transferred the supply chain operations, a specialized and experienced one (for our purposes) should be preferred, rather than "all kind of services to all customers" type of one. At this stage, one the most critical factors comes out to be the mutual confidentiality and secrecy. Managers generally evaluate the 3PL firms according to their financial strength, information systems integration and technical sufficiency, cost structure, capacity and references. Besides these, factors and qualifications such as flexibility, ability to meet the demand immediately, industrial specialization and experience, and sufficiency of the staff should also be taken into account in the evaluation process (Sink, Langley ve Gibson, 1996).

According to Sanders & Locke (2005), the companies' satisfaction level with the performance of 3PLs is about 50%. If such is the case, what is to be done to increase the satisfaction level? The important points that we have to consider during the selection process of a 3PL firm are as below:

1) While choosing a 3PL company, irrespective of the scope of the functions to be outsourced, it has to be evaluated thoroughly according to its ability and sufficiency. This evaluation has to comprise the company's core business, its ability to offer special services, respectability in the industry, experience, references and staff's capability. A logistics company should acquire a flexible organizational structure so as to meet the customers' potentially growing and changing demands. Another problem may occur when we consider the size of the company relative to the vendor (3PL company). Sometimes, smaller companies might feel that large vendors do not give them enough attention. A good relationship between client and the vendor contributes to business success, especially when both parties work around a clearly understood goal. A good relationship also is very much related with the compatibility of the organizational cultures of the client and the vendor. As the relationship between the parties develops, trust among them also develops. Trust is one of the key factors in outsourcing engagements, no matter at what strategic level it is.
2) A good relationship management is quite important. Most companies do not take this point seriously and neglect this point. Especially in comprehensive outsourcing engagements, the company must determine (or hire) and train the necessary human resources. And it is also necessary to build relationship architecture to manage the relations between the parties.
3) All the operations and processes should be performed appropriate to the contract. It is necessary to describe the mutual duties and responsibilities in detail in the contract. Generally, these articles in the agreement are not paid much attention and seen as "paper work" but the contacts' importance is increasing in today's volatile business and economic environment and increasing global transactions.
4) Another important point of a successful outsourcing agreement is the measurement of the performance continuously and accurately. Every key point related with the goals and objectives has to be monitored by measurable metrics. These metrics can be operational, financial or strategic. Measuring the vendor's performance is quite a complex issue than it appears.

## 3. Risks of outsourcing

Prof. Sunil Chopra from Northwestern University points out that, there are many issues supply chain management, such as procurement, inventory management, estimations related with the operations, customer relations, information systems, capacity management, and intellectual property rights; and each of these includes its own risks; therefore, risk averted strategies have to be required to be developed (Biederman, 2005).

"*Despite the promising benefits of outsourcing, companies still need to carry out a proper assessment of the scope and timing of outsourcing as well as the choice of 3PLs to which outsource. A company must compare costs and advantages of providing logistics functions in-house with those of outsourcing*" (The United States E-Commerce and Development Report, 2001).

According to the Boston Consulting Group specialists, while outsourcing is *rescuer* for some companies, it may be disastrous when it is handled and applied in a wrong way. While it is fatal sometimes not to outsource a function, it is fatal sometimes outsourcing with a wrong strategy. Many companies are trying to understand the risks related with outsourcing; and these risks become more serious when the company attempts to outsource the functions related with its core business such as engineering and design, which maintain competitive advantage against the competitors. If a company out sources the critical processes related with the product life-cycles, then the company itself becomes a distributor and loses all its control and elasticity on the products (Biederman, 2005).

Although the usage of outsourcing strategies are in an increasing trend, there are some points that cause managers to be anxious, such as the security problems in information-sharing, the anxiety about loosing the control and flexibility of the information systems, the reliability degree of the suppliers, and probable quality and performance decreases (especially when the company loose the control over the processes). Since most of the companies focus on the issue of "decreasing the costs", generally they make concession from the flexibility of their supply chain system.

Consequently, every step in the supply chain has also to be evaluated from the risk perspective. The possible precautions in order to attenuate these risks could be; tracking and monitoring the suppliers regularly, using analytical measurement and performance evaluation tools, detailed examination of the costs caused by the estimation errors and transportation defects, developing the communication and collaboration with the 3PL company to know them well, assessing the insurance opportunities, and preparing the alternatives of the third-party logistics firm in an urgent case.

## 4. Conclusion

In this study, we examined the factors and advantages that cause managers to prefer outsourcing, to perform some of the business functions. Although the general aptitude is through outsourcing, there are of course some disadvantages and risks of it. We also mentioned the risks and the important points of outsourcing agreements.

There is an important issue about this study, which could be the topic of another study. The metrics that was mentioned here, in order to measure the performance of a third-party logistic company, could be chosen as the topic of the next study because it is quite a complicated area in outsourcing. Therefore we can evaluate objectively and decide whether they are worth to outsource our functions or not.

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# DECISION SUPPORTING MODEL AND METHOD FOR OUTSOURCING OF DISTRIBUTION LOGISTICS SYSTEM OF PAPER FACTORIES

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## Abstract

*Introduction of paper making technology and its effects on the distribution logistics. Description of distribution logistics tasks to be outsourced: storage of finished products, distribution warehousing, delivery of finished products to the consumers. Analysis of parameters which have effects on stock level of finish product warehouse, storage capacity demand, average value of productivity demand for loading-in and loading-out activities. Evaluation system for determination of logistics characteristics of different distribution warehouses (own storage, general warehousing, consignation warehousing) in aspect of outsourcing. Analysis of different alternatives for distribution processes. Elaboration of mathematical model and method for decision supporting and monitoring of parameters of total distribution logistics system or its parts to be outsourced.*

*Keywords: outsourcing, distribution logistics, paper industry*

## 1. Introduction

Today logistics outsourcing is an important tool of the lean production which is applied by manufacturing companies who want to have a more cost-efficient management. The following play a relevant role in the growth of logistics outsourcing: recently such logistics provider companies appeared in Hungary too, who could handle certain logistics operations of manufacturing companies on a high technical level and more economically, providing they undertook these tasks. Among the logistics operations of manufacturers the full or partial outsourcing of the following occurs:

- Outsourcing of procurement logistics,
- distribution logistics or
- the material flow / warehousing between workshops and technological processes.

Outsourcing has two sources of advantages for the company:

- the outsourced logistics service can be fulfilled cheaper by the outsourcee
- through the pull effect of the higher level of service the company can reach higher sales revenue or lower losses; thus meeting delivery deadlines and increased reliability lead to the following:
  - better ability to deliver,
  - less complaint about quality,
  - lower stock levels and
  - better adaptivity to the dynamically changing end-user needs.

What kinds of logistics services can a logistics provider as an outsourcee offer

- with more advantageous logistics properties and
- lower costs?

Generally outsourcing can be more beneficial if

- the need for logistics resources of a company shows relevant fluctuations in the function of time. These fluctuations can be handled optimally by the "logistics provider", because it provides such services to several clients simultaneously, thus the fluctuations arising at these companies together balance the overall capacity need to a certain extent.
- the company is only able to reach a higher level of the logistics service by investment – in material or manpower -, but the outsourcee is ready to provide the equipment needed. Thus the investment can be postponed, which action is well-founded especially, if
  - there is no guarantee that the need for the certain logistics service will last for a longer term or
  - currently there are no favorable conditions for the source of investment to be made available.

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## 2. Prelude to this paper

Papers dealing with the outsourcing of logistics tasks are important parts of international technical literature. Generally these papers determine which factors must be analyzed at companies and logistics providers. They also analyze which influencing factors make outsourcing practical. [Simoni B.] [Metz M.], [Stoll M.] In the literature we can find references to methods, which can not only decide whether logistics outsourcing is practical, but can select the optimal one from several logistics providers. [Cselényi J.] In the case of mathematical methods papers favor multi-target programming, a method of fuzzy logic, which can take uncertainty into account. In these papers we have not found a detailed method of examination this far that would take into account mathematic-statistical methods and simultaneous handling of multiple target functions. This is just what this paper strives to do: to outline the assessing methods and basic equations of decision models of such a detailed method of examination.

## 3. The aim of this paper

This paper examines and analyzes whether it is favorable to outsource the distribution logistics system of a company producing paper products. We outline what logistics parameters must be analyzed at the distribution logistics system characteristic for such a company, based on the historical data that have been processed with statistical methods.

We introduce the logistics parameters which can be compared to the parameters reachable by an outsourcee. This leads to a multi-parameter decision model, for which we have to know not only the logistics parameters expressed in natural measurement units, but also the specific cost-factors respectively.

## 4. Introduction of the Distribution Logistics System of a Typical Paper Industry Company

Figure 1 shows the distribution logistics system of a paper industry company:

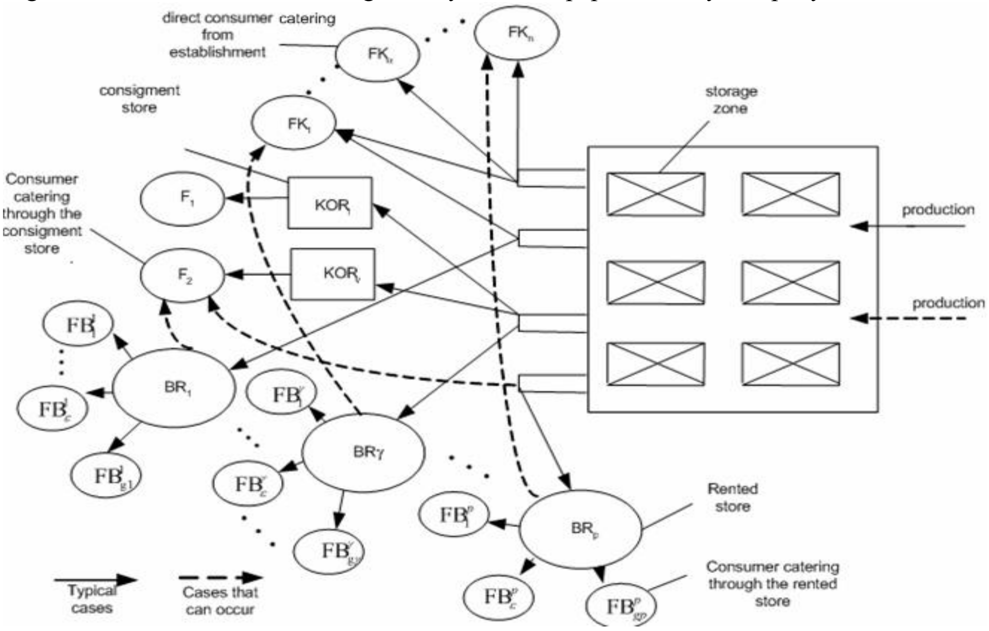


Figure 1 The typical distribution logistics system of a paper industry company

The results of production are unit loads:

- that vary extremely in dimensions
- the storage method of which can be
  - rack storage or
  - block storage

Regarding the supply to end-users we can determine three kinds of distribution courses:

- direct catering from the establisment,
- consumer catering through consignment store,
- consumer catering through rented store

According to the vehicles' routes we can isolate four types of delivery courses:

- round and shuttle services from the establishment
- round and shuttle services from the rented warehouse

When planning the production schedule the cost function is made up of:
the paper cutting plan resulting in a minimal amount of waste

the maximum capacity of the production equipment

The product structure consists of unit loads that are made up of 3, 5 and 7 layers of laid-out cardboard box sheets stored on various sizes of pallets.

## 5. Analysis-structure of the distribution logistics system

Figure 2 shows the structure of analyses carried out on the outsourcing of distribution logistics system

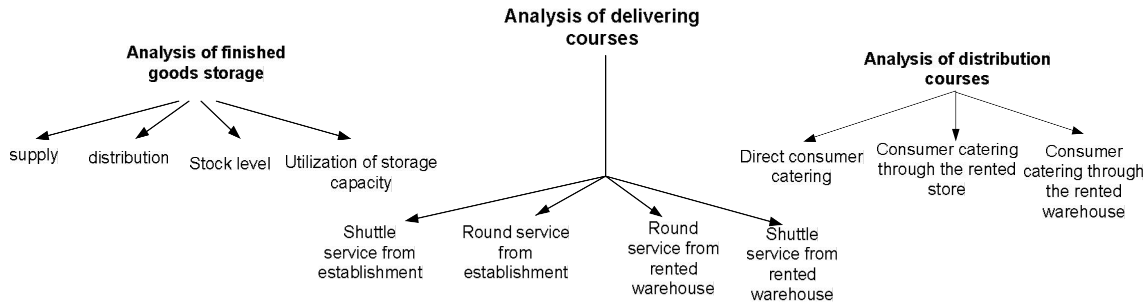


Figure 2 Structure of analyses carried out on the outsourcing of distribution logistics system of a company producing paper products

A wide-range analysis regarding monthly and annual data will be required in connection with the distribution logistics system system of the examined company.

When examining finished goods storage it is important to analyze the following – from the point of view of outsourcing:

- the distribution of unit loads incoming and outgoing from the finished goods warehouse (storage zones)
- the stock levels
- storage capacity utilization
- all this on a daily and monthly basis.

Analysis of distribution channels was needed, because we had to know about the methods of supply to end-users in detail. In this case we have to examine:

- the distribution of distribution channels between:
  - inland and outland
  - road and railway

  on a daily and monthly basis.

In the case of rented warehouses:

- Comparison between rented warehouses:
  - the amount of unit loads transported in and out
  - running performance of in/out transport
  - the ratio of incoming and outgoing shuttle services

  based upon aggregated monthly and annual data.
- Separate analysis of rented warehouses:
  - number of incoming/outgoing unit loads and transport services
  - distribution of incoming/outgoing transport among methods of transport
  - running performance of in/out transport
  - the ratio of incoming and outgoing shuttle services

  on a daily and monthly basis.

In the case of consignment warehouses:

- number of incoming/outgoing unit loads and transport services at the consignment warehouse
- the ratio of incoming shuttle services
- running performance
- unit loads per transport

on a daily and monthly basis.

In the case of direct supply to end-users the distributions of:

- inland and outland,
- road and railway
- round trips and shuttle services

When examining the outsourcing of delivery channels it is important to analyze each of the following values of the delivery services outgoing from the finished goods warehouse on a daily and monthly basis:

- number of delivery serices,
- running performance,
- running performance of delivery services,
- unit loads per delivery service,
- shuttle services and round trips.

Analyses are usually carried out in three versions using mathematic-statistical parameters:

- monthly interval with daily resolution,
- annual interval with monthly resolution,
- annual interval with daily resolution.

The statistical indicators used for analysis:

- minimum value of logistics indicator: $X_{min}$
- maximum value logistics indicator: $X_{max}$
- standard deviation logistics indicator: $\sigma$
- expected value logistics indicator: $\overline{X}$
- relative standard deviation logistics indicator: $\sigma_{rel} = \sigma / \overline{X}$
- relative minimum value logistics indicator: $\gamma_1 = X_{min} / \overline{X}$
- relative maximum value logistics indicator: $\gamma_2 = X_{max} / \overline{X}$

Drastic conclusions can be drawn from these indicators according to the dynamics of the logistics parameters under examination.

The next examples shows the form of analyzing indicators under examination:
changing of daily closing stock level:

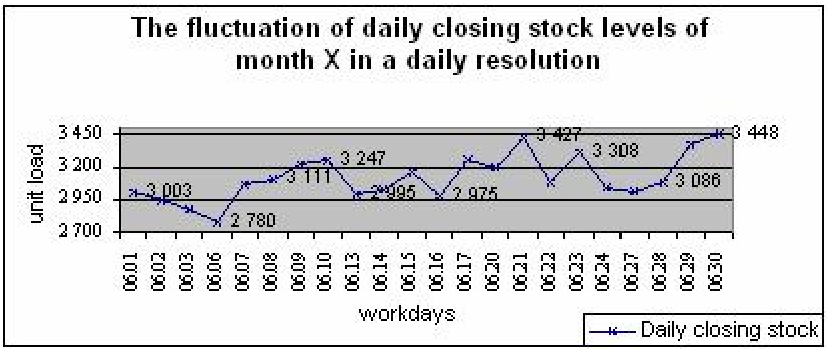


Figure 3 The fluctuation of daily closing stock levels in a daily resolution

Statistical properties:

Table 1 Statistical properties of closing stock level

| Minimum | Maximum | Expected value | Standard deviation | Relative minimum | Relative maximum | Relative standard deviation |
|---|---|---|---|---|---|---|
| 2780 | 3448 | 3119,95 | 174,56 | 0,89 | 1,11 | 0,06 |

Based on the values of statistical properties determined by historical data we can assess the following:

- the daily stock levels (closing) vary between the minimum and maximum values
- the amount of fluctuation
- and the expected values of the next time periods

Among the assessed statistical properties relative standard deviation and expected value play a great role in the development of specific cost of storage:

- The increase in relative standard deviation results in the decrease in the capacity utilization of warehouses, thus the specific cost of storage increases
- The decrease in expected values results in increase in specific costs (cost per product increases).
- thus these properties form the parameters of a multi-parameter decision model.

Distribution of services

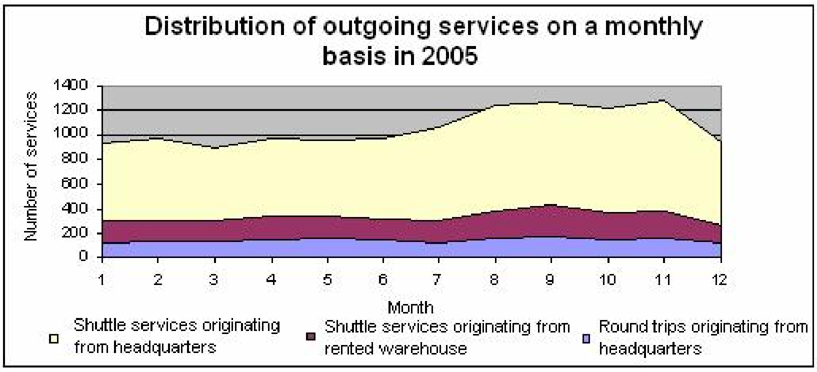


Figure 4 Distribution of services

Statistical properties:

Table 2 Statistical properties of service number

| Types of services | Minimum | Maximum | Expected value | Standard deviation | Relative minimum | Relative maximum | Relative standard deviation |
|---|---|---|---|---|---|---|---|
| Round service form establishment | 124 | 178 | 148,18 | 16,8 | 0,84 | 1,2 | 0,11 |
| Shuttle service from establishment | 595 | 906 | 733,73 | 112,3 | 0,81 | 1,23 | 0,15 |
| Shuttle service from establishment | 158 | 253 | 191,82 | 31,64 | 0,82 | 1,32 | 0,16 |

Based on the values of statistical properties determined by historical data we can assess the following:

- the daily stock levels (closing) vary between the minimum and maximum values
- the amount of fluctuation
- and the expected values of the next time periods

Among the assessed statistical properties relative standard deviation and expected value play a great role in the development of specific cost of storage:

- The increase in relative standard deviation results in decrease in transporting capacity utilization, because the carrier company cannot properly dispose its vehicles, thus the specific cost of transport increases
- The decrease in expected values results in increase in specific costs, because cost for a single product increases.
- Thus these properties form the parameters of a multi-parameter decision model.

The analysis of the other logistics parameters goes as above. During this process properties that can form the parameters of the decision model are chosen from the assessed statistical properties. In most cases these properties are the expected values and values of relative standard deviation, because they play a decisive role in the development of specific costs.

## 6. The Aspects of Assessing Data Obtained from Logistics Parameters Important in the View of Outsourcing

For parameters under examination we have to make out mathematic-statistical parameters. If these parameters change in an unfavorable way, we have to include them into the multi-parameter decision model, the result of which states

- which system of the distribution logistics is advantageous to be outsourced
- taking into account the offer of a given logistics provider

### 6.1. Logistics Parameters Used for Assessing Finished Goods Storage

- number of incoming and outgoing unit loads and their relative standard deviation,
- the relation of internal warehouse transport work to a expected level
- stock levels and their relative standard deviation
- utilization of storage capacity and its relative standard deviation

Outsourcing can provide advantages:

- by introducing more sophisticated storage equipment (first of all control systems and handling equipment), because it can reduce the inner material transport operations by a certain amount, furthermore as a result of this a drop in specific loading costs can be experienced,
- by applying more sophisticated equipment and higher level of expertise, a more efficient production schedule and more efficient delivery originating from the warehouses can be achieved, resulting in the decrease of warehouse stock levels – thus giving lower specific storage costs,
- in the case of utilization of human and machine capacities occurring in the field of storage. Here the advantage can be reached by using the opportunity to rearrange resources which also lead to a decrease in specific costs.

### 6.2. Logistics Parameters Used for Assessing Delivery Channels

- number of daily outgoing services and its relative standard deviation
- running performance of services and its relative standard deviation
- number of unit loads per service and its relative standard deviation
- ratio of round trips and shuttle services
- of each delivery direction (county) and each delivery channel.

Outsourcing regarding delivery channels can reach better utilization, thus lower specific transportation costs by

- transforming most shuttle services into round trips
- optimally disposing services (higher skill level)
- combined transports to multiple costumers.

### 6.3. Logistics Parameters Used for Assessing Storage in Rented Warehouses

- number of incoming and outgoing unit loads and its relative standard deviation
- running performance of incoming and outgoing services and its relative standard deviation
- average distance of rented warehouses and its standard deviation
- the following properties of outgoing services to end-users from each rented warehouse:
  - annual number of services and its relative standard deviation
  - distance and relative standard deviation
  - interpretation of the deviation from average for each rented warehouse with regards to the properties seen above

Regarding using rented warehouses in the case of outsourcing lower specific costs can be obtained by storing goods for multiple customers.

## 7. Method for Comparing Analysis Costs of Outsourcing Opportunity

In the view of outsourcing, the decision is made using a multi-parameter decision model, the parameters of which are defined by the statistical properties of the logistics parameters as discussed in chapter 5.

$$k_f = k_f(Q_{avg}, R_{avg}, C_{avg}; \sigma_{(q)rel}, \sigma_{(R)rel}, \sigma_{(C)rel}) \quad (1)$$

where:

$Q_{avg}$, $R_{avg}$, $C_{avg}$: the average of the examined sub-system's logistics parameters

$\sigma_{(q)rel}$, $\sigma_{(R)rel}$, $\sigma_{(C)rel}$: and the relative standard deviation of these

Cases: ( $k_o$: specific cost in the case of outsourcing; $k_i$ specific cost in the case of insourcing)

Outsourcing: if $k_o<k_i$

(specific cost of outsourcing is less than that of insourcing).

Insourcing: if $k_i \leq k_o$
(if specific cost of outsourcing is higher than that of insourcing).

The next inequality shows the relation between specific costs:

$\delta = k_o / k_i$ ($\delta$: outsourcing factor)
$\delta < 1$ outsourcing, $\delta \geq 1$ insourcing

$\sigma_{(q)rel}$, $\sigma_{(R)rel}$, $\sigma_{(C)rel}$: if these are increasing, the value $\delta$ is moving towards outsourcing otherwise $\delta$ tends to insourcing

$Q_{avg}$, $R_{avg}$, $C_{avg}$: if these are decreasing, the value $\delta$ is moving towards outsourcing otherwise $\delta$ tends to insourcing

## Summary

The paper introduces a method for analysis of outsourcing of distribution logistics of a paper-industrial product producing company. In the introduction we detailed that the outsourcing when and on which fields can be advantageous. A typical distribution logistics system of paper-industry products producer companies is introduced. Structure of logistics parameters of the distribution logistics system and a mathematical statistical evaluation method for historic data originated from the above mentioned parameters are discussed. Critical values of logistics parameters are determined which have important role in the outsourcing of finished product warehousing, service activities and general warehousing. These parameters should be go through additional analysis relating to outsourcing. Finally, the specific cost components are analyzed which should be taken into consideration in case of outsourcing.

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# EARLY SUPPLIER INVOLVEMENT (ESI) WITHIN THE PROCUREMENT AND SOURCING MANAGEMENT PROCESS – AN OPPORTUNITY TO ACHIEVE WORLD CLASS STATUS IN OUTSOURCING

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## Abstract

*As supply chains compete against one another within the globalization processes, the function of procurement within each chain becomes a major area for examining applications for best practices and gaining efficiencies. Those whose responsibilities lie in the formation of strategies and tactics are often promoting the inclusion of the procurement and sourcing management departmental representative from the earliest planning stages of a project – rather than later – thereby setting up the best opportunities to achieve project savings. Those who support this early participative role for the procurement function may point to the department's knowledge of the supplier base and of which one may be best qualified for the project. To the extent that the early presence of the supplier during the planning period of the project when specifications are being drawn up, schedules for performance milestones are being charted, and cost budgets are being developed may contribute to the project's ultimate success, there is an indication that purchasing personnel can prepare themselves for this early involvement by spending time with suppliers to learn about products and services specifications and descriptions to help in the procurement decision. How these contributions are best achieved is the subject of this paper as the researchers performed primary surveys of various companies and also reviewed industry trade and media data by which to gain an understanding and appreciation of this role by the procurement and sourcing management organization.*

Key Words: Early supplier involvement, Outsourcing, Sourcing management

## 1. Introduction

The increased importance of the role of suppliers and procurement departments in the manufacturing and service companies within the globalization process has encouraged the development of robust strategies in the implementation of early supplier involvement (ESI) processes (Wynstra, VanWeele and Weggemann. 2001; Vonderembse and Tracey, 1999; Smith and Zsidisin, 2002; Rigby, 1996; Regatz, Handfield and Scannell, 1997). To take the advantage of ESI at the beginning of design and manufacturing, suppliers need to form up with their wide variety of expertise (Milligen, 1999; McIvor and Humphreys, 2004; McGinnis and Vallopra, 1999; Laseter and Ramadas, 2002). Planning for the initial stage for ESI should be taken as a critical factor within the total company strategy (LaBahn, 2000; Kannan and Tan, 2002;' Hartely, Zirger and Kamath, 1997). The collaboration between buyers and suppliers with an overall commitment to the total corporate strategy will ensure that ESI is a success.

The objective of this paper is to provide a conceptual framework and to present real-world considerations focusing on supplier and procurement department functions through the use of regional data.

## 2. Procurement and sourcing management functional activities in an effort to manage supply chain management and its risks

From the very beginning, it is essential to develop a detailed list of procurement and sourcing functional activities in an effort to manage supply chain management and its risks. The two sided view of the structure of supply chain management, including the buyers and suppliers, will demonstrate how each part interacts.

Table 1 lists the observed activities briefly. The list of these activities is ranging from the customers', buyers' perspective to the suppliers' perspective. Moreover, it includes some particular details in itself, such as corporate strategies, objectives, communication, value engineering studies etc.

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Table 1 – The observed activities.

| |
|---|
| - Establishing customer need |
| - Identification of project based on customer requirements |
| - Development of target costs for supplier components |
| - Preparation of project and milestone plans |
| - Collaboration with operating units |
| - Determination of commodity sub-groupings |
| - Development of potential supplier listing |
| - Arrival of business objective and project package |
| - Scheduling of supplier workshops |
| - Review of workshop expectations with supplier |
| - Engaging in supplier workshop |
| - Conducting value engineering studies |
| - Evaluating suppliers' rough order magnitude (ROM) pricing and technical input |
| - Arrival at supplier evaluations and score according to pre-established selection criteria |
| - Supplier selection recommendations |
| - Communication with supplier bidders for bidding process |
| - Development of working agreements and implementation of project plans |

With the aid of the activities listed in the Table 1, it is possible to gain general, and oftentimes more specific, points of view about the suppliers' interactions. As a result with the advantage of ESI as a commitment to corporate strategy, it is possible to determine the exact roles and benefits at the initial stage of ESI.

Procurement and sourcing processes are at the heart of the overall ESI processes. When dealing with ESI, or starting its initial phase, it is helpful to study detailed interactions concerning the deployment of ESI.

## 3. Procurement and sourcing processes

The basic role of the procurement/sourcing function is shown in the figure with Early Supplier Involvement process.

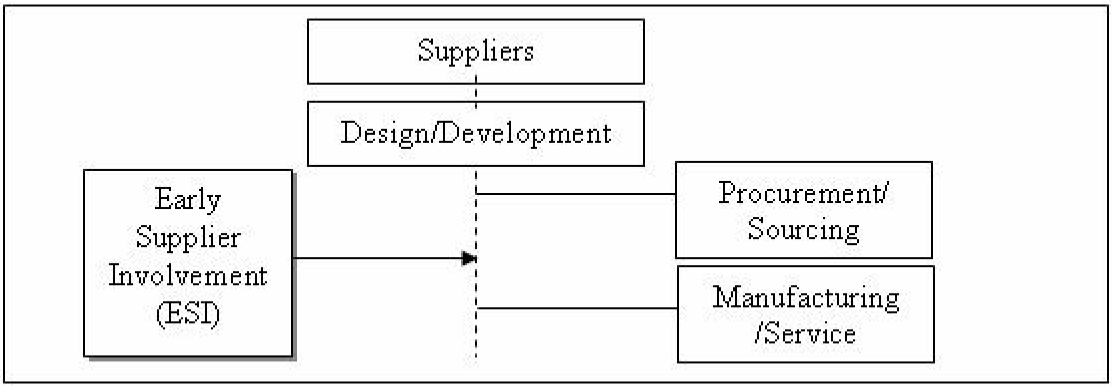


Figure 1 – The ESI involvement

The design and development phase is the initial part of the total procurement process. The involvement of the ESI process at the initial stage is shown in the Figure 1.

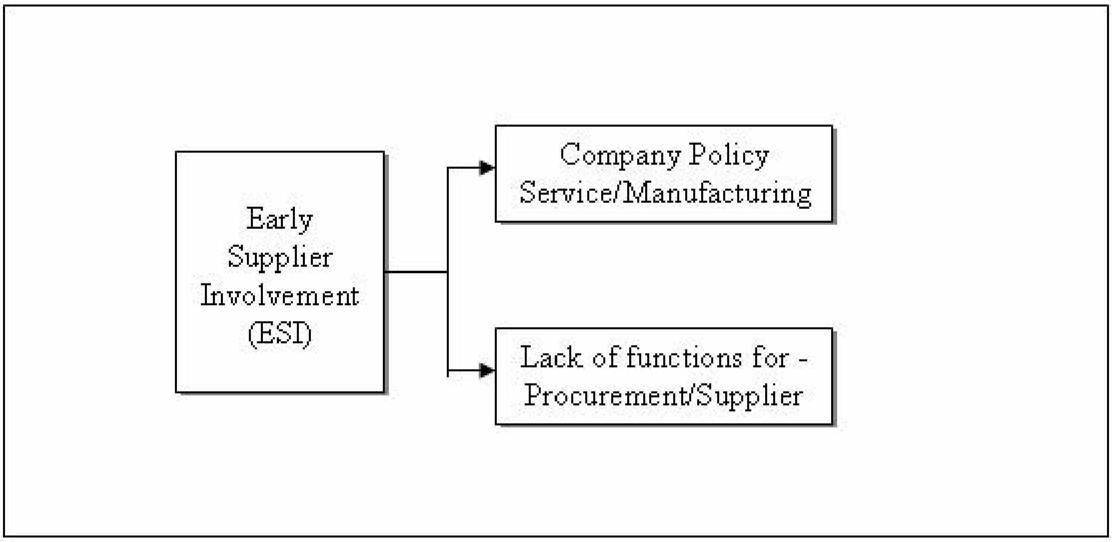


Figure 2 – Barriers to ESI

Within the design and development phases, it is essential to place the ESI at the right phase in process flows. Figure 3 shows the basic and general point of view for the ESI function. Step-by-step involvements of functions within the total service process can be clearly noted. Inside the time slices there are numerous processes to fulfill the total requirements of the service. At the beginning the ESI process defines the whole part of the process flows. Full success can be experienced only when all of the processes are activated to play crucial roles.

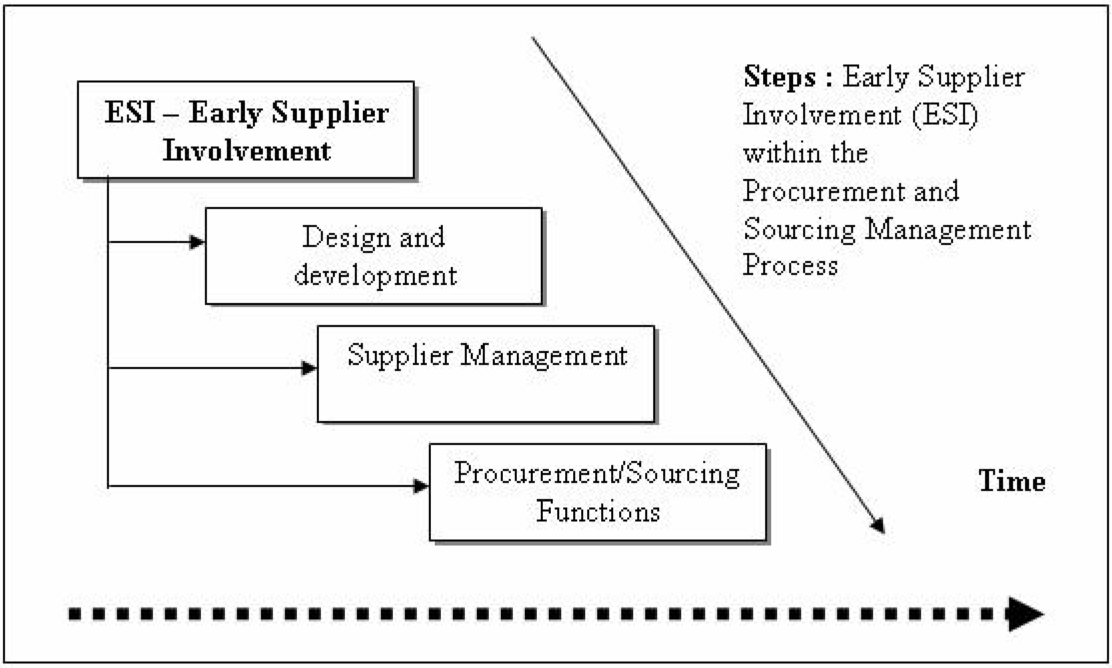


Figure 3 – The initial ESI role as deployed within time phases.

The initial start of the ESI process, in contrast, is not independently determined. There are some barriers that affect its initialization. These drawbacks associated are with implementing early supplier involvement. For example Monczka and Trent (Monczka R, Trent R. Purchasing and sourcing, 1997 ) determined that almost 50% of the firms they studied indicated that significant barriers exist that limit their ability to include suppliers. The instances of these barriers at a basic level are shown in Figure 2. These barriers can be classified into two groups; "Company Policy" and "Lack of Interface Functions of the Procurement Department with external suppliers". The "Company Policy" barrier can be considered as the traditional way of doing company operations. Thus, neither the ESI concept nor the placement of ESI process at the initial part of the Procurement and Supplier relations is always possible. The other barrier is the lack of function for the procurement department. Business operations within the procurement department are pre-defined. Therefore adding the necessary functions will take considerable time in consideration of the learning curves of affected departments.

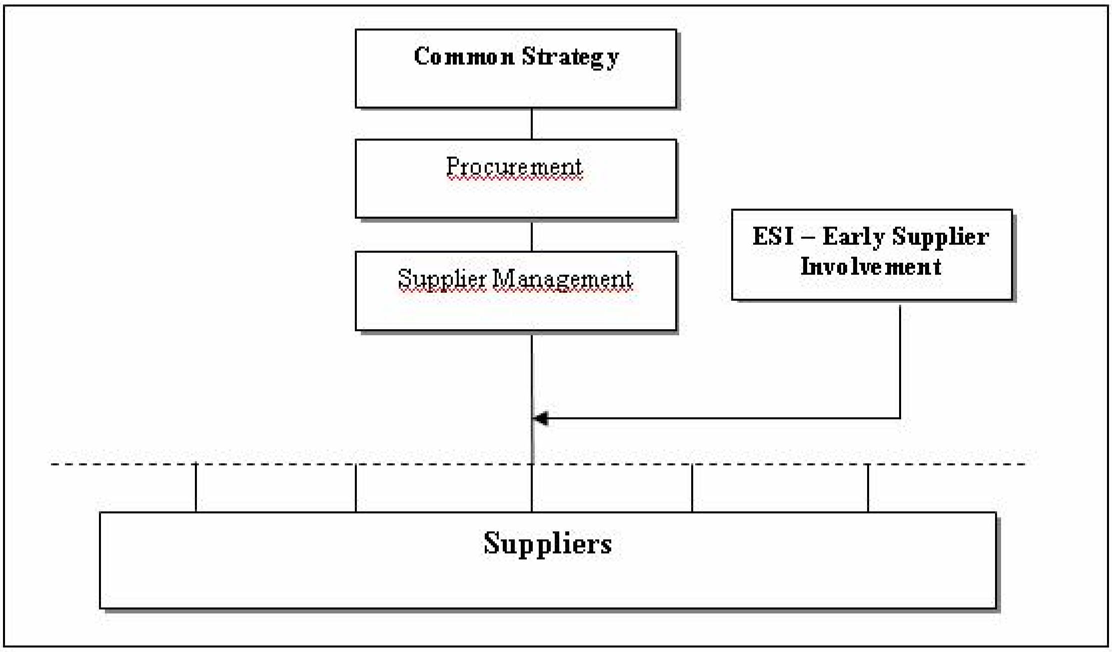


Figure 4 – The share of "Common Strategy" within the whole company strategy.

One of the most crucial parts of the ESI success solely depends on the total commitment to the company strategy. Figure 4 shows the basic conceptual view of how to place company strategy into the hierarchy of the supply chain. For the success of ESI, "Common Strategy" should be shared among the functional departments of the supply chain as well with senior management.

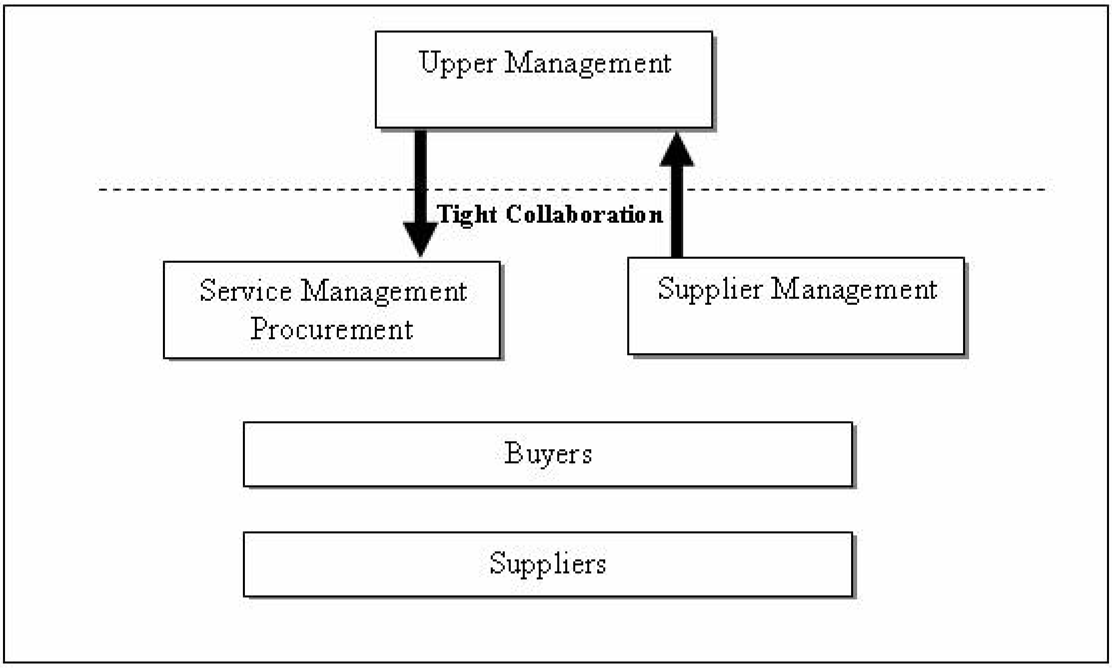


Figure 5 – Effective collaboration between Upper Management and Supply Chain.

Early Supplier Involvement achievement, at some degree, depends on the interactions of the functional departments. Therefore, the communications of each individual function and the development of effective collaboration are important. Figure 5 clearly shows the 2 factors in play within this relationship – the Upper Management Side and the Operational Side – as a collaboration model for ESI achievement.

Another essential factor in ESI achievement is to consider the short, middle and long term effects. Figure 6 at a basic level shows how technical capabilities and collaboration levels increase based on the period of time duration for overall company activities.

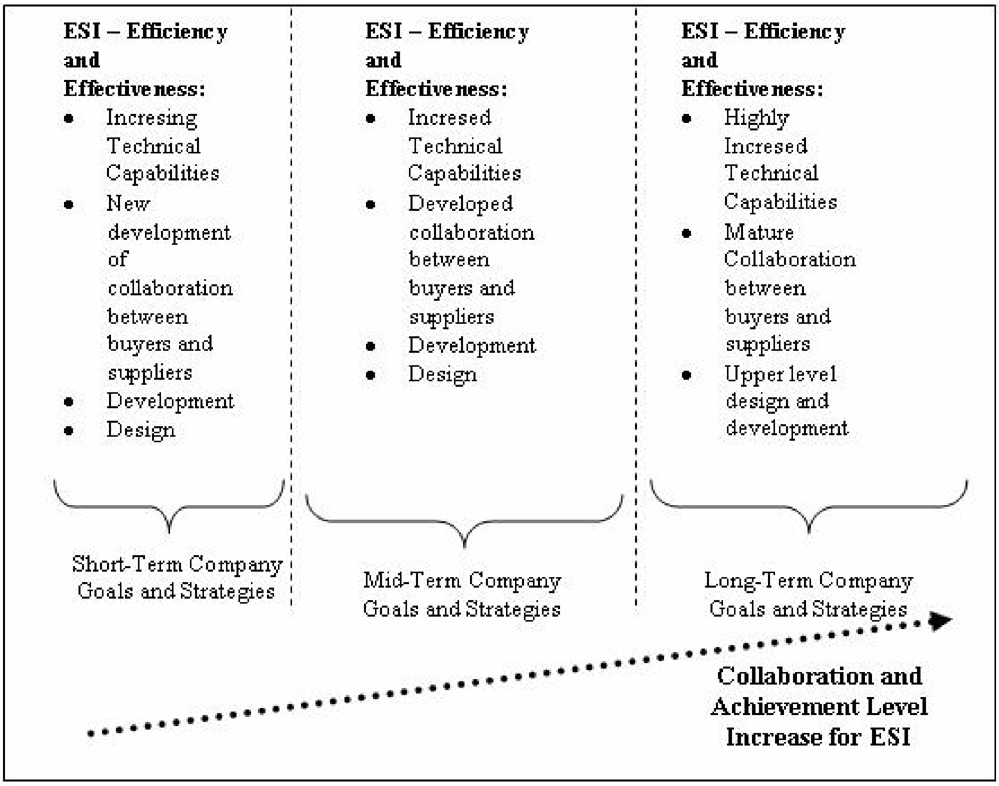


Figure 6 – The conceptual model for the ESI achievement term based company goals.

## 4. Evidence of early supplier involvement within the process – results of company surveys and industry trade media

To explore the evidence of ESI surveys were made of numerous regional companies. Those surveyed ranged from small to large size enterprises, with employment levels of less than 10 to more than 100 employees. Almost all companies have ISO implementations in common and they are all committed to further improvements of their service levels.

Survey forms were distributed via electronic platform and some survey forms filled in by telephone conversations.

## 5. The Research and Findings

### 5.1. The Survey Form

The survey form includes 9 questions in total. The questions are basically ranging from "how companies implement procurement and sourcing functions" to "the operational implementation of the procurement functions in detail". In addition to commenting on past procurement and sourcing experiences and ESI, the participants of the survey were asked the questions listed in Table 2 below.

Table 2: Table of processes being performed.

| Survey Assessment Type | The number of responses |
|---|---|
| Acquisition process | 60 |
| Purchasing function | 30 |
| Decision making | 90 |
| Suppliers interaction | 30 |
| Working agreements | 90 |
| Project and milestone plans | 30 |
| Customer Requirements | 30 |
| Target costs | 30 |
| Collaboration with units | 30 |
| Potential Supplier Determination | 30 |
| Supplier Evaluation | 30 |
| Communication with suppliers | 30 |

Table 3: Table of processes being performed – with response rates in groups.

| Responses to Survey Questionnaire: | Yes | | Unsure | | No | |
|---|---|---|---|---|---|---|
| | Counts | % | Counts | % | Counts | % |
| Acquisition process | 12 | 20,0% | 25 | 41,7% | 23 | 38,3% |
| Purchasing function | 10 | 33,3% | - | - | 20 | 66,7% |
| Decision making | 78 | 86,7% | 12 | 13,3% | - | - |
| Suppliers interaction | 26 | 86,7% | 4 | 13,3% | - | - |
| Working agreements | 52 | 57,8% | 25 | 27,8% | 13 | 14,4% |
| Project and milestone plans | 26 | 86,7% | 4 | 13,3% | - | - |
| Customer Requirements | 5 | 16,7% | 25 | 83,3% | - | - |
| Target costs | 5 | 16,7% | 25 | 83,3% | - | - |
| Collaboration with units | 5 | 16,7% | 25 | 83,3% | - | - |
| Potential Supplier Determination | 5 | 16,7% | 25 | 83,3% | - | - |
| Supplier Evaluation | 5 | 16,7% | 25 | 83,3% | - | - |
| Communication with suppliers | 5 | 16,7% | 25 | 83,3% | - | - |

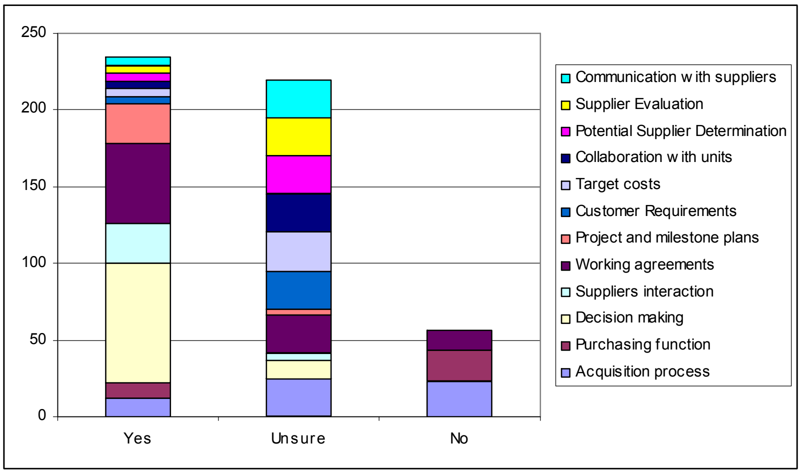


Figure 7. Responses to Survey Questionnaire about ESI

5.2 Review of results of primary research survey of respondents

In the fall of 2006 in İzmir, Turkey, a research staff engaged in a survey that questioned the respondents that included corporate and public official representatives from the geographical region. The participants surveyed included company representatives from a mixed range of business operations. All company representatives responded to the survey questions and showed strong interest in responding to the survey.

As a general survey of attitudes and feelings amongst those surveyed, the participants were asked to comment on ESI processes related material.

Almost all of the those surveyed responded (%89) and approximately (%48) of the companies indicated that they had visited or otherwise were involved in any form of ESI and only 3 out of 4 (3/4) of these had been used procurement data as the source of management decision making.

It was noted from the survey respondents that approximately sixty-two percent (62%) either agrees or are neutral about the acquisition process activity. This volume of responses may reflect the lack of importance given to ESI in the procurement process and of the need for greater efficiencies in the relationships between the supplier and the customer.

Analytical Methodology

From the responses to the survey questionnaire as portrayed in Table 2, each individual business response is different, with different financial goals, different levels of risk tolerance and different personal preferences. From the point of view of purchasing management, these characteristics are often defined as objectives and constraints. Objectives can be the type of justification for ESI being sought, while constraints include factors such as time horizon/window, how conservative and strategic the procurement department's behavior is, and how risk is handled and managed at each company. This represents itself as a balancing act between risk and the perception of gains received from with each company's procurement department having unique requirements, as well as a unique financial and procurement outlook – essentially a constrained utility maximization objective.

5.4 Findings of Survey of SMEs

With 30 out of 34 (response rate of 89%) responding to the research project survey in İzmir, Turkey of SMEs professionals and managers from SMEs and others interested local business persons, 48% (14 out of 30) of those responding indicated that they are familiar with and had contemplated a form of ESI but only 2 of these were or had been engaged in ESI within the recent 5-year period.

Most significantly, it was noted from the respondents that the 46% generally agree while the rest are unsure or are neutral about the advantages and usage of ESI as having a role in the corporate day-to-day activity. (This volume of responses may reflect the perception of the need to circulate / publicize the advantages of ESI processes and of the need for greater efficiencies in the relationships between the SMEs and companies using ESI.)

For the SME that engages in considerations of ESI procedures, the development of successful and productive deals can be an important factor in the differential advantage for these companies. From the perspective of the SME benefiting from ESI processes exchanges, there is evidence that they are largely interested in the scope of the ESI procedures and other applications of this concept within the corporate environment.

To analyze how well a company's procurement department utilizes ESI into a particular history of acquiring goods and services, there has been designed a structured survey questionnaire with nine but detailed questions that one of the question has to be answered with values from 1 to 5 with 17 different sub-questions in it. The questions range from business background to what the respondent expects from ESI (examples of good things from the survey listing that come from using ESI, etc.).

A *fuzzy logic system* has been designed for the evaluation of the answers to the above questions. In the researchers' work, we have used the familiar framework of neo-classical utility theory to try and devise a structured system for procurements classifications according to the utility preferences of individual ESI users.

The theory of procurement buyer behavior in modern microeconomics is entirely founded on observable utility preferences, rejecting hedonistic and introspective aspects of utility. According to modern utility theory, utility is a representation of a set of mutually consistent choices and not an explanation of a choice. The basic approach is to ask an individual to reveal his or her own company's utility preference and not to elicit any numerical measure, see [1] (Arkes, 2000).

However, the projections of the consequences of the options that we face and the subsequent choices that we make are shaped by our memories of past experiences – that "mind's eye sees the future through the light filtered by the past". However, this memory often tends to be rather selective. *Normative utility* contends that *optimal* decisions do not always reflect the *best* decisions, as maximization of instant utility based on selective memory may not necessarily imply maximization of total utility. This is true in many cases, especially in the areas of economics and social choice theory.

The neo-classical utility maximization approach

In its simplest form, we may formally represent a procurement buyer's utility maximization goal as the following mathematical programming problem:

Maximize $U = f(x, y)$

Subject to $x + y = 1$,

$x \geq 0$ and y is unrestricted in sign

Here x and y stand for the proportions of ESI-oriented procurement buys (amount of funds involved) allocated by the procurement buyer in the ESI process in terms of a risk-free action (here put some of the characteristics of ESI) that could lead to savings or risk minimization due to better coordination between buyers, manufacturers and sellers, etc).

The last constraint is to ensure that the procurement buyer can never justify avoiding or staying out of the procurement process (ESI) to meet the traditional purchasing responsibilities activities by his exclusion from the ESI processes, as this is clearly unrealistic, in that the procurement actions (without ESI) will have more exposure to risk than and will be obviously higher than the risk-free activity that any companies aspire to.

As in classical microeconomics, we may solve the above problem using the *Lagrangian multiplier* technique. The transformed Lagrangian function is as follows:

$Z = f(x, y) + \lambda(1-x-y)$ (1) (Arkes)

By the first order (necessary) condition of maximization we derive the following system of linear algebraic equations:

(i) $Zx = fx - \lambda = 0$

(ii) $Zy = fy - \lambda = 0$

(iii) $Z\lambda = 1 - x - y = 0$ (2) (Chiang)

The procurement buyer's equilibrium is then obtained as the condition $fx = fy = \lambda^*$.

$\lambda^*$ may be conventionally interpreted as the *marginal utility of money* (i.e. the amount of funds at the disposal of the procurement buyer) when his/her utility with ESI is maximized, see [2] (Chiang, 1984).

As a result we can state that the motivation and activity prompting the decision for action taken by the procurement buyer in compliance and in observation of the ESI process procedures are done at a point when the marginal utility of money and for value received (usefulness and derived benefit from the ESI procedures) will be at his/her maximized utility.

From a macro perspective, the implications for the early inclusion of the supplier into the procurement and sourcing activity within the supply chain (value stream) may be far-reaching and powerful with high impact on the nature of businesses operations in Turkey.

## 6. Conclusions

Within the corporate organization, there has been a push to manage the efficiencies in their processes. It is estimated that various industries have hundreds of millions of dollars tied up in their procurement processes, but few businesses handle these business operations and processes neither with ESI deployment nor in the most optimal way. The need for and identification of ways to ensure efficiencies in the procurement process are evolving and ESI appears to address a variety of issues and challenges. This research work has highlighted many of these issues and presented the contemporary challenges in achieving TQM and optimization of efficiencies within procurement operations. In conclusion, early supplier involvement into the processes can be a useful and beneficial way to demonstrate how both a supplier and their customer can acquire needed vision and attendant goals and objectives while gaining important progress in its own operational competitive advantage (Dowlatshahi, 1998; Birou and Fawcett, 1994). Companies that need to gain new opportunities for successful sourcing activities, have the option to achieve them through an early supplier involvement program within the procurement and sourcing process (Hartley, Meredith, McCutcheon and Kamath, 1997). Procurement acquisition programs are growing in frequency and size, yet research shows that many firms have not yet tried to use the ESI as an innovative ingredient to their projects – particularly as a role player in the supply chain. Involvement of the early supplier involvement activity offers a number of advantages, as reflected above. Specifically, it may be a useful process in the business operations, while not a panacea to every specific difficulty that exists between the firms approach to its operations, the results of this approach suggests that there are specific advantages to be gained by the involvement of acquisition as a contributor to a world class procurement and sourcing program – particularly in light of supply chain management (Bidault, Despres and Butler, 1998). Procurement and sourcing management planners who have not examined this supplier tie-in involvement may be overlooking an opportunity to engage in more effective and rewarding projects acquisition phases in their operations.

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## Appendix 1: ESI Survey Form

1. Evaluate the importance of the steps in acquisition process. According to you, which are the two most important steps in acquisition process to affect the value of the product:

☐1. Need recognition
☐2. Description
☐3. Potential suppliers
☐4. Selection
☐5. Receipt
☐6. Payment

2. Referring to the question above please indicate the practise in your company. From which step on you include the purchasing function to the acquisition process. (Please select only one step which means from that step on you include purchasing.)

☐1. Need recognition
☐2. Description
☐3. Potential suppliers
☐4. Selection
☐5. Receipt
☐6. Payment

3. Do you consider the Procurement department as a source of data and information to support management decision-making? Yes ☐ No ☐ Please explain

4. Use a scale of from 1 to 5 to evaluate each activity with a (1) indicating you strongly agree to a (5) indicating you strongly disagree.

Our procurement/purchasing department personnel can be effective in:

| 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | Establishing customer need |
| ☐ | ☐ | ☐ | ☐ | ☐ | Identification of project based on customer requirements |
| ☐ | ☐ | ☐ | ☐ | ☐ | Development of target costs for supplier components |
| ☐ | ☐ | ☐ | ☐ | ☐ | Preparation of project and milestone plans |
| ☐ | ☐ | ☐ | ☐ | ☐ | Collaboration with operating units |
| ☐ | ☐ | ☐ | ☐ | ☐ | Determination of commodity sub-groupings |
| ☐ | ☐ | ☐ | ☐ | ☐ | Development of potential supplier listing |
| ☐ | ☐ | ☐ | ☐ | ☐ | Arrival of business objective and project package |
| ☐ | ☐ | ☐ | ☐ | ☐ | Scheduling of supplier workshops |
| ☐ | ☐ | ☐ | ☐ | ☐ | Review of workshop expectations with supplier |
| ☐ | ☐ | ☐ | ☐ | ☐ | Engaging in supplier workshop |
| ☐ | ☐ | ☐ | ☐ | ☐ | Conducting value engineering studies |
| ☐ | ☐ | ☐ | ☐ | ☐ | Evaluating suppliers' rough order magnitude (ROM) pricing and technical input |
| ☐ | ☐ | ☐ | ☐ | ☐ | Arrival at supplier evaluations and score according to pre-established selection criteria |
| ☐ | ☐ | ☐ | ☐ | ☐ | Supplier selection recommendations |
| ☐ | ☐ | ☐ | ☐ | ☐ | Communication with supplier bidders for bidding process |
| ☐ | ☐ | ☐ | ☐ | ☐ | Development of working agreements and implementation of project plans |
| ☐ | ☐ | ☐ | ☐ | ☐ | Assist management to make decisions and to control risks |

5. What experiences have you had with your procurement personnel?
Good ☐ Bad ☐ Please explain.

6. Do you consider the Procurement department as a source of data and information to support management decision-making? Yes ☐ No ☐ Please explain

7. What interests you most about these sessions with the procurement personnel?

8. What would you do if your were the head manager/director of procurement/purchasing at your company? Please explain

9. Have you worked for another company and how did they use the procurement/purchasing personnel?
Yes ☐ No ☐ Please explain.

Your Name Company Name

# LOGISTIC SERVICES CUSTOMERS BEHAVIOR

Milorad Kilibarda[1], Slobodan Zečević[2], Snežana Tadić[3]

## Abstract

*The behaviour of logistic services customers is a continual and dynamic process through which the customers pass through different phases of purchase and use of a service. This work represents the specific behaviour and the determinants of behaviour of the logistic services customers, with special attention paid to the customers' behaviour in the process of quantitative and qualitative characteristics of logistic demands.*

*Keywords: logistic service, customers' behaviour, logistic demands*

## 1. Introduction

The customers of logistic services buy and use the services in order to satisfy different demands. Logistic demands outcome from certain economic, economical, social or personal needs - the needs for the concrete materials and services which should be on the right place in the right time. Without logistic services, none of the materials is available to the buyer and to the customer, where, when and the way he may need them. In other words, logistic services are preconditions for functioning of every manufacturing, sales, service, social, or every other system. The demands for the logistic services determine a great number of different characteristics which are the direct consequence of the customers' needs and requirements. Basic goal of every logistic system is to meet the customers' needs, expectations and demands on the market. The key factor of successful business is creating satisfied and loyal customers. However, these goals are very often followed by questions about exact demands of a customer, or what makes the customer satisfied. The answers to these questions cannot be obtained if the customers' behaviour in certain phases of purchase and use of logistic services is not known and anticipated. Understanding of customers' behaviour is the basic assumption for successful marketing and logistic services creation, which will completely satisfy the demands and expectations of customers.

## 2. What is specific about the logistic services customers' behavior?

During the process of purchase and usage of the logistic services, the customers' behaviour depends on different factors, such as: structure and volume of demands, market conditions, place and role of the customer in the decision-making process, degree of importance of his decision, the context of the decision, time available for the deciding, degree of available information, experience, attitudes and mood of the customer. In the real system, the customer is differently included in the purchase and logistic services usage, which directly influence his behaviour. Thus, for example, weak involvement of the customer leads to the routine and automated decision, based on habit, and while choosing among the alternatives, the customer is guided by simple rules. Some authors think that such type of decision making is less rational, while others claim that the logistic services decision makers usually have to distribute their time and efforts to different tasks. The context in which the decisions about the logistic services are made, influence directly the customers' behaviour. Depending on the real situation and the context for making decision, the customer can behave in the completely different way than the expected or the usual one. The customer's behaviour depends on the degree of the importance of the decision. When the decision of logistic services becomes more important, the customer is more oriented to the problem, he invests greater effort into collecting information, there is the greater usage of the external resources, and less of the customer's intuition and memory, more alternatives are taken into consideration. During the purchase and usage of services, the customer goes through different phases in his making decision, and every phase is characterised by several specific details connected to the very behaviour of the customer. As far as the most logistic services are considered, it is necessary to investigate and foresee the specific behaviour of the customer in the three key processes: defining of logistic demands, realisation of logistic service, and evaluation of the value delivered (see figure 1).

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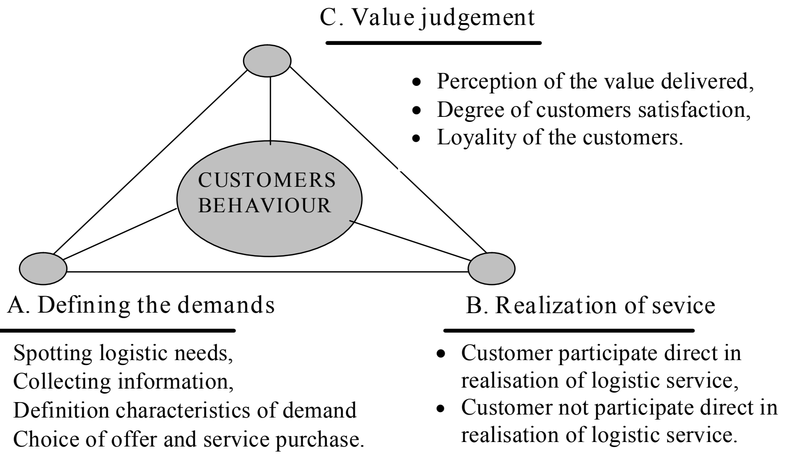


*Figure 1: Specific behaviour of the logistic service customer*

In order to understand the customer properly and completely, it is important to take into consideration all specific issues of his behaviour, from the moment of his understanding the logistic necessities, until the moment of evaluation of value and quality of the service delivered. In this work the attention is directed to the customer's behaviour in the process of defining logistic demands. However, before the more detailed consideration of the decision making process about the logistic demands is made, a shorter view is given, according to the determinants and factors which are crucial for the behavior of the customer of the logistic demands.

## 3. The determinants of the behaviour of logistic services customers

Logistic services customer behaviour in the concrete situations is determined by numerous and various factors of external and internal character. However, it may be said that three groups of determinants are crucial: environmental, organizational and individual.

### 3.1 Environmental determinants

The process of offer and demand on the logistic market is running under the influence of different factors of macro and micro environment. The logistic flows from sender to the recipient of goods pass through different areas and markets, and the logistic demands are formed in various geographic, demographic, economic, economical, social, cultural, technical, technological, political, legal, natural and ecological environments (figure 2). Macro and micro environment, through various factors, directly form the behaviour of the logistic services customer.

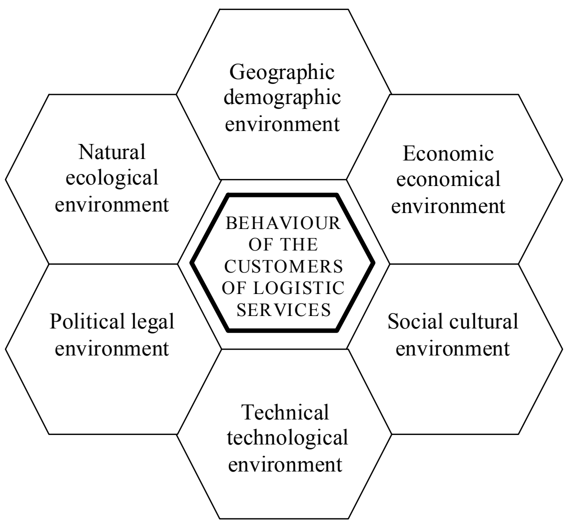


*Figure 2: Impact of environment on the customers' behaviour*

*Geographic and demographic environment* consist of the factors such as: location of the customer, climate, and relief, concentration of the customer, number and structure of population. Customers which live on the certain geographical location have similar values, attitudes, needs and desires, which differ to the customers who live in other distant regions and locations. Climate (continental, maritime) through factors such as: temperature, humidity, wind and precipitation, can significantly influence the structure of the logistic demands and the behaviour of the logistic services customer. The degree of customers' concentration in certain industrial regions and zones, i.e. consumer centres, predetermines greatly the customers' behaviour and the demand of logistic services. *Economic* *and economical surrounding*, through the factors such as: general economic condition, competition, income, purchase conditions, price, inflation and costs, influence directly the behaviour of the customers and the basic determinants of real and potential market demands.

*Sociological and cultural environment* underestimate: culture, social class, level and status of the customer, relevant and referent groups of customers and leaders on the market. Culture, through the value system, folklore, religion and language, greatly predetermines the behaviour of the customers and the logistic services carriers. Social classes of customers, as relatively homogeneous groups of similar values, business styles, attitudes, wealth and status, have very similar demands about the structure and quality of logistics service. Relevant (according to influence) and referent (according to comparison) groups of customers have great influence to the formation of offer and demand of logistic services. Naturally, the customers want to hear relevant opinion, or to compare themselves to others, before they make the decision, form the attitude or go for action. Market leaders are the users of the services and they have the leading opinion and set the rules on the market. *Technical and technological environment* is manifested as: development degree of logistic technologies and telematic systems, development degree of technology for the goods industry, influence of technology development on the shape, structure, means of purchase and spending the goods, etc. The degree of technological development in a certain region changes the very system of purchase, delivery and spending of goods and services. Technological changes in the sphere of production and spending generate different structure and the volume of logistic services demands, and, simultaneously, generate the changes in the behaviour of customers. *Political and legal environment* influence the customers and the logistic services market by the means of: legislation, legal and political risks and political stability. Legislation, through certain laws, legal acts, standards, directives and criteria, directs and forms the processes of offer and demand on the logistic market. Market risks caused by legal and political circumstances, must be taken seriously when acting and positioning on the market. Frequent and radical political changes cause instability on the market, which could be crucial for the behaviour of the customers, and, in that sense, crucial for the offer and demand of the logistic services on the market. Natural and ecological environment of customers relates to: Environmental protection, managing natural resources, raw materials and energy costs. Demands for the environmental protection impact directly to the choice and type of the transport technology, loading and stocking the goods, i.e. the expected quality of the logistic services.

### 3.2 Organisational determinants

Organizational determinants of customers' behavior origin from the internal structure and organization of the customer. It could be said that two groups of factors impact the behaviour of the logistic services customer. The first group refers to the organisational structure and management in the company. These factors maintain the hierarchy and the organisation of the decision making itself, the degree of centralisation, the procedure of decision making, goals, policy, structure and the criteria of purchase of material goods and services. The second group manifests interpersonal questions and mutual relationships within multidisciplinary teams which decide about the purchase of goods and services. The purchase of goods and logistic services related to the transport of goods, have to be solved together. During the decision making process, various expert are involved, as well as people from different professional areas, of different authorities, knowledge, skills, loyalty to the company, etc. The conflict of goals and interests of certain groups and team members is often present. Thus, for example, sales specialists emphasise the price of goods and purchase conditions, industry people insist on the quality, and the logistic sector insist on efficient end economical flaw of the material and goods in every phase of the logistic chain (from the supplier to the end-user).

### 3.3 Individual (psychological) determinants

The behaviour of the logistic services customers is directly conditioned by individual (psychological) determinants, such as: personality, attitudes, knowledge, education and professional skills, experience and habits, degree of information, perception, etc. Human behaviour mostly represents the personality. Persons differ according to the degree of intelligence, communication skills, memory and similar. Personality can be neither touched nor seen, thus, it is very difficult to identify and examine the influence of these factors. Every person has his/her own concept, or attitude, which was formed on the basis of feelings, belief, learning and experience. The customers can accept differently certain services, and due to their opinion formed, they can define different demands for the service. The customer's perception, i.e. the way the customer chooses, receives and interprets information, is ultimately subjective. According to the customer's perception, it is possible to create the perceptional maps, which demonstrate the level of customer's differentiation of certain service characteristics had what are the possibilities for the new service, or the service with new attributes. The perception of the customer very much depends on the efficiency of the marketing instrument and the strategy of the provider (carrier) of the logistic service. The learning processes have also the great influence on the structure and characteristics of the logistic demands. When buying and using the services, the customer here acquire new knowledge and experience, and apply them in future decisions. The customer learns from his/her own experience, and also from others, and everything learned (habits, knowledge and experience) uses when forming and defining the logistic demands, or evaluating the logistic service quality. Knowledge and experience of the customer is closely related to the education, professional training, and length of work. The experience of the customer has a great impact on the process of defining the demands. If the experience in purchasing the logistic services is positive, and thus can be repeated, then it could be said that, the customer formed his/her habits and tends to satisfy his/her needs and demands always in the same and trusted way.

## 4. The behaviour of the customer during the process of defining the logistic demands

The defining of the demand for the logistic services includes several phases. The customer passes through four key processes (figure 3):

- Identification (spotting) the needs for the logistic services
- Motivational process - search for the necessary information,
- Definition and choice of the alternative solutions for satisfying the needs,
- Defining the quantitative and qualitative characteristics of the demand.

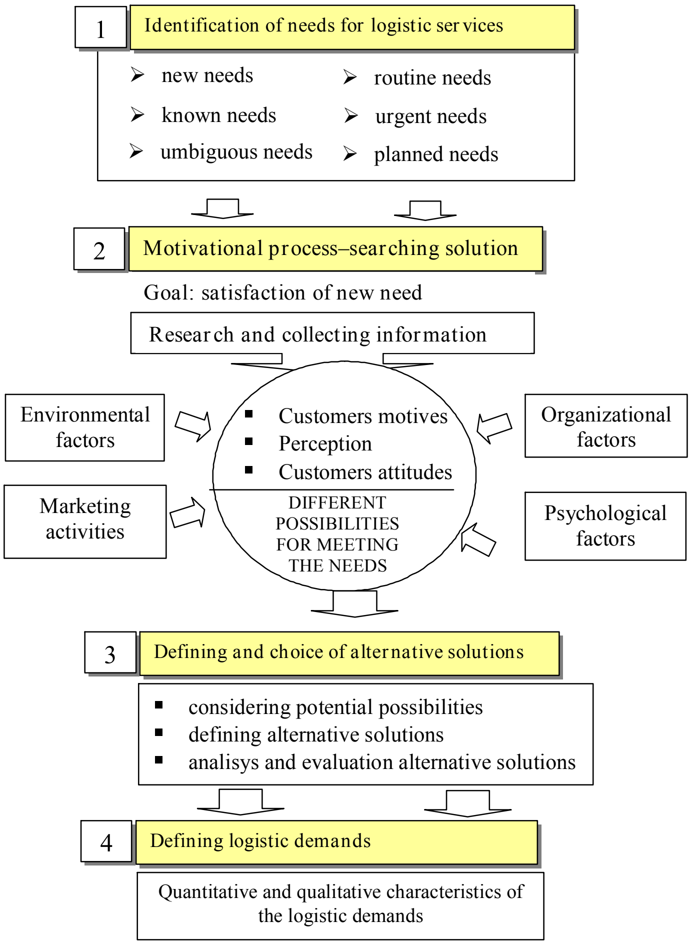


*Figure 3. Defining the logistic demands*

The process of defining the demands starts when the customer sees, recognises, and becomes aware of the needs. When solving concrete problems, the customer can be in different situations:

- New demands for services can appear, and the customer has never met with them before; and it is necessary that the customer understands the needs, as well as the he/she should meet them,
- Repetition, i.e. appearance of already known needs; the customer is fully aware of them and solves the demand in the routine way,
- Appearance of the needs that the customer is not fully aware of, i.e. he has not identified and seen their entire dimension, especially the ways he can meet them.

The needs for the logistic services have different time dimensions. Depending on the type of the customer, with certain services, the time interval between the spotting the need and the moment of making the decision about the service, can be very short, and along with other services, can be very long. Considering the time needed to recognize the needs, we can make the difference between the following:

- Usual, routine, recognition of problems, where the customer relatively quickly reacts and defines the demands for the service
- Haste or hurried recognition, where the needs usually appear unexpectedly, and the customer’s instant reaction is requested;
- Planned recognition, where the needs are expected (projected) and where there is no necessity for fast reaction, but the demands are defined through a systematic planning process.

At the moment when the customer becomes aware of the certain needs, the motivational process appears, through which he/she wants to satisfy them. It is a dynamic process which continues uninterruptedly under the influence of various external and internal factors. The goal is to satisfy the new needs in the most suitable way, and the customer passes through different states and behaviour on the way of reaching the goal. The intensity of needs directly influences the intensity of customer's motivation, and the intensity of motivation influences the way the demands are defined, the degree of punctuality and the character of demands. Different information and stimulants (promotional activities) can have big impact on the customer's motivation. However, there is a great difference between the stimulants (giving information) and perception (receiving the stimulants) of the customer. The customer's inertia can cause weak motivation, and the experience is significant when forming the demands. Having in mind that the customer has different goals and motives, and that he/she is usually under pressure when defining the demands, either because of time, or limited funds, there may come to the conflict of goals.

Conflicted goals can appear due to various reasons and in different situations, and most frequently it is the case when the customer:

- considers good and bad sides of certain logistic service at the same time, with the tendency to prevail positive characteristics,
- chooses one, between two similar solutions,
- chooses one between two bad services offered, which is the most unfavourable situation.

The motives themselves can be in conflict, which is the case when they are of the similar strength and significance. Sometimes, the motives are based on the customer's habit. If the carrier of the logistic service can have the qualitative judgement of the customer's motives, he is in the position to offer adequate logistic service. The customer reflects easily some motives. These are, so called "reflectable" motives, which are easy to determine, because they are known both to the customer and to the carrier of the logistic service. However, there are frequently present, so called, "hidden" (latent) motives, and for their unveiling there should be undertaken certain motivational research. In the same manner we can talk about primary motives, which point to the structure and the volume of logistic demands, i.e. secondary motives, which are manifested through the qualitative and quantitative characteristics of the demand. Logistic demands can be formed under the influence of rational or emotional (irrational) motives of the customers. Rational motives underestimate objective economical reasons (price, structure, volume, quality), and emotional ones, underestimated subjective and personal reasons (image, status, pride, prestige). It could be summarised that the first group consists of conscious, and the second one of unconscious motives, which is connected to defined and non-defined needs of the customer. In real conditions it is difficult to separate rational and emotional motives, because the customer passes through different processes during his defining the demands, being under the influence of various factors at the same time. The process of defining logistic demands is mainly of mental character, because it underestimates planning, evaluation and decision making. However, sometimes the customer formulates the logistic services in the affected environment, where the emotions, feelings and mood are predominant.

On the basis of identified needs, information collected, preferences formed and wishes, the customer forms the attitudes towards certain logistic services, i.e. qualitative and quantitative characteristics of the service. The attitude of the customer means his/her regarding (opinion, judgement) towards certain attribute of the logistic service. The attitudes represent the essential component of the thinking process and can serve in prediction the customer's behaviour during the process of defining the logistic demands. The attitudes of the customers are crucial in defining the qualitative and quantitative characteristics of the logistic demands. When we speak of performances and the quality of the logistic service, the customer can have: positive, neutral, or negative attitude. Positive attitudes, according to the most values of performances, predict that the customer will define his demands in accordance with these values, i.e. most probably he/she will decide for that type of service. Neutral attitudes mean a certain type of indifference of the customer toward the certain logistic service offer. It can be the result of insufficient information about all relevant characteristics of the logistic service. It is necessary to have in mind that the customers are, principally, very cautious in accepting new technologies and strategies for offering the logistic services. Negative attitudes of the customers towards certain characteristics of the service, bring to the rejection of the offer.

The customer forms his/her attitudes through the process of information and learning, i.e. on the basis of own or somebody else's experience. Classical attitude from the domain of research of customers' and buyers' attitudes denotes their three components: cognitive, affective and behaviouristic. Cognitive component underestimates that the customer has information and knowledge about the characteristics of the concrete product or service. With the logistic services, this component is manifested through: "logistic conscience" of the existence of certain service which can successfully satisfy needs and desires of the customer; belief that certain logistic service have requested (desired) characteristics and the judgement about the significance (relative importance) of every attribute of the logistic service. Affective (emotional) component of the customer's attitude reflects feeling, i.e. positive or negative preference of certain attributes of the logistic service. Behaviouristic component refers to the customer's intentions and behaviour during the decision making and defining the quantitative and qualitative logistic demands.

## 5. Conclusion

Behaviour of the logistic services customers is crucial for the business of the logistic systems on the market. Marketing concept, as well as the complete business strategy of the logistic system must be based on the best understanding of the customers, or continuous research and prediction of their behaviour during the process of purchase and use of the services. However, it is not an easy task at all, because most logistic systems do not have adequate methodologies, models and tools for the research and prediction of the customer's behaviour. Due to such reasons, it is necessary to develop theoretical and practical methodological approaches and the model of prediction, having in mind all specific issues and determinants of the customer's behaviour in the real logistic systems and market conditions. As the customer's behaviour is very complex and dynamic field for research, it is necessary that interdisciplinary approach is used, which rely on various economical, psychological, sociological, engineer, anthropologic and other scientific disciplines. For modelling the behaviour of the logistic services customers, different models can be used, such as: descriptive, quantitative, qualitative or complex system models.

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# TRACEABILITY OF GOODS IN A TRANSPORTATION NETWORK AND THE POTENTIAL IMPACT ON LOGISTICS AND TRANSPORTATION SERVICES

Pehr-Ola Persson[1]

## Abstract

*Currently there are a number of interesting issues unfolding in transportation logistics. Information technology has made transportation one of the most adaptive areas as to how to use and develop new applications. It is also an industry experiencing tremendous pressure and contradictory demands from shippers, competitors and society. Therefore it becomes increasingly important to take advantage of new technologies and the possibilities that comes with it.*

*A concept, the Foliated Transportation Network, is presented and proposed as a solution for how a mixed transportation network can benefit from information based on information sharing between the shippers and the transportation company via increased traceability and integrated information systems.*

*The paper also elaborates on the role of RFID in logistics and transportation. The conclusions in the paper are based on both previous findings in the literature and the prerequisites and demands of the foliated transportation network and the current development in RFID.*

*Given the problems associated to the current development of RFID in the transportation area the outcome of a similar solution, the future of the concept is related to the willingness of the involved actors to adopt new technology and to cooperate to ensure better resource utilization and the development of costs related to transportation*

*Keywords: Foliated Transportation Network, Transportation, Traceability, Mixed transportation networks*

## 1. Introduction

A key issue in transportation is to maximize resource utilization. By doing so, more environmentally and financially sustainable transportation systems can be developed and negative impact on transportation such as increasing fuel prices, inefficiencies due to road congestion, long lead-times, etc., can be reduced. Maximizing resource utilization is also of great importance considering the growing amount of goods being sent on the roads both in Europe and globally. According to ERF, the European Union Road Federation, the growth of the transportation area has been approximately 30 percent (tkm) from 1994 to 2004. On a yearly basis the average yearly growth has been about 2,8 percent during the last ten to twelve years, currently employing more that eight percent of the total European workforce, generating a turnover of about 20 % of the European GDP (ERF, 2006). Due to the impact on the economy, transportation is a very important part of the financial development within the EU. However, there is also a great risk involved due to the environmental and financial consequences related to increased traffic and limited access to resources. According to ERTRAC, European Road Transport Research Advisory Council, it is therefore *…"vital that efficiency and the overall effectiveness of freight transport can be optimized to avoid waste, improve business processes and reduce impact on the environment"* (ERTRAC, 2006, p.11). Thus, based on the environmental and financial aspects of transportation, there is an imminent need for more efficient solutions within the area.

Other factors that highly affect logistics and transportation services are the increased global sourcing of components and the need for global coverage of the transportation networks. Many companies are looking for reliable modes of transportation and transportation partners it becomes increasingly important to design logistics solutions that can be proactive in case anything goes wrong. It is important to be able to trace the goods on an item level in order to notify the shippers and receivers in case of a delay, theft or other unplanned events that could interfere with the shipping of the goods (Stefansson and Tilanus, 2001). If it was not for the decreased costs sending real-time information and the development of the technology involved, it would have been impossible to achieve. There are also more sophisticated systems for interpreting historical data, analysing the information enabling interpretation of the data. Thus, increased integration and information sharing and the development of mobile solutions and decreased costs related to real-time communication have had a major impact so far. The Internet has by many means changed the fundamentals of logistics and transportation (Lasserre, 2004; Tjokroamidjojo et al. 2006).

To guide the forwarder and support the execution of the transport assignments, there are route planning systems using geographical information and real-time traffic information in their calculations, systems that are already in use. These systems can be described as a combination of decision support systems, using data from traffic

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surveillance systems, historical, real-time and predicted data and information, to find the most efficient route in a transportation network (Taniguchi and Shimamoto, 2004). So far, this type of information systems has been proven useful mostly in city logistics (Taniguchi and Shimamoto, 2004; Crainic et al., 2004; Zeimpekis and Giaglis, 2006) However, as cheap and efficient real-time data transfer is being enabled by the development in ICT, the scope for these solutions are getting broader, leading to better applications integrating other types of networks and processes than initially intended. Today, this type of integrated information solutions are available for transportation companies, shippers and forwarders and ready to use in case they decide to implement the technology.

Given the problems that the transportation industry is facing and the increased costs involved, there are many reasons for why transportation and transportation networks have to be designed differently from the way they are today. The growth in the transportation sector, the negative environmental impacts from road transportation and the increased awareness in society all call for new ways of thinking. Previous literature on the area, therefore provide an important foundation for further research combined with the possibilities of information technology and the recent development within information and communication technology (ICT). In the long run it will also open up possibilities for combinations between and within different transportation modes where the flexibility of road transportation can be combined with other more sustainable transport modes depending on the specific situation and the goods to be transported.

This paper will discuss some of the challenges in transportation related to the demands that shipper and society have on transportation as well as the potential solutions available to the problems that they give raise to. The ones that are being discussed in this paper can be summarized as: *Increased resource utilization to reduce the impact of goods transportation, road congestion etc.; Better coordination of goods providing increase in visibility for the shippers; Environmentally sustainable transportation systems enabling high filling rates and alternative routing of goods; and, Cost efficient transportation services that combining high customer service and flexibility for the shipper.* By introducing new technology and better use of resources it will be possible to tackle these challenges. This is also why a concept called the Foliated Transportation Network is being introduced in this paper as a way to shoulder some of these challenges. The rest of this paper is dedicated to solving some of the issues described above.

## 2. Finding new solutions

A strategy that has been discussed in logistics research is the possibility to use a combination of transportation principles, creating a transportation network that are better prepared to handle the demands of shippers and the variation of goods in the transportation system. Due to several reasons, this kind of mixed transportation system is complicated to achieve, which in turn gives raise to other problems that have to be solved.

### 2.1 Transportation networks

The mixed transportation network referred to in this paper is a network where terminals are interconnected by links. Previously, mixed transportation networks have proven to have a great potential (Crainic, 2002; Liu et al., 2003) where some of the potential benefits include better equipment utilization, decreasing waiting time at the original terminal and ensuring more rapid service for the customer (ibid.). Other benefits relates to the physical changes in the network. By physically changing the relations in the network creating shortcuts, *interhub links,* where the amount of goods is large the total cost of the network will be reduced (O'Kelly and Bryan, 1998). Thus, depending on the amount of goods in each relation, the goods are sent in the most efficient way, enabling higher filling rates and better resource utilization.

Furthermore, a mixed transportation network also enables involvement of other transport modes. Using other modes such as rail and sea transportation will for some routes and distances mean substantial savings in terms of fuel (energy) and resources. Road-rail combinations and other intermodal transportation combinations often lead to less environmental impact and subsequently more environmentally sustainable transportation systems (ERTRAC, 2006). On the other hand, many of the intermodal transportation solutions are restricted by the physical handling in the nodes and the operations required when the goods are transferred between the modes. Partly due to this extra handling, intermodal transportation involving rail has difficulties in competing with unimodal truck services over distances less than 400 to 500 km (Trip and Bontekoning, 2002). The transition between the modes is also time consuming and quite costly which further reduce the competitiveness of intermodal road-rail transportation. However, under the right conditions, intermodal transportation is a viable alternative to road transport (Trip and Bontekoning, 2002; Groothedde et al., 2005).

The important driver and a motivation for the renewed interest looking into the possibilities of mixed transportation networks are the possibilities that arise with new technology, the changed cost structure and environmental concerns in society. Several of the factors that previously have prevented that it has been put into practice can now be managed and solved. An important factor is the possibility to share and to transfer information between shippers, transportation companies and receivers. The possibility of sharing of information will most likely prove important in case a mixed transportation network is to be used and where factors such as routing of traffic, service level at each route, and the costs and service at each terminal have to be considered (Persson, 2006). Additional activities caused by the mixed network will also apply: additional unloading, consolidation and loading operations have to be dealt with and compensated for. It also means increased congestion levels at the intermediary terminals and a risk for decreased reliability of the shipment (Crainic, 2002). It is heavily depending on the information systems infrastructure and the ability to control the processes in the whole network. Each decision has to be taken globally and in an integrated manner (Crainic and Roy, 1988; Crainic, 2002). As the different information systems are being integrated and the information is shared between them the degree of complexity will also increase. The number of differentiated components and the number of interacting components increase and the nature of interactions between these components is getting complicated (Alter, 2001). Practically this means that decisions on the selection of services, traffic distribution, terminal policies, and general empty balancing strategies have to be considered for every decision made in the network. Thus, to be successful organizations have to be able to handle this complexity.

### 2.2 Information systems

The Internet is becoming the main source and carrier of information and also an important part in the development of services and products in the transportation area. Combined with the development and implementation of ERP systems, the Internet has changed the way that planning is being made and how decisions are taken (Lasserre, 2004). Internet technology has also meant that many of the formerly proprietary information systems acting inside organization have been integrated to other systems within the company. From being more or less monolithic to their nature this type of systems are becoming an integrated part of the corporate information system or the ERP system. The opportunities to integrate information and data are increasing in a rapid pace due to the increased amount of applications available in information and communication technology (ICT). For organizations this means that information is becoming increasingly available given that the business processes are able to support and back up the IT investments (Heinrich and Simchi-Levi, 2005).

Due to strategic decisions depending on the each specific situation, information sharing is usually of varying importance, ranging from *transactional* to *strategic and competitive* (Seidmann and Sundararajan, 1998). Transactional information is purely informational and neutral whereas higher levels of information sharing usually means increased value for both the information owner and the receiver. On transactional and *operational* information levels, information exchange can be facilitated by using EDI and Internet-based information systems reducing the cost for information transfer. It means also that information will be sent more often between the actors (Sahin and Robinson, 2002).

Increased integration between information systems makes these applications increasingly useful for transportation companies having operations depending on complex relationships and where data is collected in real-time from many different sources (Gayialis and Tatsiopoulos, 2004). Due to the development in information technology it is possible to take parameters into consideration and to design integrated information systems that can handle complex situations (Kasilingam, 1998). Available transportation means, products, depots, customers and road network can be integrated into the decision process and help the LSP to make the transportation network more efficient, using the resources more effective. As transportation processes have become increasingly important and strategically important for many companies, it is important for the logistics companies to provide solutions that are more that providing transportation from A to B (Lasserre, 2004). Shippers and receivers are depending on punctual deliveries and the delivery time windows are getting narrower. In many cases, the supply of materials is crucial. The manufacturing companies have a genuine interest to choose the right logistics service provider, therefore it is crucial for the LSP to be able to respond to the demands of their customers and to be able to provide high customer service.

### 2.3 RFID and traceability

In the foliated transportation networks concept, information is needed to be able to coordinate the goods and resources in the transportation network. The information has to be shared voluntarily between the shipper and the logistics service provider in order for the system to work as intended. Today, when the customer enters an order, information is provided in order for each shipment to be sent to its final destination without any detailed information on the characteristics of the goods. As long as the goods can be referred to a given destination it will be sent through the network. However, for the goods to be handled in a mixed transportation system, other restrictions apply due to the demands related to the handling of the goods in the intermediate terminals. To make it successful, the goods handling time must be short and the readability of the information media has to be good, which motivate the choice of automatic identification technology.

Among available automatic identification technologies, there are several possible solutions available, among which barcodes is the most reliable and well-spread but as the technology has its limitation, there are other promising technologies that could provide a better solution. The reasons for choosing RFID as the main identification technology are several. In the literature, improved inventory management; inventory visibility; enabled operational improvements; reduced inventory shrinkage; improved asset tracking are especially singled out as benefits of RFID (Prater et al., 2005; Smith, 2005; Twist, 2005; Jones et al., 2005). The list can be made even longer, depending on the context in which it is being evaluated there are different characteristics being pointed out. The benefits that are achieved are also to a high extend results of the environment in which the technology is being implemented in. In recent paper, Lee and Özer (2005) states that the potential benefits can be narrowed down significantly, mainly because of all the structural and organizational changes following an implementation. They claim that the only real benefits that can be directly derived from an implementation of RFID are related to either *visibility* or *prevention*. More specifically they mean that benefits are related to either increased visibility of goods and resources in the supply chain or prevention of unnecessary operations, avoiding shrinkage and to make operations more efficient (ibid.).

To avoid the risk of confusing the benefits of traceability and RFID with results and effects related to other structural changes, operations can be listed and matched to the known problems occurring in a supply chain (table 2). This suggests that a better fit between the problems that the organization experiences and the characteristics of RFID, the more it is that the technology is an appropriate way to go for the company to. The success of RFID is related to the interacting business processes and the fit of the technology into the physical processes in the organization (Lefebvre et al., 2005 and 2006; Bendavid et al., 2006).

*Table 2 Diagnostics for implementing traceability and RFID,*

| Studied area | Problems encountered |
|---|---|
| Identification | Item identification processes |
| Information management | Re-keying of data for physical items |
| Capacity for handling | Inefficiencies in tracking items or assets |
| Sorting | Automatic sorting and matching of goods |
| Inventory check | Inventory status and shrinkage |
| Security and fraud | Counterfeiting and fraud |
| Data reliability | Errors and mistakes |
| Timely data | Readability |
| Environment | Harsh conditions |

Previous implementations within RFID also emphasize the importance of a business and to fully benefit from the technology there have to be an underlying demand for the fundamental characteristics that can be verified to come from the technology, e.g. when the identification of goods or information management have to be improved. RFID generally requires large changes in the physical processes involved which means that each implementation has to be preceded by careful preparations. Furthermore, supply chain partners have to be willing to participate and share information (Lefebvre et al., 2006).

The main drawback of the technology is the slow implementation rate and the lack of experience among potential users (Persson and Stefansson, 2006). Despite a long history the interest among potential users has been very poor - it was not until the late 1990s that the technology became somewhat more widely used and standards begun to emerge (Roberts, 2006). Partly because of the lack of standards, most companies currently using the technology do so in closed systems. Open systems require standardized tags and readers as well as cheap tags, something that so far has proven to be hard to achieve, slowing down further development and spread of the technology. Therefore, commitment from organizations taking part in the development of the technology is extremely important. Large organizations like Wal-Mart, Tesco, Metro Group and US Department of Defense (DoD) are heavily promoting the technology and thus driving the development of standards which has lead to slowly but continuously growing number of users (Angeles, 2005).

Both Wal Mart and US DoD are running large projects incorporating their suppliers. The suppliers are expected to comply with the specifications, not always voluntarily:

*"We expect that each supplier will explore its own unique benefits, and determine the most cost effective way to incorporate RFID technology into the organization."*

US Department of Defense (Supplier Guide, p. 6, accessed August 16th 2006)

For most potential users the use of RFID is less certain even if the suppliers to these major companies have to comply with the demands from their customers (Persson and Stefansson, 2006). The technology is still in a state corresponding to the *fog of innovation* meaning that supporting technologies are still being developed and that the benefits are not entirely clear (Sheffi, 2004). Compared to other, similar, technologies it still has a lot to prove before it can be relied on and the alternatives are experienced as equally good or better. For RFID it means that research is on supporting technologies is being carried out and an increasing number of applications are being developed bringing the technology further towards a stage where it can take over from earlier technologies (ibid.)

## 3. Efficient resource utilization

The Foliated Transportation Network concept can briefly be described as a mixed transportation network using real-time information in order to find the most appropriate way to transport goods through a transportation network (Persson and Waidringer, 2006; Persson and Lumsden, 2006). The key to the selection of carrier and route through the network is the traceability of goods and resources. This information is then used to plan and allocate the goods to a destination using the proper route and vehicle. If successful, it will mean that the logistics company will be able to maintain high customer service having a more efficient production system and simultaneously reduce the environmental impact of the system (Persson, 2006).

- *Mixed transportation network*
- *Information sharing*

- *Information and data capturing*

For a large logistics company using a mixed strategy, the use of direct shipping becomes increasingly complex as the number of customers and direct relations increase (Crainic, 2002). As the number of relations in a network is growing a considerable number of resources is required to maintain a high service level as promised to the customers. This means that the delivery times and express deliveries will cause many trucks to be poorly used. As a consequence of the vast number of relations, the amount of goods to each terminal decreases and thus the resource utilization of the trucks decreases. Demands from customers on high frequency deliveries and short lead times further reduce the possibilities to coordinate the goods for the forwarder.

An important part of the technological development is the evolution taking place in field of mathematics and information systems science. So far it has been beyond the capacity of the existing information systems to provide this type of support. Either there has not been sufficient computer/network capacity or the cost for this type of solutions has exceeded the savings. First when the cost for inefficiency exceeds the cost for computer/network capacity and when the information systems are capable of handling the complex flow of data change is possible. Today, this equilibrium has been reached. Direct costs, such as fuel and machinery, and indirect costs such as congestion and taxes are increasing. By making transportation more efficient these costs can be reduced. As many of the measures that are taken involve physical resources, these changes will also make transportation environmentally sustainable.

## 3.1 Mixed Transportation networks

The main principle for a foliated transportation network is that as soon as the amount of goods in a relation is sufficient or when the limit for a full truck load is reached, the goods will be sent directly to the distributing terminal. The rest of the goods, the overhang, will be sent through a hub-and-spoke-based terminal network. On the other hand, if the amount of goods does not reach that level all goods will be sent via the hub-and-spoke based network and no direct relation will be established. Thus, the goods will be transported in full truck load direct to the distributing terminal as long as the amount of goods is sufficient. If not, an intermediate hub will be used as a consolidation point where it will be coordinated with goods from other terminals to form a full truck load before being sent to the distributing terminal as described in figure 1.

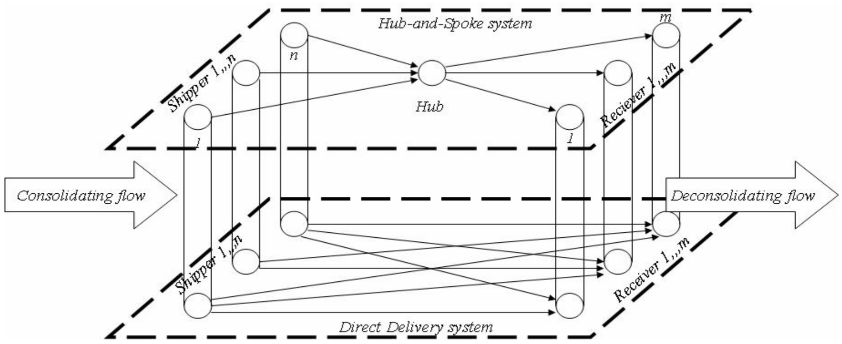


*Figure 1 Foliated transportation network of a logistics service provider (Persson and Lumsden, 2006)*

The efficiency of the network is very much depending on how the goods are being allocated to resources and locations in the terminal network. Therefore, information technology and the use of real-time information play an important role. By tracing the goods when entering and during operations in the network, activities and goods can be coordinated based on the actual situation and more easily be allocated to the proper resource or destination. Identification technologies, high speed wireless communication and geographical information systems further facilitate the decision-making process in and between hubs in future transportation networks (Persson, 2006).

## 3.2 Information sharing

Information sharing is a vital component in the use of identification technologies, especially in transportation where the main function is to coordinate and consolidate goods as efficiently as possible. It does not normally mean that all available information is being shared, many shippers are likely to wait until the same day of load pick-up before booking transportation (Tjokroamidjojo et al., 2006). Despite this approach it has been shown that the value of information often increases when being shared, better planning, less variation and increased customer service. In a supplier-customer relation the most common information to share is the Point-of-sales data (POS), which allows the supplier to increase demand forecasting accuracy and to gather information on sales patterns (Samaddar et al., 2006). For the transportation company, advance load information has the potential to lower the costs associated with each assignment, using both vehicles and drivers more effectively (ibid.).

Today, transportation companies rely on their expert knowledge and previous experiences to manage their networks which in many cases have proven to give them strategic advantage. As the goods flows and the relations in the transportation network grow increasingly complex, it takes more than experience to manage all the processes involved. Updated and real-time information has to be used to better administer goods flows and physical resources, advanced information systems are used both for transport administration and systems for daily operations that physically manage the goods in the network. Thus, the importance of information sharing will become an issue both strategically and competitively.

### 3.3 Information and data capturing

Traceability of goods and resources is an important part of the process of integrating information systems. Making the identification process as simple and smooth as possible will increase the overall traceability in the supply chain. As the traceability of goods and resources is one of the main components of the proposed strategy the presence of well functioning identification systems is of great importance. Barcodes is the technology that so far has been the prevailing way of labeling and identifying goods. However, there are many characteristics of the barcodes that makes the technology less suitable for systems that require both flexibility and redundancy. Barcodes require line-of-sight and they are sensitive towards wear and tear, they are also limited in the amount of information that can be stored. Due to the vast possibilities attached to the technology, radio frequency identification, RFID, is preferred for information and data capture in the Foliated Transportation Networks approach. Compared to barcodes, the use of RFID means that traceability will be improved as each piece of goods will be easily identified due to the information stored on the tag. Frequent identification and tracking of the goods will also increase security avoiding fraud, theft and errors in a supply chain (Lefebvre et al 2006). Thus, by using RFID, visibility and prevention can be obtained, enabling better use of available resources, resource utilization and higher filling rates and Better control of the goods leading to higher security and less misplaced items and thus higher reliability

There are also benefits regarding the way information is stored, physically attached to the items, enabling new kind of solutions. Goods can be made intelligent or *smart* by communicating goods-specific information (Lumsden and Stefansson, 2006). Designing a transportation system where the package, when read will be able to tell the system its characteristics and final destination creates possibilities for the logistics service providers. The *smart goods* concept means that an item or package will be able to find its way to its destination without any further human interference.

## 4. Analysis

As has been discussed so far related to the existing literature on transportation networks and the supporting information systems there are many factors to consider making the Foliated transportation Network function as intended. Based on previous studies on mixed transportation networks, there is a large potential in combining transportation networks, both by shortcuts in the network as well as incorporating other transport modes. It also means that a number of structural problems arise regarding goods handling, lead times and available capacity in terminals and other resources, problems that have to be solved. The solution provided in this paper has been very much focused on the use of information and ICT. The remaining problem is however, how to combine physical resources in a way that provides high efficiency and better resource utilization by allocating goods and resources in a transportation network.

### 4.1 Changing conditions

From previous research, it is known that problems will occur related to the extra handling of goods such as additional unloading, consolidation and loading operations that have to be dealt with and compensated for. Increased congestion levels at the intermediary terminals and the risk for decreased reliability of the shipment are other factors that will occur. It also means that many of the weaknesses and potential pitfalls are known and thus can be avoided. Therefore, it is also very tempting to continue this research and to revisit some of the early findings in the literature and try to find new solutions to old problems. There are also other factors to be considered that considerably have change both the prerequisites and the outcome of the solution such as customer demands, cost structure and environmental awareness. In short, three different demands have to be fulfilled: A terminal network including physical resources and sufficient capacity, customers willing to share information about their current and future needs and a technology enabling efficient identification and tracing of goods and resources.

### 4.2 Information systems

Information systems handling both i*nternal* and *external* data have to be in place for the system to be successful. Therefore route planning-, transportation management- and warehouse management systems (WMS) will be needed as well as information systems that can process external data have to be available*,* table 2.

*Table 2 Information systems environment*

| *Internal information systems* | *External information systems* |
|---|---|
| Route planning | Goods identification (RFID, barcodes, etc.) |
| Transport management systems (TMS) | Traffic (road) information (congestions, etc.) |
| Warehouse management systems (WMS) | Shipment information (amount, destination, etc.) |

Whereas internal information systems are used and controlled by the transportation company, external information systems provide information and data of a recent nature. Internal information systems can function without any further integration using available information. The challenge is therefore to integrate real-time or recent data into the planning and execution operations that are being made in the in transportation companies today. In that way, goods characteristics, specific information on shipments and traffic information can be a part of the scheduling and allocation of resources in a transportation network. The more integration that can be achieved between the supporting information systems, the more accurate and complete information can be provided increasing the possibilities to get a foliated transportation network to function as intended. It is, however a very complex environment that these systems are set to handle which also means that there are many actors with different agendas that have to be connected, sharing information with their suppliers and customers. This is also why a third group of systems can be related to the information systems environment on which the concept depends: ERP and Supply chain information systems. Due to the integral function of the ERP system, in many providing the information infrastructure backbone of an organization, both internal and external information systems are connected via the ERP system.

### 4.3 RFID

RFID has been discussed as a way to increase the efficiency in goods handling operations but so far, there are still many question marks regarding the future development of the technology. Only a few companies have taken the decision to implement and use the technology, which in turn put restrains on other potential users from trying. There is an imminent threat towards the technology itself, that the lack of interest will stop further development to take place. Issues related to the development of standards and applications are therefore extremely important, leading to a future integration of traceability and identification technologies into logistics and business processes and to provide the visibility needed for the development of new more efficient transportation solutions. First then the technology can prevent unnecessary operations and by that increase the efficiency of logistics operations. In the end it depends on how far the technology can be developed and what can be accomplished by the users. Merely RFID being a tool, other factors are equally important for the future development of applications and supporting information systems infrastructure.

### 4.4 Potential and consequences of a Foliated transportation network

As result of the previous discussion and the implications from previous literature on mixed transportation systems and identification technologies, tools, potentials and threats can be listed and related to the physical considerations of mixed transportation networks, information systems and identification technologies (Table 3). The potential lies in the opportunity to increase resource utilization achieving a sustainable transportation system with visibility and prevention through increased traceability and availability of information.

*Table 3. Potential of a Foliated transportation network and its implications*

| | Physical considerations<br>*Mixed Transportation network* | Information systems<br>*Information integration* | Identification technologies<br>*Traceability* |
|---|---|---|---|
| | IMPLICATIONS | | |
| Potential | Resource utilisation<br>Filling rates<br><br>Sustainability | Integrated planning of resources and personnel<br><br>Availability of information<br>*Credibility and accuracy* | Visibility<br><br>Prevention |
| Tools | Hardware<br>*Tags, antennae*<br><br>Handling equipment | Information systems<br>*ERP, GIS, GPS*<br>Simulation and planning<br>Traffic information | Auto ID<br>*Bar codes*<br>*RFID tags*<br>Handling equipment |
| Threat | Realisation<br>Reliability,<br>Development of hardware | Protectionism<br><br>Impact/penetration | (Lack of) Cooperation<br><br>(Lack of) Integration |

Although the complexity of the solution should not be underestimated, there are many factors in favour of the concept. Current systems are by many means operating on similar principles, but limited to a few rather simple rules how to handle the goods when entering the transportation network. A well functioning identification system is needed that can handle the goods generated by the shippers, identifying the goods and then use this information when goods and resources are being allocated. Threatening to jeopardize the concept are factors related to difficulties of sharing data and information across the supply chain. Subsequently lack of cooperation and integration is contra productive for increased visibility and the realization of information integration and the sharing of goods specific information. The technical issues to be considered are related to how information can be made available to the actors, agreeing on standards, interfaces and how to make sure that information systems can interact. Thus hardware such as tags and antennae are important as well as the handling equipment, both vehicles and capacity in the terminals.

The variation in the amount of goods sent by a shipper means that the transportation company always has to be prepared to make late changes in the scheduling of shipments. Resource utilization and subsequently also the filling rates will be affected as a direct consequence of the variation in demand leading to increased negative environmental impact. Handling the variation thus means that hauliers can provide better customer service using fewer resources and subsequently will become better prepared to respond to customer demands. Due to environmental and economical issues it is also of utmost importance that goods will be shipped as efficient as possible. As environmental and financial considerations often are tightly connected, finding a solution both benefits the costs related to the service as well as the environment.

## 6. Conclusions and further research

In this paper some of the most urgent issues in transportation have been lifted and a concept called the Foliated Transportation Network has been discussed as a possible solution to some of these problems. Visibility of goods and resources in a transportation network has been discussed as a measure to prevent a transportation company from doing unnecessary operations by using a mixed transportation network. It is important that goods can be allocated to the right resources and destinations to increase the efficiency in a transportation network. This can also be related to the combination of transport modes, having updated information on goods specific data also enables efficient transfer of information between different operators given that standards are developed that support the transaction.

A mixed transportation network will not always be the best way to solve the current problems in transportation. For shipments that have a sufficient filling rate, increased information will have a very limited importance. However, given factors such as congestion, fuel prices and other obstacles to road transportation, for goods that require more attention and thus have to be delivered according to certain standards, a foliated transportation network can have a large impact. Being a conceptual construction so far there are also many issues that have to be dealt with, the current state of RFID and the degree of information sharing in supply chains are serious restrictions to what can be accomplished. Further research will therefore tell whether RFID can respond to the potential benefits suggested in the literature. Due to the lack of full scale implementations the results are merely hypothetical, however, given the fast development within information technology and eventually also RFID, more substantial results will soon appear.

Further research involves quantifying the results of the proposed solution.

## Remarks:

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# A STUDY ON THE IMPACT OF DIFFERENT EXPRESSWAY TOLL LEVELS IN THE VOLUME OF INTERREGIONAL FREIGHT TRANSPORTATION

Shigeru Shimizu[1], Yoji Takahashi[2] and Sideney Schreiner[3]

## Abstract

*In Japan, around 20 to 30% of the vehicles trips are estimated to be longer than 50km. However, only 13% (2003) of these trips use the expressway system. Moreover, the expressway utilization ratio of trucks is lower compared with the same index of passenger cars for the same trip lengths. This shows that a considerable number of trips can be potentially induced to use the expressway system.*

*The use of the expressway system, when increased, would represent positive impacts from the perspective of energy consumption and CO2 emission.*

*The objective of this paper is to assess these impacts, specially focusing on the volume of the interregional freight transportation induced to the expressway system as a result of different toll levels.*

*A model for freight transport was developed based on the "Freight Census of Japan in 2000", considering trip length, travel time, and generalized travel cost, which represents fuel cost, toll fees, and personnel costs. The model evaluates the preference in using the expressway system or ordinary roads. The model has considered two main groups: "commercial" for the freight transported by third part forwarding agents; and, "private" for freight transported by goods' owners.*

*The results obtained with this model have shown a stronger increase in the use of expressways by commercial trips rather than private trips, concerning the system when a reduction of toll fee is implemented.*

*Keywords: Freight, Expressway, Reduction of tolls, Impact study*

## 1. Background

The length of the expressway system in Japan was 8,540 km by March, 2004 [1].

*The promotion and induction of expressway utilization are important policies from the viewpoint of reducing the urban traffic congestion, reducing $CO_2$ emission and energy consumption.*

In 2004, transportation was estimated to be responsible for 21.2% of $CO_2$ emissions, in which trucks were responsible for 35%, while rail and ship together corresponded to 3% [2]. Transportation's main source of energy is still petroleum derivate fuels; therefore, improvement in the management of energy consumption is important from the environmental point of view, especially for goods flow. The reduction of energy consumption and $CO_2$ emission of trucks can be achieved by inducing these trucks to use the expressway system. Currently, however, this utilization is lower than the expectations, possibly due to the high toll fees [3].

In recent years, Japanese Expressway Management Company has conducted an experiment, which offered discounts to specific sections in certain time periods for the ETC system. During this experiment, an increase of the traffic volume in the experiment section was observed. Similar experiments have been conducted in an increasingly number of sections to confirm the initial observation [4]. For example, after reducing the toll of the ETC passage vehicle of Tokyo Bay Crossing Road by about 23 %, the traffic increased by about 9 %.

As the travel time increases, the expressway utilization ratio increases [5]. Therefore, the promotion and induction of expressway utilization is necessary for the interregional freight transportation.

The implementation of such experiments requires the cooperation of several organizations, which prevents the experiment to be conducted in a wide area. The relation between the toll fee and the increase in the traffic volume must be assessed to complement the localized studies and support a wide area network experiment.

## 2. Japanese highway infrastructure

The construction of high-speed train system "Shinkansen" and highway networks was decided in the general development plan in 1969 by the Japanese government, under high economic growth. The plan consisted in the correction of the disproportion on land use, balance of the depopulated and overpopulated area, and the correction of the living standards differences, which occurred all over Japan.

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According to Japan's 4th National Development Plan (1987), the objective for the transportation system was "Traveling Japan's area within a day", meaning that the main cities should be integrated by a high-speed transportation infrastructure, which would benefit private and business trips. The volume of passengers expanded as a background for the construction and extension of such high-speed infrastructure. From 1970 to 2000, Shinkansen passengers increased about 2.6 times, while air passengers increased 6 times. On highways, the vehicle-km increment was adequate to the expansion, increasing about 13 times from 1971 to 1999, especially after the second half of the 1980s.

The National Development Highway Construction Plan (1966) established the basic highway network in 7,600km. After the law was reviewed in 1987, the highway network was expanded to 11,520km. The objective is to implement the network so that, from anywhere in the country, the highway system could be accessed within 1 hour trip.

The first target in the network extension is 9,342km (81% of the final objective). However, reconsidering the planning for the highway system extension has became necessary since the demand has decreased along with problems in defining funds for construction and difficulties in the road toll management.

By April 2002, 6,959km of the highway network was completed [7]. Along with local roads, the system reaches 7,200km, possible to be accessed, from anywhere, within 2 hours trip.

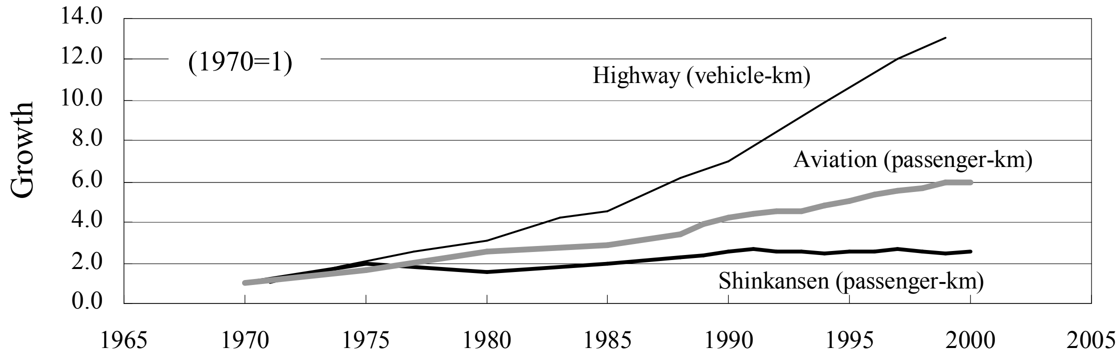



Figure 1 Changes in Highway, Shinkansen, and Air transportation performance [6]

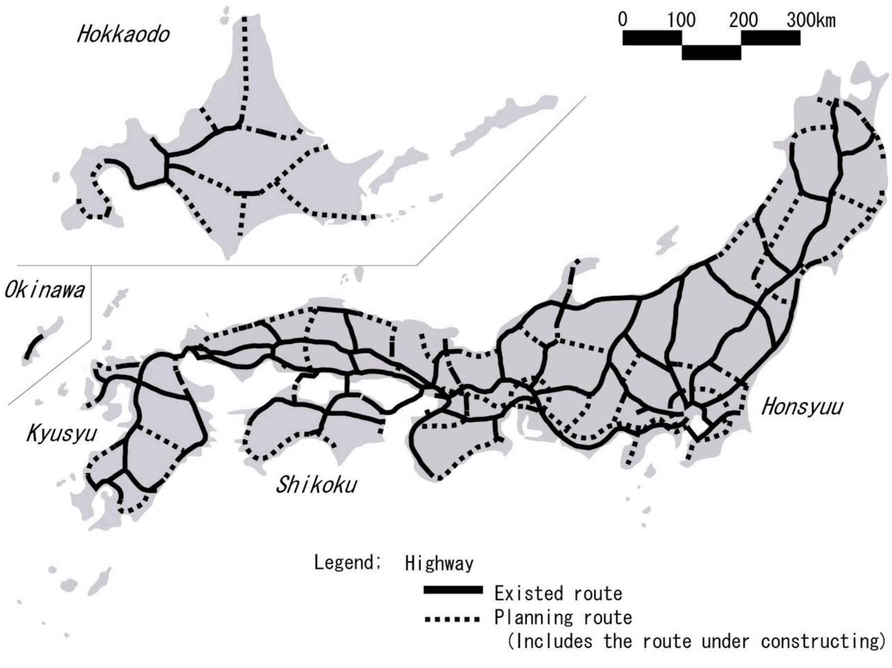



Figure 2 Existing plan for highway network [7]

## 3. Review and Objective

In a previous study on the freight modal split, factors of the truck-transportation, of which variables are cost types, quotient activity, reliability, adaptability and handling freight, are pointed out to be important. Therefore, this paper shows that the promotion and induction of expressway utilization may not be described only at the size of the generalized cost in the freight truck transport [8].

In the study on the future estimation of the interregional passenger and goods flows, eleven freight modal split models were built using the generalized cost. These models consider the possibility of using or not the expressway system, however, no references on the use promotion and induction of the expressway utilization was considered in that study [9].

On the interregional passenger trips, the feasibility of the use promotion and induction of the expressway system is assessed by the existing study and the implementation of an experiment which reduced the generalized cost, composed by value of time and tolls [10].

The general objective of this paper was to assess these impacts, specially focusing on the volume of interregional freight transport induced to the expressway system operating under different toll levels. Specifically, the first objective is to build a macro freight transportation model to assess the utilization of the expressway system. The second objective is to evaluate the impacts of different reduced toll levels on the volume of freight trucks using the expressway system.

## 4. Methodology

The average trip length of trucks using expressways is 101 km. Freight transportation using the expressway system is mostly interregional. Therefore, this study concentrates in the interregional transported goods volume (among the prefectures).

The main definition in this study is the “expressway utilization ratio”, hereinafter referred to as EUR, which represents the percentage of transported goods that use the expressway system.

In order to analyze the relation between the trucks expressway utilization and toll fees, it is necessary to assess which factors influence expressway utilization. In this study, the following factors were considered: trip length, travel time, and travel costs which represent fuel cost, toll fees, and personnel costs. The expressway utilization decision can be described in comparing utilities of “when using an expressway” and “when not using an expressway”, calculated by those factors. That utility definition was implemented in a model, used to evaluate the impacts of different toll levels in the expressway utilization rate by sensibility analysis.

The structure of this study is shown in Figure 3.

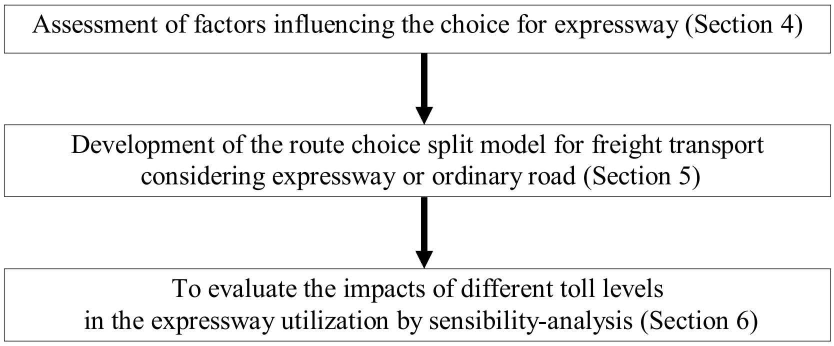



Figure 3 Study structure

Trip data among the prefectures considered by this study was obtained from the “Interregional Freight Census of Japan in 2000”, hereinafter referred to as IFCJ.

## 3. Statistics of Freight Transportation on the Expressway System

### 3.1 Domestic Truck Freight Tonnage

The freight flow tonnage has considered two main groups, “commercial” for the freight transported by third part forwarding agents, and “private” for freight transported by goods’ owners. Moreover, “commercial” group divides into 3 types shown Table1. Then, the freight tonnage, the EUR, and average travel time were compared among each group in Table 1 to assess factors influencing the rate of utilization

The EUR on every travel time section is shown in Figure 4. The accumulated share of freight tonnage by trucks using expressways on every travel time section is shown in Figure 5.

It was observed that the average travel time of the trucks of third part forwarding agents (hereinafter "commercial truck") is higher than average travel time of the trucks of goods' owners (hereinafter "private track"). Moreover the EUR by commercial trucks is higher than that by private trucks.

Therefore, it is possible to observe that, the expressway utilization decision might be strongly influenced with the travel time.

Table1. Freight Tonnage by Truck

| | Utilization of expressway | "Commercial" Home delivery and Consolidation | "Commercial" Car reservation | "Commercial" Trailer | "Commercial" Total | "Private" | Truck Total |
|---|---|---|---|---|---|---|---|
| Freight Tonnage (1,000 ton) | Use | 240 (10.9%) | 1,447 (65.8%) | 301 (13.7%) | 1,988 (90.3%) | 213 (9.7%) | 2,201 (100%) |
| | Non- use | 411 (8.5%) | 2,863 (59.0%) | 754 (15.5%) | 4,028 (82.9%) | 828 (17.1%) | 4,856 (100%) |
| | Total | 651 (9.2%) | 4,311 (61.1%) | 1,055 (14.9%) | 6,016 (85.3%) | 1,041 (14.7%) | 7,057 (100%) |
| Expressway utilization ratio (EUR) | | 36.8% | 33.6% | 28.6% | 33.0% | 20.4% | 31.2% |
| Average Travel Time (hours) | Use | 7.3 | 4.9 | 5.2 | 5.3 | 2.8 | 6.0 |
| | Non-use | 11.1 | 6.8 | 7.4 | 7.4 | 3.3 | 6.7 |
| | Total | 9.7 | 6.2 | 6.8 | 6.7 | 3.2 | 6.2 |

Notes: (1) Each value was totaled based on the "Freight Census of Japan in 2000", considering the modal split and the expressway use. (2) The average travel time is calculated using the network shown in Figure 2.

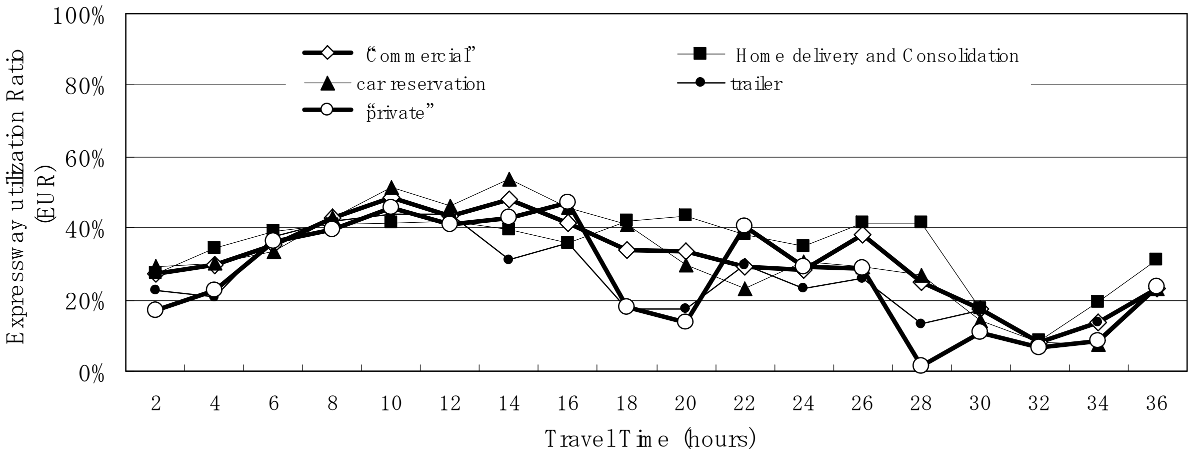



Figure 4 Expressway utilization ratios (EURs) on every travel time section

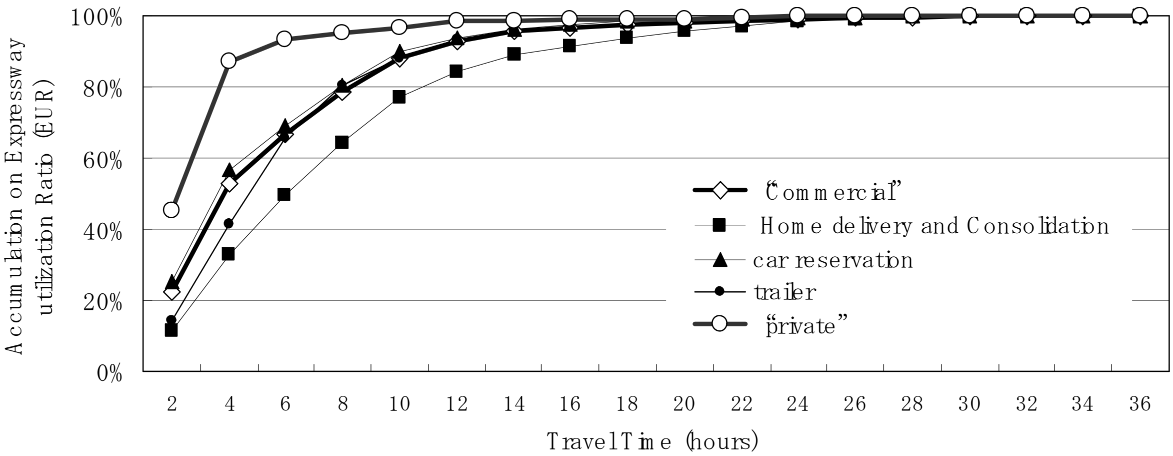



Figure 5 Accumulated share of freight tonnage by trucks using expressways

The travel time considered in the model refers to the shortest path between the O/D pairs using the network shown in Figure 4. The average travel time also considers the loading/unloading time and rest times.

The EUR of the freight tonnage among prefectures has a peak of about 49% at Commercial and of about 46% at Private in trips with 10 to 14 hours of travel time (Figure 4). For trips with travel times over 14 hours, it shows a significant decrease.

It is important to notice that 96 % of the freight tonnage by the commercial track is included within the 14 hours of travel times. Moreover, in the same travel time section, 99 % of the freight tonnage is included when considering private trucks (Figure 5).

As an example, 14 hours of travel times are equivalent to the time from 7 a.m. to 9 p.m. or from 5 p.m. to 7 a.m., representing the maximum operating time in one working day. However, when traveling time exceeds 14 hours, the night time operation and travel times longer than 2 days must be considered. Therefore, in this study, tonnage which exceeds 14 hours of traveling time was excluded from the analysis.

### 3.2 Expressway Use and Commodities

The fundamental idea of the expressway system is the reduction of travel times. Therefore, when the speed or the regularity of the transportation is important, the EUR must increase. The EUR of freight tonnage by commodity type are shown in Table 2. They are different among the commodities. Light Manufacturing Products (26.2%) is the highest and Miscellaneous Products (23.6%), Fabricated Metals Products and Machinery (16.9%), Agricultural and Aquatic Products (13.6%) exceed 9.7 % of the total EUR by freight tonnage. On the other hand, Mining Products (0.8%), Forestry Products (6.0%) and Chemical Industry Products (7.1%) represent the lowest EUR.

Considering the composition in tonnage using the expressway system, Fabricated Metals Product represents 29.4%, while Chemical Industry Product is 27.2%, and Light Manufacturing Product is 23.2%, accounting for about 80% only with these 3 commodities.

Table 2 Freight Tonnage and Expressway Utilization Ratio (EUR) by Commodity Type

| Commodities | Expressway Use | | Expressway Non-use | | Total | | |
|---|---|---|---|---|---|---|---|
| | Freight Tonnage (1000 ton) | Share | Freight Tonnage (1000 ton) | Share | Freight Tonnage (1000 ton) | Share | Expressway Utilization Ratio (EUR) |
| Agricultural and Aquatic Products | 151 | 5.6% | 961 | 3.8% | 1,112 | 4.0% | 13.6% |
| Forestry Products | 23 | 0.9% | 359 | 1.4% | 382 | 1.4% | 6.0% |
| Mining Products | 56 | 2.1% | 6,788 | 27.1% | 6,844 | 24.7% | 0.8% |
| Fabricated Metals Products and Machinery | 786 | 29.4% | 3,877 | 15.5% | 4,663 | 16.8% | 16.9% |
| Chemical Industrial Products | 728 | 27.2% | 9,561 | 38.2% | 10,289 | 37.2% | 7.1% |
| Light Manufacturing Products | 622 | 23.2% | 1,753 | 7.0% | 2,375 | 8.6% | 26.2% |
| Miscellaneous Products | 197 | 7.4% | 640 | 2.6% | 838 | 3.0% | 23.6% |
| Special Products | 115 | 4.3% | 1,072 | 4.3% | 1,187 | 4.3% | 9.7% |
| Total | 2,678 | 100.0% | 25,011 | 100.0% | 27,689 | 100.0% | 9.7% |

Source: Freight Census of Japan in 2000

## 4. Model for Freight Transportation

### 4.1 Network

This study considers the freight transport among the prefectures in Japan. Therefore, the analyzed network is composed by nodes representing the centroids of each prefecture; and by links, connecting these nodes, representing the available road connections.

The network for this study is shown in Figure 6. It also contains certain attributes necessary to the analyses, such as travel times, the link length and toll fees.

The network links represent expressways, ordinary roads and strait ferries. The links representing expressways were overlapped by links representing ordinary roads in order to preserve the possibility of choice between the two types of connection.

The routes among the prefectures were calculated using the Dijkstra method [12] which considered the travel time of each links as the attribute for minimization.

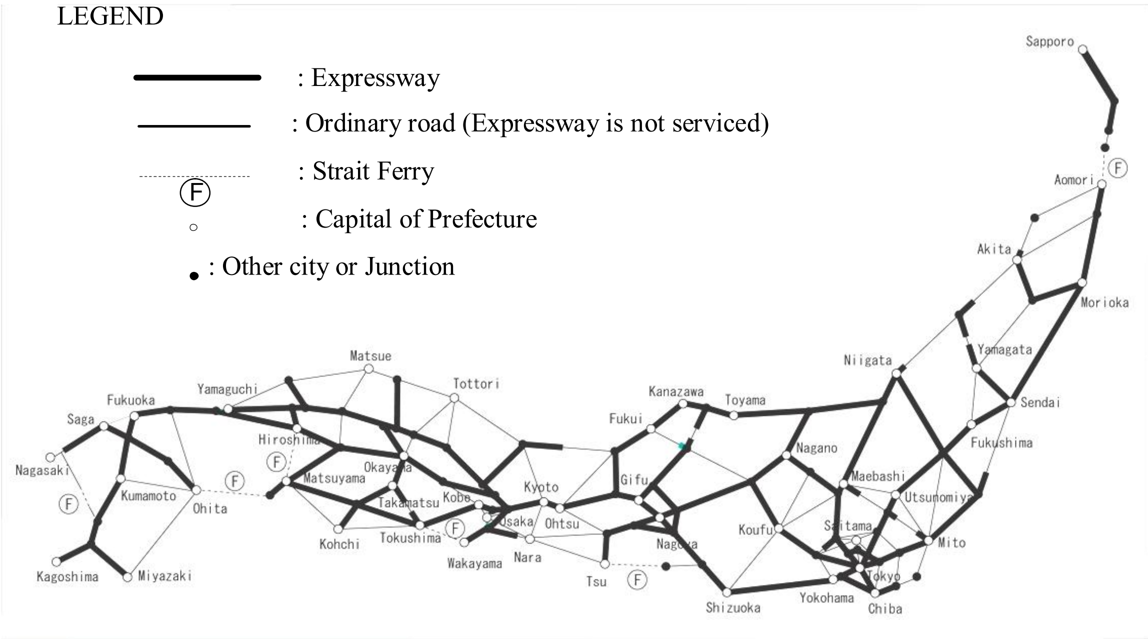



Figure 6 Network model (In case of expressway use)

4.2 Model for Freight Transport Tonnage Using Expressway System

The utilization of the expressway is influenced by the type of trucks, commodities type, the travel time and the transportation fee. The model used an aggregated logit model which could reflect these factors and was used in a previous analysis example [8, 9 and 10].

The utility function adopted is based on the generalized cost. The road length was used as additional attribute for the shortest route search in the case of expressway utilization. In the other case, when not using the expressways, the index representing the commodities' characteristics was used for the shortest path search.

The model is shown in equations 1 and 2. Table 4 shows the adopted parameters.

$$P_{mij} = \exp(U_{mij}) / \{\exp(U_{1ij}) + \exp(U_{2ij})\} \qquad (1)$$

$$U_{mij} = \sum_{l=0}^{L} \beta_l \cdot X_{lmij} \qquad (2)$$

Where:

$m=1$ shows the case where expressways were used, and $m=2$ shows the case where expressways were not used.

$P_{mij}$: The probability to use (or, not to use) an expressway

$U_{mij}$: The utility in case of using (or, non-using) an expressway between zone $i$ and $j$.

$\beta n$ : Parameters ($n=0$: Constant, $n=1$-$L$: The explanatory variable)

$X_{1mij}$: The generalized cost between zone $i$ and $j$ (Added a cost to the product between the total travel time and the time value)

$$X_{1mij} = TTIM_{mij} \cdot TVAL + COST_{mij} \qquad (3)$$

$TTIM_{mij}$: The total travel time between zone $i$ and $j$

$TVAL$: The time value (*30.75* JPY/minute) is made from the personnel cost per hour of the driver. It was obtained dividing the yearly personnel cost by the working hours. Source: Ministry of Health, Labor and Welfare - monthly working statistical survey.

$COST_{mij}$: The cost is composed by the fuel cost and the expressway toll fee.

$$COST_{mij} = \alpha_1 \cdot DH_{mij} + \alpha_2 \cdot R_{mij} \qquad (4)$$

$DH_{mij}$: The expressway use length in the route between zone $i$ and $j$ (km); in case of $m=2$, $DH_{2ij}=0$

$R_{mij}$: The ordinary road use length in the route between zone $i$ and $j$ (km)

$\alpha_1, \alpha_2$ : The fuel cost per traveled length (Using the Table 3)

Table3. The fuel cost per traveled length.

| | $\alpha_1$ (Expressway use) | $\alpha_2$ (Ordinary road use) |
|---|---|---|
| Small truck | 12.72 JPY/vehicle-km | 20.42 JPY/vehicle-km |
| Ordinary truck | 17.75 JPY/vehicle-km | 25.86 JPY/vehicle-km |

Source: Ministry of Land, Infrastructure and Transport of Japan - Road Bureau

$C_{mij}$: Expressway toll (JPY/vehicle) calculated by a regression model of the toll and length among entrances and exits of the expressway. The model is as follows;

-When utilized length is less than 55 km by the ordinary track

$$C_{mij} = 51.53 \cdot DH_{mij} \quad (R^2 = 0.96) \tag{5}$$

*T-Value (18.98)*

-When utilized length is equal to or more than 55 km by the ordinary track

$$C_{mij} = 21.82 \cdot DH_{mij} + 3645 \cdot BR_{ij} + 1668 \quad (R^2 = 0.99) \tag{6}$$

*T-Value (142.1) (21.82) (15.21)*

Here, $C_{mij}$: Expressway toll (JPY/vehicles)

$DH_{mij}$: Length of expressways use section

$BR_{ij}$: Honshi-renrakukyo use dummy

$F_{mij}$: The toll of Strait Ferry (JPY/vehicle)

$X_{2mij}$: The length of the minimum route among the prefectures (km)

$X_{3mij}$: The commodity's attribute is defined as follows;

By the following equation, the index of the commodity which is specialized to "Using at the expressway "or "Not using an expressway" on the freight tonnage of every O/D pair, is shown.

$$(X_{31})_{ij} = \frac{\sum_{k=1}^{K}(q_{ijk1})}{\sum_{n=1}^{N}(q_{ijn1} + q_{ijn2})} \times 100, \quad (X_{32})_{ij} = 1 - (X_{31})_{ij} \tag{7}$$

$n$: Number of small items of freight commodities *(n=1 to N, N=79)*

$k$: $k$ means the group with the freight commodity to specialize to " not using an expressway ". Then, 32 small items were selected in 79 small items by eq8. *(k=32)*

$q_{ijn1}$: Freight tonnage of small item $n$ which is "Using an expressway" among zone $i$ and $j$.

$q_{ijn2}$: Freight tonnage of small item $n$ which is "Not using an expressway" among zone $i$ and $j$.

Table 4 Model's variables and the adopted parameters

| | *"Commercial"* for the freight transported by third part forwarding agents | | | | *"Private"* for freight transported by goods' owner |
|---|---|---|---|---|---|
| | *"Commercial"* Total | Home delivery and Consolidation | Car reservation | trailer | |
| $\beta_1$ Generalized cost (Common-variable) | -3.014E-04 (-1.28) | -6.549E-05 (-0.36) | -3.3576E-04 (-1.29) | -1.460E-04 (-0.31) | -1.951E-05 (-0.12) |
| $\beta_2$ Route Length (Peculiar variable) | 1.553E-03 (3.23) | 1.131E-03 (2.73) | 1.489E-03 (2.81) | 2.594E-03 (3.16) | 3.694E-03 (1.90) |
| $\beta_3$ Commodity's attribute (Peculiar variable) | 1.633E-02 (5.89) | 7.134E-03 (2.51) | 1.831E-02 (6.24) | 1.011E-02 (2.02) | 2.825E-02 (4.55) |
| $\beta_0$ (Fixed value) | -4.579E-01 (-2.99) | -6.339E-01 (-4.29) | 3.307E-01 (2.00) | -8.994E-01 (-3.50) | -6.152E-01 (-1.67) |
| Likelihood ratio | 0.05 | 0.01 | 0.05 | 0.03 | 0.08 |
| Number of sample | 1,327 | 1,311 | 1,167 | 471 | 364 |

$$\frac{Q_{n1}\times 100}{Q_{n1}+Q_{n2}} \geq (\fallingdotseq 7:3) \frac{\sum_{n=1}^{N} Q_{n1}}{\sum_{n=1}^{N}(Q_{n1}+Q_{n2})}\times 100 \qquad (8)$$

The left side shows the share of the freight tonnage of small item *n* which uses an expressway, and the right side shows the share of total freight tonnage of each small item which uses an expressways. Incidentally, $Q_{n1}$, $Q_{n2}$ is shown as next equations.

$$Q_{n1} = \sum_{i,j=1}^{NIJ} q_{ijn1} \quad (9) \qquad Q_{n2} = \sum_{i,j=1}^{NIJ} q_{ijn2}$$

When equation (8) is concluded, the small item of freight commodity *n* will be judged to the specialized to use an expressway.

### 4.3 Reproducibility of Model

The estimated parameters are shown in table 4. Each parameter has logical and appropriate sign-conditions. However, the estimated EUR does not reproduce the present situation in all O/D pairs, as indicated by the statistical analysis. Because the element of EUR when the travel time becomes long wasn't reflected, it might be the strongest influence in the low obtained likelihood ratio (<0.1).

Then, the EUR was calculated for every travel time segment, as shown in Figure 2, due to the stability of t-value of the parameter $\beta_2$. Figure 7 and Figure 8 show the comparison of the estimated expressway utilization rate and measured figures of Goods Flow Census 2000. Moreover, in the travel time which is dealt with for the study, the coefficient of correlation of the expressway rate of utilization is 0.60 for private trucks, and 0.94 of commercial trucks. A similar result was also obtained in the home delivery and the consolidation, car reservation and the trailer. (Refer to Table 5)

The reproducibility for commercial trucks decreases as the travel times exceed 12 hours, and for the private trucks decreases as the travel times exceed 8 hours. These results indicate that the model is not appropriate to evaluate the freight tonnage during night time.

However, because the freight tonnage of commercial which travel time is smaller than 10 hours, and the freight tonnage of private which travel time is smaller than 8 hours show 88.3% and 93.2% each of the whole tonnage, this model is judged to have an utility to analysis.

Table 5 Coefficient of correlation on the expressway utilization ratio (0 - 14 hours of travel times)

| | Freight tonnage | Expressway Rate of Utilization |
|---|---|---|
| Commercial track total | 0.99 | 0.94 |
| Home delivery and Consolidation | 0.98 | 0.63 |
| Car reservation | 0.98 | 0.95 |
| Trailer | 0.94 | 0.47 |
| Private track by goods' owner | 0.97 | 0.60 |

Figure 7 Comparison between the census values and the model estimated value (Commercial Track)

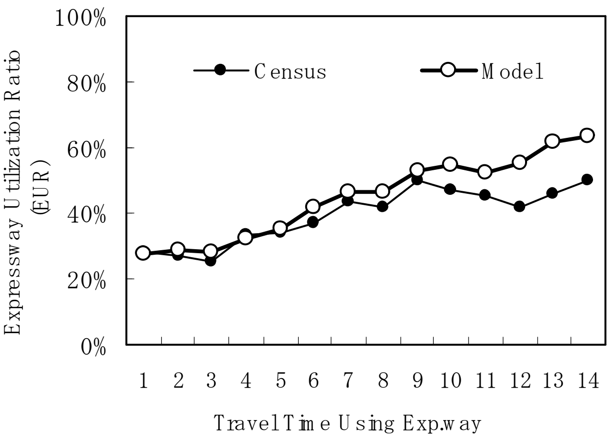
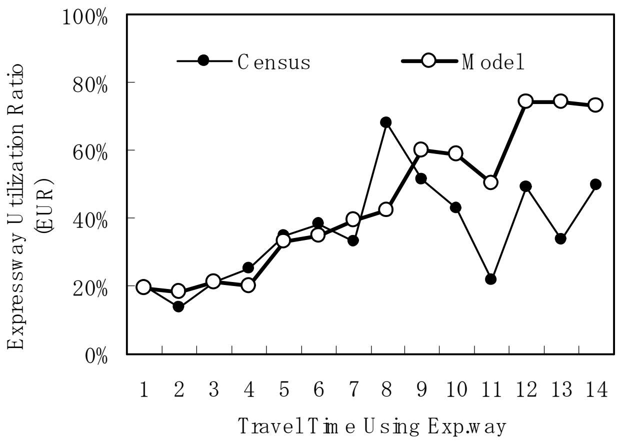



Figure 8 Comparison between the census values and the model estimated value (Private Track)



## 5. Impacts of different toll fee levels

The difference among the parameters of the models explains some characteristics of the freight transportation on the expressways as follows.

The parameter $\beta_1$ of the generalized cost model for commercial trucks is higher than for private trucks by about 3 times. It shows that, the EUR is more sensitive to changes of the generalized cost of commercial trucks rather than the changes for private trucks.

On the other hand, the parameter $\beta_2$ of the road length and the parameter $\beta_3$ of the characteristics of commodities in the private truck are both higher than that in the commercial truck by each of 2.4 times and 1.7 times (Refer to Table4) . The parameters which indicate the trip length and the type of commodity mean higher sensibility in the case of the EUR of Private compared with Commercial.

The influence of the expressway toll fee level was also assessed. Initially, uniform reduced rates were applied to the present expressway toll (10 %, 20 %, and 30 %). The EUR was, then, recalculated considering the new set of toll fees for the entire Japanese expressway network.

The influence of the EUR is shown in figure 9. When lowering a toll by 20 % uniformly, EUR of whole Commercial increases by 4.6 %, and also Private increases by 0.2%. Moreover, lowering it by 30 % uniformly, EUR of whole Commercial increases by 6.9 %, and Private increases by 0.3%. Specifically, it was observed that the increase of the EUR was stronger for commercial trucks than for private trucks. According to the results, for a toll fee reduction of 10%-30%, the increase in the EUR is proportional to the increase in the travel time.

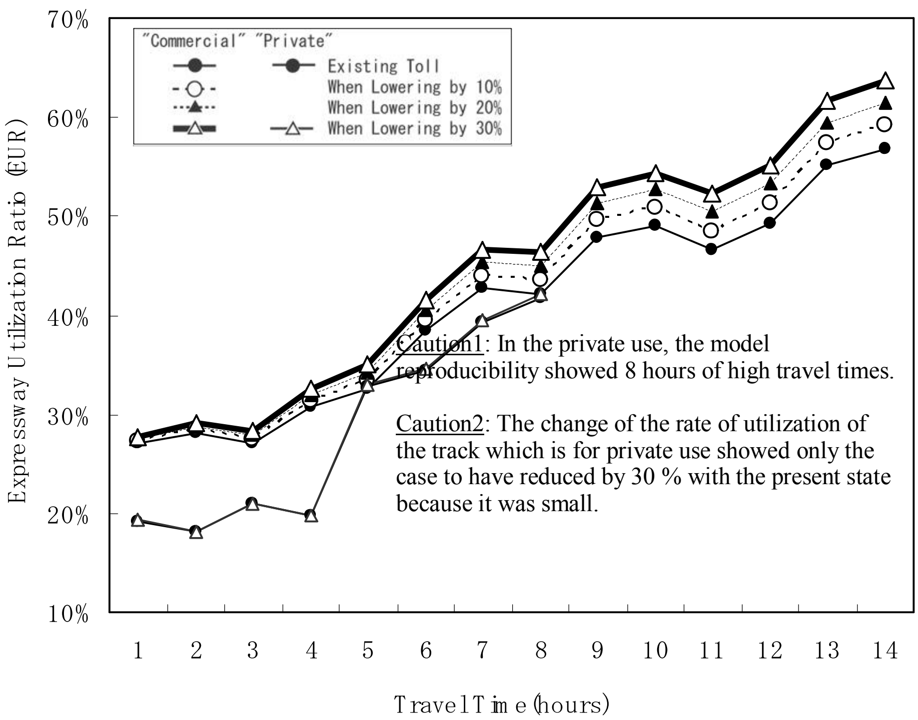



Figure 9 Influence of the change in the expressway toll fee over the expressway rate of utilization

## 6. Conclusion

This study concluded that the EUR of the freight transportation among prefectures has a peak of about 49% at Commercial and of about 46% at Private in trips with travel time between 10 hours to 14 hours. For trips with travel times higher than 14 hours, it decreases. Also, this study showed that more than 96 % of the inter-prefecture freight transportation has travel times within 14 hours.

The commodity types "Fabricated Metals Products and Machinery", "Chemical Industry Products", and "Light Manufacturing Products" account about 80 % from the total tonnage transported in the expressways.

The EUR was obtained for every travel time section. The comparative analyses of the rates estimated by the model and the value from the "Goods Flow Census 2000" showed a coefficient of correlation of 0.94 for commercial trucks and 0.60 for private truck.

The parameters obtained for the model show that, the influence of the change of the generalized cost on the EUR is higher for commercial trucks than for private trucks by about 3 times. These showed a higher sensibility to the trip length and the type of commodity, because the parameter which indicated the trip length of Private was bigger compared with that of Commercial by 2.4 times, and also the parameter of the type of commodity of Private was bigger compared with that of Commercial by 1.7 times.

The model analysis showed that the reduction of toll fee levels caused a higher increase on the EUR for commercial trucks rather then private trucks. When lowering a toll by from 20 % to 30% uniformly, EUR of whole Commercial increases by from 4.6 % to 6.7%, and also Private increases by from 0.2% to 0.3%.

These matters are considered to be reflected in the difference of the parameter of this model. Then, the transit route and the transit time band may become optimized transportation because the goods' owner can manage the schedule of the transportation. In the future, the details must be clarified.

The model developed in this study cannot precisely estimate the EUR for each O/D pair individually. Hence, the improvement of the results` precision will be the objective in the next steps of this research.

Finally, this model can assess the influence of the changes in toll fee levels in the specific area or section due to the model structure which permits individual settings of toll fees for every link. Therefore, a complementary study is suggested, concerning elasticity according to areas, sections, the type of trucks, in order to create a complete comprehensive view on the Japanese expressway as a high-speed transportation infrastructure in the future.

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# RESEARCH ON TRANSPORTION GOODS CLASSIFICATION BASED ON CURRENT AND FUTRUEFREIGHT STRUCTURAL CHARCTERISTICS IN CHINA

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## Abstract

*In this paper, we mainly focus on the research of establishing a standard classification of transportation goods, which not only reflect the current stage transport structural characteristics but also meets the need of keeping in line with international standard. This paper composes of six parts, firstly, we analyzed features of transportation goods; secondly, review of international classification standard and rules, together with existed standard in several countries, including United States, Canada, Japan, Jordan, China, et al., thirdly, analysis on the standard changing with time in different countries, such as United States and Canada; fourthly, the research on the new standard which taking transport structural feature and goods transport characteristics in to consideration and introduced the concept of time stage, with the methods of Delphi and Fuzzy Clustering, then we applied it to some case city in China, the last not least, the conclusion. All in all, the paper presents an improved classification on transportation goods which considered the actual situation at different time stage and the transportation features of goods to meet the needs of international trade and research on logistics prediction.*


Key word: transportation goods; classification standard; structural feature; time stage

## 1. Introduction

Standard classification of transportation goods is always a significant issue for the international cargo transportation. How to establish a uniform international classification standard catalog is an urgent problem to both developed and developing countries. It's not only benefits the international trades between countries but also meaningful to experts and researchers for statistic data collection and research of prediction, simulation, evaluation, et al. in logistics field.

*Currently, with the globalization of international trade, China as one of the largest developing countries plays an increasing important role, especially after access to the WTO (World Trade Organization) since 2001. During this process, seaports along east coastline of China develop rapidly, for instance Shanghai Port and Shenzhen Port, which respectively rank 3 and 4 in the container trade.*

*The fast development brings not only great change for economic development of the nation, but also challenge of sorts of aspects, one of which is the goods classification standard. The issue becomes even more serious after the entrance to WTO, since the current classification standard of goods in China is quite different from the widely used standard around the world. Therefore, how to smoothly connect with the international trade standard is an urgent issue China faces.*

*This issue is also faced by many other countries attending the world trade, since each nation has its own rule to classify the goods, which make the international trade between countries becomes more complex.*

*Herein, in the paper we focus on the research of a generalized classification standard for China, not only suitable for the current home and abroad trade, but also for the future.*

With high speed economy development in China, there's an urgent need of a high efficiency goods transportation system. International logistics is a significant part of the whole logistics system, especially after China entering WTO, hereby, standardization turns to be one of the most important issues.

## 2. Transportation Goods Feature

### 2.1 Feature of Typical Goods in China

Before the study on classification standard, features of transportation goods must be researched, this is the foundation for the next step study.

Generally, there are four properties of goods, which are physical property, chemical property, biological property and mechanical property. The four features determine the transportation feature of goods. Table 1 shows the 19 typical goods now in China according to the statistics based on current classification.

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Table 1 Transportation Goods Feature of 19 typical Goods in China

| Goods | Category | Transport conditions | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Package | Temp. | humidity | Water | Ventilate | Open pile | Compound | |
| Tea | Light industry product and medical product | Bag, basket, crate, | <15ºC | <70% | Damp proof | Good | No | No | |
| Fertilizer | Chemical fertilizer and pesticide | Bag, paper bag, sack, plastic bag | | | Damp proof | Good | — | No | |
| Natural rubber | Chemical material and products | Bag, sack, wooden case, Nude | Preference | dry | Water-tight | good | No | No | |
| Cement | Cement | Cask, sack, paper bag, bulk | — | dry | Water-tight | — | No | No | |
| Metal hardware | Machine, equipment, electric appliance | Nude, bundle, crate, metal cask | — | dry | Water-tight | — | Yes | Yes | Reinforce |
| Glass products | Non-metal ore | Wooden case | — | dry | — | Good | No | Yes | Fragile |
| Cotton | Agriculture, products | Gin bale | Preference | Dry | Damp-proof | Good | No | No | |
| Sugar | Grain products | | <30ºC | <75% | Damp-proof | Good | No | No | Prevent frostbite |
| Raw hide | livestock | Cold, dry, in salt, | — | Dry | Water proof | — | Yes | No | Avoid rain and snow |
| Sausage casing | Agriculture products | Wooden cask | Preference | Dry | — | Good | No | Yes | |
| Structural section | Iron | Nude, bundle, | — | Dry | Water proof | — | Yes | Yes | |
| Lumber | Lumber | Bundle, Nude | — | — | Water proof | Good | Yes | Yes | |
| Raw silk | Valuables | Kraft | <20ºC | <75% | Damp proof | Good | No | No | |
| Food | Agriculture products | Cold storage | -1~10ºC | >80% | — | Good | No | Yes | |
| Salt | Salt | Bag, sack | preference | Dry | Damp proof | Good | No | Yes | |
| Coal | Coal | Nude，Bulk | <60ºC | Dry | Water proof | — | Yes | Yes | |
| Oil | Oil and natural gas | Pipe | — | Dry | Water-tight | Good | No | No | |
| Cereal | Agriculture product | Bulk | Preference | Dry | Damp proof | Good | No | No | |
| Ore | Metallic(non)ore | Bulk | — | Dry | — | — | Yes | Yes | |

## 2.2 Feature of Freight Structural Characteristics in China

### 2.2.1 Current Freight structural characteristics

Presently in China, the main transportation mode has been changing greatly. Before the year 1978, railway took up the most transport, while after that the highway becomes the largest part, which increases in a fabulously fast speed. While railway and marine increase in a relatively stable speed, and pipeline together with air increase comparably lower than the other three.

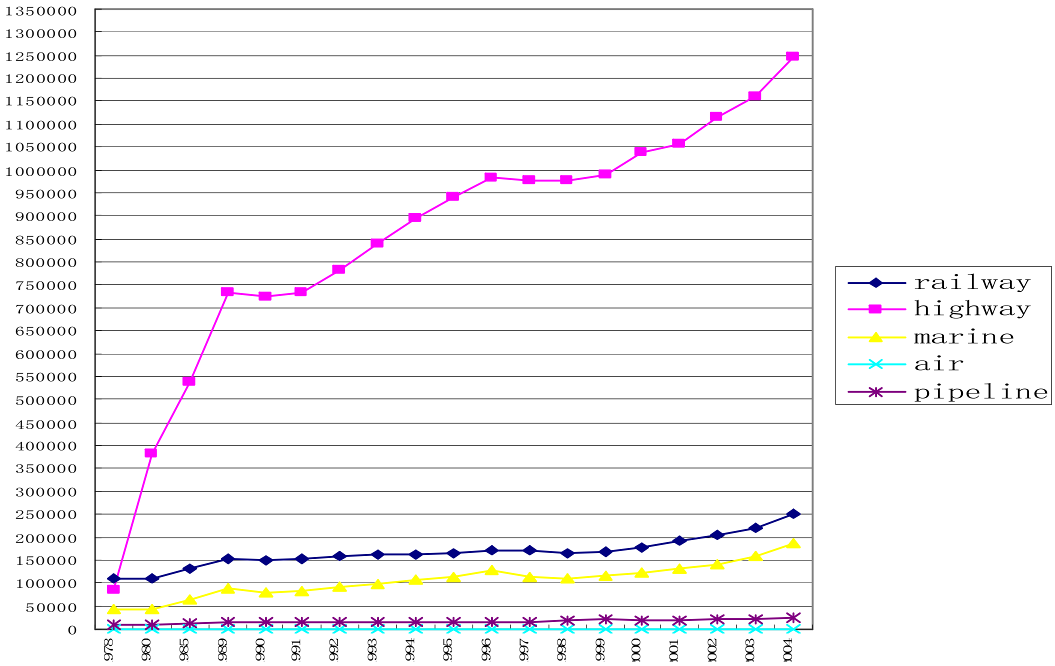


Figure 1. Transportation structure evolutions 1978-2004 in China

As Figure2 demonstrate, it's obviously that for railway, coal is the most important freight goods in China; raw materials such as metallic ore, non-metallic ore, oil, and grain et al. take grate part of the total. This is quite different from developed countries as US and Canada, which mainly transport the manufactured products. Marine plays an increasing important role during this process. The classification of other takes the greatest part of the total, which represent the diversification of transportation goods in current china.

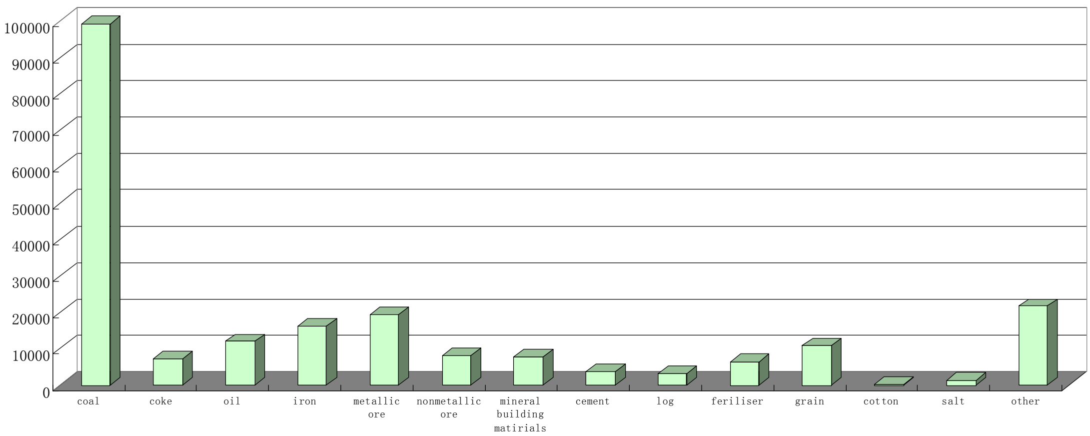


Figure 2. Freight volumes of 14 transportation goods in 2004 in China (railway)

2.2.2 Future Freight structural characteristics

With the development of society and economy, the transportation goods become divers and more finished product would take more part in this process, the semi-product and raw materials would take smaller part in the future, which demonstrate the developing level of the total

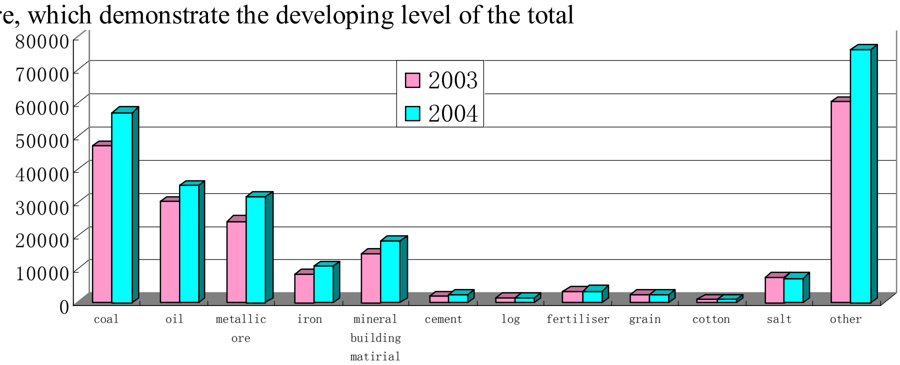


Figure 3. Freight volumes of 12 transportation goods in 2003, 2004 in China (marine)

## 3. Classification Standard Review

### 3.1 Classification in China

In1988, the first version of Classification and Code of Transport Cargo (CCTC) has been promulgated and applied. More than ten years later, with the rapid development of economy and society in China, the former one could not meet the need of the nation and trade. In April 2001, the current version of CCTC had been promoted based on the version of 1988 and Harmonized System (HS) published by the World Customs Organization (WCO), which falls into 17 sections, 122 sub-classes and 197 sub sub-classes. Because in the year 2000, General Administration of Customs of the People's Republic of China had published the as the Import and Export Goods Classification and Codes of the People's Republic of China as the nation standard, while the CCTC has been used for decades, thoroughly changing to a totally new standard is not reasonable, the two should set up a parallel table to cooperated with each other.

The system is four digits, the first two digits represent the section goods belong to, the third digit represents the subclass, and the fourth are the sub subclass. The 17sections are shown in Table 2 as follows.

*Table 2 The current classification in China*

| | Section | Sub-section | Sub sub-section |
|---|---|---|---|
| 1 | Coal | 7 | 9 |
| 2 | Oil and natural gas | 9 | 12 |
| 3 | Metallic mineral | 9 | 9 |
| 4 | Iron | 6 | 12 |
| 5 | Mineral building material | 9 | 9 |
| 6 | Cement | 1 | 1 |
| 7 | Lumber | 6 | 6 |
| 8 | Non-metal ore | 9 | 9 |
| 9 | Chemical fertilizer and pesticide | 3 | 3 |
| 10 | Salt | 2 | 2 |
| 11 | Grain (cereals) | 9 | 14 |
| 12 | Machine, equipment, electric appliance | 9 | 32 |
| 13 | Chemical material and products | 8 | 17 |
| 14 | Nonferrous metal | 6 | 14 |
| 15 | Light industry product and medical product | 7 | 50 |
| 16 | Agriculture, forestry, livestock, fishery products | 9 | 32 |
| 17 | Other | 1 | 1 |
| | Total number | 110 | 234 |

The system is quite different from the Harmonize System (HS), which shows in Table3, first section of the whole system. The first 2-digits, 01-21, represent the section, and the last two 1-97 represent section notes.

*Table 3 the HS classification*

| Section | | NO | Section Notes. | 0100 |
|---|---|---|---|---|
| I | LIVE ANIMALS; ANIMAL PRODUCTS | 1 | Live animals. | 0101 |
| | | 2 | Meat and edible meat offal. | 0102 |
| | | 3 | Fish and crustaceans, molluscs and other aquatic invertebrates. | 0103 |
| | | 4 | Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included. | 0104 |
| | | 5 | Products of animal origin not elsewhere specified or included. | 0105 |
| | | 10 | Cereals. | 0210 |

For example, 'edible oil and products thereof', with code 1621 in CCTC, while the code in HS is 0315.

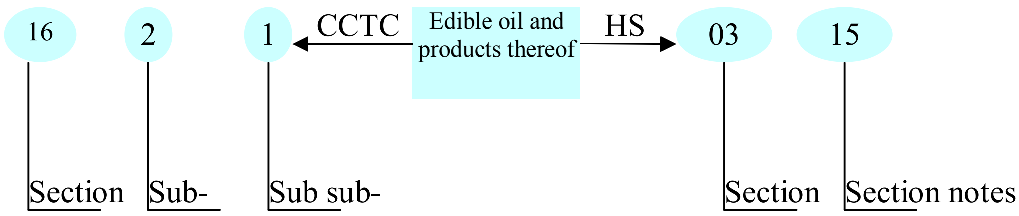


Figure 4. The comparison between codes of CCTC and HS

It's obviously that the current classification make it more difficult for international trade of China. Also the unsmooth connection during the trade process makes the transportation more complex. The transport features for each sort of goods are quite different by deferent tools, therefore the first job for us is to make a more reasonable classification for Chinese traders, which surely will bring more easily process for them and increase the efficiency to some extend, also make it easy for statistic department to get the useful data more conveniently. There are several flaws for present classification,

- Not harmony with the international standard;
- Not cover all aspect of goods, including some very important ones;
- Criterion for each kind is not conform to each other, some are too fine, while some are broad;
- Not suitable for the current economic development;
- Some codes are used repeat for different goods;
- Hard for statistic, the collected data could not meet the need of researches;

3.2 United States

The U.S. used the Standard Transportation Commodity Code (STCC) for the collection and publication of 1993 CFS data, but it was inadequate, because, among other weaknesses, STCC is primarily a rail-carrier-based classification. The Commodity Flow Survey (CFS), however, is a shipper survey that collects information about commodities shipped by all modes, as well as intermodal movements. The Standard Classification of Transport Goods (SCTG) has been designed to provide commodity groupings that better reflect goods transported by all modes.

In the United States, the current FAF uses the Standard Transportation Commodity Code (STCC) system, which has evolved since the 1960s and is used primarily for analyses involving the railroad industry. The Standard Classification of Transported Goods (SCTG), which was developed in the 1990s by the statistics agencies in the United States and Canada to provide better detail of commodities not typically carried by rail and to provide better comparability with the Harmonized System (HS) used worldwide for international trade.

## STCC

*General information:* The STCC system was developed in the 1960's as a unique comprehensive commodity classification system. The system was designed to be used in the collection, presentation, and analysis of commodity data associated with the first Census of Transportation in 1963, which was designed to measure the economic health of the U.S. transportation systems, allowing detailed comparisons between rail traffic and the total transportation pattern by industry and commodity. Recognizing the need for a commodity code to facilitate such comparisons, the Board of Directors of the Association of American Railroads (AAR) authorized the formation of a Special Commodity Code Committee to investigate such a development.

Currently, the STCC is maintained and published by the AAR. The code has been updated by AAR over the years to meet the needs of its users, particularly the North American Freight Railroads. The annual Railroad Waybill data, 1993 Commodity Flow Survey (CFS), and the first generation of the FAF all used the STCC coding system.

By design, the STCC has excellent detail for commodities carried by railroads. Under the STCC system, hazardous materials as well as waste that are hazardous can also be readily identified.

*Structure of the Coding System:* The hierarchical STCC structure allows data collapsibility. This feature enables the summarization of meaningful commodity information at various levels. Although data on the Surface Transportation Board (STB) Carload Waybill Sample is at the 7-digit STCC level, the STB Public-Use Waybill data is only available in the 5-digit STCC. A summary of the various 5-digit STCC levels is presented in Table 4.

The first two digits of the STCC cover the major industry groups in the product class code.

The third digit of STCC denotes the minor industry categories within the major industry groups.

The fourth digit identifies specific industries within the minor industry categories.

The fifth digit of STCC provides product classes within these specific industries.

The last two digits of the STCC were added by AAR to provide railroad-specific commodity identification.

Table 4 Level of Classifications in STCC (5-digit)

| Level | No. of Categories | Grouping (example) |
|---|---|---|
| 2-digit | 37 | Major industry classes (01 - Farm Products) |
| 3-digit | 182 | Minor industry classes (012 - Fresh Fruits or Tree Nuts) |
| 4-digit | 444 | Specific industries (0121 - Citrus Fruits) |
| 5-digit | 1,202 | Product classes (01214 - Oranges) |

*SCTG*

The structure of the SCTG is hierarchical, consisting of four levels that contain groupings based on HS or SCG "building blocks". These groupings are designed to create statistically significant transportation categories. The SCTG follows the classification principles that each level covers the universe of transported goods, and that each category in each level is mutually exclusive. These levels range from a minimum of 42 categories to a maximum of 512 categories.

*Table 5 The SCTG structure and instruction*

| Hierarchy Level | Categories Number | Target Users | Information Provided | Remarks |
| --- | --- | --- | --- | --- |
| First (2 digits) | 42 | overview of groupings | Analytical overview | |
| Second (3 digits) | 137 | Canada-U.S. comparisons; compensate the lack of international agreement on useful sub-headings of HS 27.10 | US-Canadian product groups | group non-food waste products (SCTG 41); refined petroleum &coal products (SCTGs 17-19) |
| Third (4 digits) | 291 | reflect industry patterns and transportation characteristics not provided for in HS | Transportation characteristics | SCG-based categories |
| Fourth (5 digits) | 512 | capture significant data reflecting industry patterns and transportation characteristics | CFS collection level 2002 | |

By design, SCTG classification made the transportation data from the U.S. and Canada comparable. Furthermore, the HS-based SCTG coding also allows other international comparisons (i.e., imports and exports). As a result, SCTG creates an integrated commodity classification system that is useful for economic analysis, including production, shipments, and international trades.

Although the blend of the criteria used to create the SCTG resulted in four different levels of categories, many of the categories are identical at more than one level. One grouping--"Pharmaceutical Products" (SCTG 21)--is even identical at all four levels. In this case, four different criteria coincide at each level. The most-detailed, or collection, level corresponds to an industry-of-origin grouping, which is identical to an HS category that, in turn, is identified as an analytically useful product description.

The SCTG does not identify specific categories of products as being hazardous. It does not include any special groupings in its categories under the title of “hazardous.” This is a limitation by design, because SCTG is a HS-based coding system and the HS does not include the degree of hazardousness as a classification criterion.

### 3.3 Canada

#### 3.3.1 General review

Currently, Canadian transportation data are compiled according to three different classifications. The Standard Commodity Classification (SCC), which is the former Statistics Canada commodity standard, continues to be used for rail and truck data, whereas marine data for several years have been based on the Standard Classification of Goods (the SCG, which is Canada's extension of the HS (Harmonize System)).

Table 6 The current classification standards in Canada

| | Standard | Group method | Collection department |
| --- | --- | --- | --- |
| | SCC | SCC | Statistics Canada |
| | SCC | STCC convert to SCC | ARR(association of American Railroads) |
| | SCG(HS extension) | shipping documents grouped into hundred categories | Statistics Canada |

In addition, rail and truck data are not grouped in the same way, because truck data are based directly on the SCC, whereas rail data are obtained by converting to the SCC the Standard Transportation Commodity Code (STCC) of the Association of American Railroads (AAR). Truck data and most marine data are collected by Statistics Canada according to the detail provided on shipping documents and grouped into a few hundred categories. In contrast, Statistics Canada receives only aggregated rail data.

#### 3.3.2 SCTG in Canada

It is likely that Canada will only use a selection of four-digit SCTG categories, because of confidentiality, insignificant data, or data-reliability issues. For multimodal Canadian data, only some of the five-digit categories will be used, because many of these categories will yield only insignificant data. For data relating to single modes, however, more of the five-digit categories will be useful, in Canada, which is not a collection level, but the first possible level of aggregation of the micro detail obtained from shipping documents for marine and truck transport.

The SCTG is defined by HS or SCG codes only at the three-, four-, and five-digit levels, for presentation purposes. Many of the 42 categories at the two-digit analytical level would be defined by only one or a few codes. Others, however, would require extensive lists of codes, which are not as useful in defining the contents of these less-detailed categories as they are for the more-detailed distinctions.

For Canadian use only, the SCTG includes an additional category (42), which is subdivided into 4 three-digit categories that are further disaggregated into 16 categories. The first of the three-digit categories relates to mail and parcels. The contents of parcels cannot be identified, nor can the contents of mail other than items such as advertising flyers.

For rail data, the aim will be to continue to receive data obtained from the detailed STCC categories, but aggregated according to the SCTG. The richness of detail at this five-digit level is sufficient to accommodate those situations where a Canadian product is relatively more important to Canada than it is to the U.S., particularly where it is difficult to track shipments from one country to the other.

### 3.4 Comparison between current classification rules

#### 3.4.1 Comparison between CCTC and HS

Show as Table 7, some sections in the Classification and Code of Transport Cargo (CCTC) are concluded in the same section in HS, while some are not exist in HS. Space limited the details about the corresponding relations between the sub-subclass could not be shown in the paper, but we can show the result of it.

Table 7 The correspondent class of CCTC sections in the HS

| Section | | Section | Sub-section notes |
|---|---|---|---|
| 01 | Coal | V | 0527 |
| 02 | Oil, gas and products thereof | V | 0527 |
| 03 | Ore mineral | V | 0526 |
| 04 | Steel, iron | XV | 1572 |
| 05 | Mineral building materials | XIII | 1368 |
| 06 | Cement | V | 0525 |
| 07 | Wood | IX | 0944 |
| 08 | Non-mineral ore | V | (0525) |
| 09 | Fertilizer and pesticide | VI | 0631 |
| 10 | Salt | V | 0525 |
| 11 | Grain | II | 0210/0212 |
| 12 | Machinery and mechanical appliances; parts thereof., electric appliance | XVI/ XVII / XVIII | 1684/1685/1786/1787/1788/1789/1890 |
| 13 | Chemical materials and products thereof | VII | 0740/0739 |
| 14 | Nonferrous metal | - | - |
| 15 | Light industry, medical products | I/II/IV/VIII/X/XI/XII /XIII/ XIV /XVIII/ XX / XXI | 0105/0209/0417/0418/0419/0424/0841/1048/1049 /1152/1153/1154/1264/1368/1370/1369/1471/189 0/1891/2094/2095/2197 |
| 16 | Agriculture, woods, fishery industry | I/II/III/IV/ XI | 0101/0103/0104/0206/0212/0208/0315/0424/1151 /1152/1153/ |
| 17 | Other | XIX | 1993 |

There are three situations of the comparing result:

『1－1』One-to-one correspondence, 29%;

『1－M』One- to-multi correspondence, 18%;

『M－1』multi-to-one correspondence, 47%;

『1－N』Goods in HS deletion in CCTC,6%.

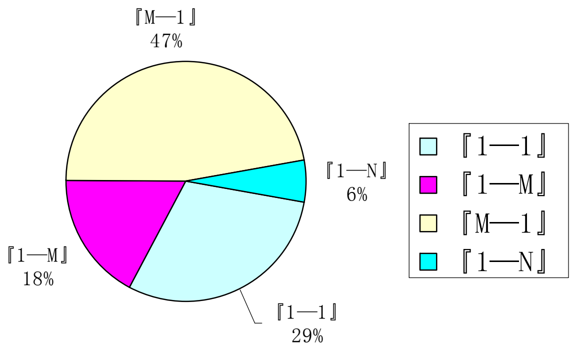


Figure 5. The corresponding relationship between HS and CCTC.

On the other hand, we analyzed the data from HS to CCTC, finding that there are 116 kinds of goods could find the respondent sections in the HS, while only 39 goods could be found in the Chinese classification system, only 40%.of the total in HS.

#### 3.4.1 Comparison between CCTC and STGC

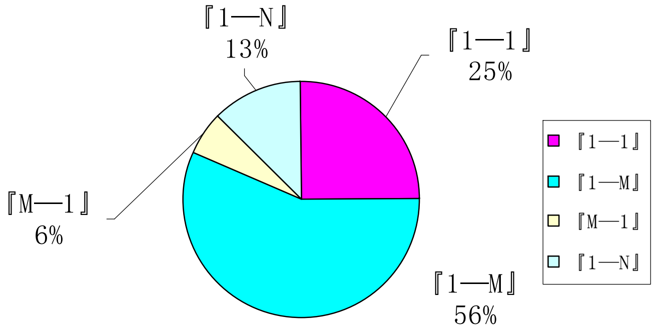


Figure 6. The corresponding relationship between SCTG and CCTC.

The transportation characteristics aimed SCTG is more similar to the new classification goal, the comparison between the SCTG and CCTC is very significant, and the result shows that the latter is quite different from the former with only 25% is one-to-one correspondent. Although the really situation in US and Canada differ a lot from that in China, but the with the development and freight structure changing in China the classification should change with it towards the same direction, which is similar with the SCTG, but surly not the same.

## 4. The Improved Standard

### 4.1 Classification Principle and Method

*4.1.1 Principle*

To establish the improved classification, we firstly set up several principles, strictly based on which the classification has been carried out:

- *Fully considered the current classification;*
- *Cooperated with the international standards, such as HS;*
- *Reflect the transportation characteristics of goods;*
- *Easy for statistics and combine;*

#### 4.1.2 Method

*Method*

Therefore now we need a newly establish classification not only harmony with the international rules, but also keep pace with the development in China, which benefit not only the business but also the government and the experts in related fields.

On the other hand, if the new classification too different from the former one, it would be hard to be accepted by the nation, herein, we should take the old one into consideration as well during we carry out the new one.

First, we compared the current one with those in USA, Canada and HS.

Second, with the statistic data of 10 cities in china, we carry out the classification calculation, so we applied the method of fuzzy logic to get a new one.

Then we check out the calculation result to give the final classification

Comparison also has been done between the new one and former one together with HS and in USA, Canada.

Last not least, we discussed the practical of the classification in the end.

*Difficulties in Creating Data-Significant Categories*

Data significance was used to select appropriate categories for TGCS, starting with the most aggregative categories and working down to the most detailed categories, according to the criteria of significance established for each of the four levels.

In developing the TGCS it was difficult to make reliable judgements about the significance of possible HS- or CCTC -based categories, for several reasons.

Firstly, there no detailed data about all kinds of goods in transportation, and most-current data were collected according to the CCTC and only the most-aggregative-level data (17 categories).

Secondly, these data could only be linked to HS categories through the use of a concordance developed by the China Customs import categories, and the quality of this concordance had not been determined.

Finally, taking into account all of the relevant classifications involved in developing the TGCS, there was an enormous amount of detail to contend with. Despite all these challenges, the TGCS should provide much better data than is currently available

4.2 Classification result

*4.2.1 Category Descriptions*

In order to achieve consistency, a number of procedures were established:

HS (harmonize System) terminology is used, unless it was deemed necessary to adjust it to reflect China usage.

Two types of identification are used for residual categories.

"Other..." is used in the title of residual categories whose content is defined by the immediately higher-level category minus specified categories. Categories beginning with "other" can be found at the 3- or 4-digit levels and are identified by codes ending in "9".

"N.e.c." is used in the title of residual categories that contain products, some of which are identified elsewhere, appear only at the 2-digit level.

"P.tho." is used when there are products of the categories.

"Including... " followed by a list of examples is used extensively in the description of 4-digit categories only.

"Except..." is used to identify those products that could be considered to be part of a particular category but not included in the category, which used at all levels, but mostly at the 3- or 4-digit levels.

4.2.1 Classification result

The new classification we call it Transportation Goods Classification Standard (TGCS), arranged in the order of transport condition from easy to strict, falls into three hierarchies:

According to the natural features of goods, divided into two classes: common, special;

According to the transportation features of goods, divided into 16 classes;

With the trade field convention, falls into 197 sub-subclasses same as CCTC.

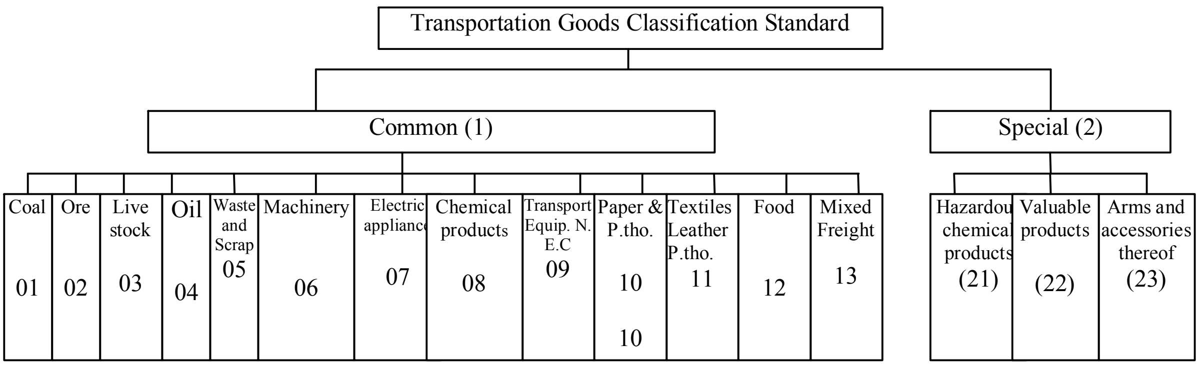


Figure 7. The new established classification hierarchy of TGCS

4.3 Improved Classification Related Analysis

4.3.1 Important issues

*According to Transportation Characteristics*

The combination of the HS and SCTG provides many thousands of categories to use as building blocks in the development of a standard classification of transported goods.

The creation of TGCS categories was done by analyzing the transportation characteristics of goods in the CCTC and selecting some from the structure of the HS or SCG (i.e., by using HS or SCG categories), or by grouping HS or CCTC categories to form more significant categories. That fully considered the transportation characteristics of most goods.

*Difficulties solved during designing TGCS*

The "non-metallic ore" and "non-ferrous metal" are categories existed only in CCTC; we change the categories and combine them into other sections which have the similar feature and transportation characteristics.

"Agriculture products" and "grain" has some parts in common; in the new classification these two sections have been regrouped.

"Parts" are difficult to categorize, and it is difficult to distinguish between parts and accessories. In such cases, we use HS as a basis to define these parts as separate pieces of equipment in their own right, however, it is the respondents that ultimately have to be relied on to appropriately identify parts.

"Log", "cotton" and "Parts" are included in a relatively generalized categries, instead of as a independent category.

How to deal with "container" is another difficulty we faced, whether it's a kind of goods or transport tools hasn't been mentioned yet in other classification.

*Data Continuity*

Since the improved classification has fully considered the former version of CCTC, the data collection, especially the details changed little, which brings no much trouble for the statistic department. But still there are some changes should be paid attention to, such as the "non-metallic ore", "grain" et al.

On the other hand, data of different transport modes could be linked together since the former classification has been applied universally; even the marine has already set up the concordance of CCTC to China Customs regulations.

*Weakness*

Due to the limitations of time, finance and other unavoidable reasons, the improved classification could not start based on a totally new data base, but have to fully make use of the current data to get a better standard which are more suitable for the present situation and future development of China. Therefore, the relationship to Industries-of-Origin is not fully considered yet in this category due to the lack of detail data.

### 4.3.2 Implementation and Possible Future of TGCS

As the foundation of all the statistic and research work, classification standard is very important, the change to which may bring a lot of troubles if the newly promoted one were not appropriate, therefore the classification we recommended here should be testified in some part of the county to see whether it's proper or not.

Anyway the new one has done a lot of improvement compared with the last one, there for it is hoped that this classification will prove useful for a variety of transportation applications and will be adopted by those who find it useful for collection and analysis of transportation data.

## 5. Conclusion

With high speed economy development in China, there's an urgent need of a high efficiency goods transportation system. International logistics is a significant part of the whole logistics system, especially after China entering WTO, hereby, standardization turns to be one of the most important issues. The consistency of different transport modes data are of significant importance to the business's trade, government's statistics and researcher's study.

All in all, the paper presents an improved classification on transportation goods which considered the actual situation at different time stage and the transportation features of goods to meet the needs of international trade and research on logistics prediction. It'll be greatly adheres to the cities of China in future research to give more sound proof to demonstrate that the catalog is practical and reasonable.

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# A PROPOSED MODEL TO MEASURE SERVICE QUALITY IN PASSENGER TRANSPORTATION

Nihan Çetin Demirel[1], G.Nilay Serbest[2], and Nezir Aydın[3]

## Abstract

*With improvement of the customer based management approaches, providing the service, which meets customers' needs and wants with the minimum price and on the right time, has become more important in the last decade. This reason makes the business world quite arduous and hard. The firms have to be more successful and more powerful than their competitors and also they have to be well-prepared to the changeable conditions in a business environment.*

*Passenger transportation sector has very changeable conditions, because sector's main structure is built on a human and also human's needs and wants are always changing. Essentially, all transportation firms have to know that the key factor of building passenger satisfaction and loyalty is to provide high service quality.*

*In this paper, we proposed a model which measures service quality in passenger transportation. Our study both synthesizes and builds on the efforts to conceptualize the effects of service quality, service value and customer satisfaction on customer loyalty.*

*Key Words: Transportation, service quality, satisfaction, sacrifice, value, loyalty, airline service.*

## 1. Introduction

It has been suggested that delivering superior service quality is a prerequisite for success and survival in today's competitive business environment (Gilbert, & Wong, 2003:519). Especially, in logistics and passenger transportation sectors all transportation firms have to know that the key factor of making their passengers' happy is to provide high service quality. By this means, firms can compete with their competitors.

The rapid growth in passenger traffic has been experienced in the deregulated domestic commercial airline market worldwide. Competition is ever increasing as airlines try to acquire and retain customers. Price is initially used as the primary competitive weapon. However, airlines soon realise that competition on price alone represents a no-win situation in the long term. This is mainly due to the fact that airlines are relatively efficient in responding to competitors' price changes. In addition, the regulators of the airline system may interfere in the price competition as it often results in declined service quality and may affect flight safety. This implies that airlines' competitive advantages based on price alone are not sustainable. In a highly competitive environment, where all airlines have comparable fares and matching frequent flyer programs airline's competitive advantages lie in the service quality perceived by customers (Chang & Yeh, 2002: 166).

In this paper, we proposed a model which measures service quality in passenger transportation. Our study both synthesizes and builds on the efforts to conceptualize the effects of service quality, service value and customer satisfaction on customers' behavioral intentions.

## 2. Passenger Transportation

Airline service is a chain of services in which the entire service delivery is divided into a series of processes. Passengers' expectations of service quality may vary at different stages in the service process. Considering the nature of air transport, air travel is broken into two stages: ground services and in-flight services. Ground services include information gathering, reservations and ticket purchases, airport check-in, and post-flight service. Passengers' attitudes toward service quality at the ground and in-flight service stages were investigated separately (Chen, & Chang, 2005: 79).

In airline services the safety is as iportant as service quality for passengers. Perhaps the difficulty in quantifying "management attitude" provides the link between service and safety quality. Studies of Total Quality Management and ISO 9000 quality programs consistently cite the presence of a "quality culture" and top management support as critical to the success of any quality program (Rhoades, & Waguespack, 2000: 90). Research into airline safety has focused on four areas of concern: financial stability, maintenance quality, pilot competence, and management attitude (Rhoades, & Waguespack, 2000: 89).

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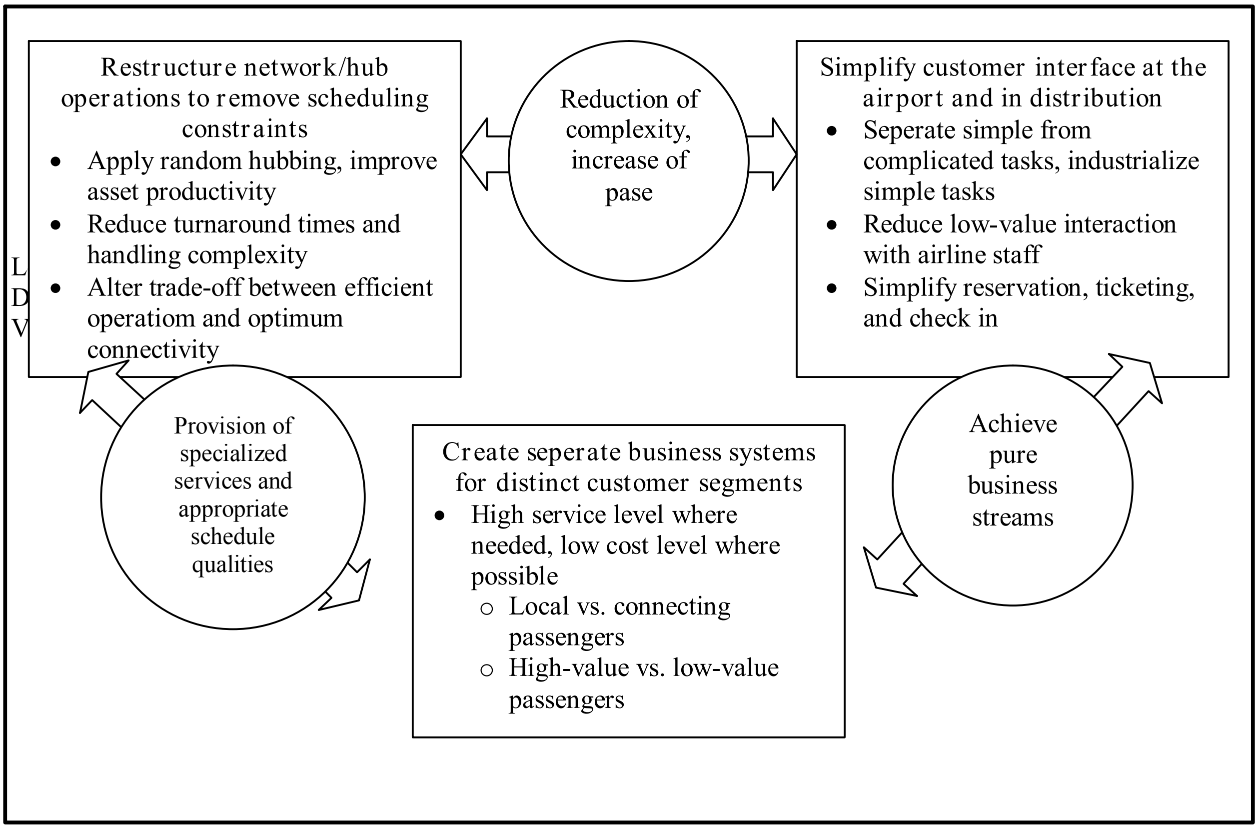


Figure 1. Three Cornerstones of New Airline Business Models (Franke, 2004: 20)

## 3. Theoretical Background

In the passenger airline industry, only the customer can truly define service quality. The quality of airline service is difficult to describe and measure due to its heterogeneity, intangibility and inseparability (Chang & Yeh, 2002: 167).

The relationship between customer service quality and passenger demand is a critical issue for air carriers, because it enables airline managers to make strategic decisions on the level of service and related resources needed to achieve market share targets (Suzuki, Tyworth, & Novack, 2001: 773).

A number of studies have addressed service quality issues in the airline industry. On-time performance, baggage handling, food quality, seat comfort, check-in service, and in-flight service were used as the criteria for evaluating airline service quality (Chen, & Chang, 2005: 80).

In this paper, there is a proposed model which aims to measure service quality, sacrifice, service value, customer satisfaction, customer loyalty, and also in this paper demostrates the relationships between these five variables.

### 3.1 Service Quality

Service quality has been perhaps the most explored topic in services marketing. Past research has linked service quality to a firm's performance, customer satisfaction and purchase intention (Choi, Cho, Lee, Lee, & Kim, 2004: 914).

Service quality can be regarded as a composite of various attributes. It not only consists of tangible attributes, but also intangible/subjective attributes such as safety, comfort, which are difficult to measure accurately. Different individual usually has wide range of perceptions toward quality service, depending on their preference structures and roles in process (service providers/receivers). To measure service quality, conventional measurement tools are devised on cardinal or ordinal scales. Most of the criticism about scale based on measurement is that scores do not necessarily represent user preference. This is because respondents have to internally convert preference to scores and the conversion may introduce distortion of the preference being captured (Tsaur, Chang, & Yen, 2002: 107).

Perceived quality is an eminently cognitive construct, which values the result, where expectations are compared to the result. Perceived value, on the other hand, is an evaluation in which benefits and sacrifices are compared, and also influenced by emotions. For this reason scales for measuring perceived quality (SERVQUAL) or performance (SERVPERF) must be completed with sacrifices and with affective responses in order to measure perceived value (Sa´nchez, Callarisa, Rodrı´guez, & Moliner, 2004: 4).

Service quality is a widely studied, and debated, construct. The weight of the evidence in the extant literature supports the use of performance perceptions in measures of service quality (Cronin, Brady, & Hult, 2000: 203).

On the other hand, SERVQUAL provides theoretical grounding for the relationship between service quality and customer satisfaction. “Service quality has been described as a form of attitude, related but not equivalent to satisfaction, that results from the comparison of expectations with performance”. Initially, 10 determinants of service quality were identified based on focus group interviews. Later these 10 determinants were reduced into five specific dimensions: tangibles, reliability, responsiveness, assurance and empathy by performing factor analysis on the 22-item instrument developed from the focus group interviews. On the other hand, customer satisfaction is the customer’s fulfilment response. It is a judgement that a service feature, or service itself, provides a pleasurable level of consumption-related fulfilment (Lai, 2004: 354).

Since its introduction in 1988, the dominant operationalisation of service quality has been the SERVQUAL model developed by Parasuraman Zeithaml and Berry (1988). The relationship of perceptions and expectations are investigated by SERVQUAL, which originally consists of 2 sections: a 22-item section to measure customer service expectations of companies, within a specific sector and a corresponding 22-item section to measure customer’s perceptions of a particular company in that sector. While customers’ expectations are determined by the personal needs of the customer, the customer’s past experience with the service providers, word-of-mouth communications and external communications

(from the service provider and others), customer perceptions of service quality are determined by the actual service performed. Service quality is therefore represented as the difference between customer perceptions and expectations of service. In short, SERVQUAL is conceptualised as a “perceptions-minus-expectations” service quality measurement framework (Lai, 2004: 355).

Airline service quality is often evaluated using the airline quality rating (AQR). The four components of the AQR are on-time performance, denied boardings, mishandled baggage, and customer complaints (Coy, 2005: 219).

### 3.2 Service Value

Marketers are constantly challenged to increase the value of their product/service by improving the product/service benefits, reducing costs through productivity or both. Superior value of a product/service represents a significant competitive advantage for the firm in building profits and customer satisfaction (Choi, Cho, Lee, Lee, & Kim, 2004: 915).

There have been several literatures measuring the relationships between perceived value and customer satisfaction. Customer’s perception of value has been defined as: “(1) value is low price, (2) value is whatever I want in a product, (3) value is the quality I get for the price I pay, and (4) value is what I get for what I give”. Zeithaml (1988) further captures the essence of the four expressions into a general definition: “perceived value is the customer’s overall assessment of the utility of a product based on perceptions of what is received and what is given” (Lai, 2004: 355).

The term value is used in many different contexts in marketing. One perspective in organizational strategy maintains that creating and delivering superior customer value to high-value customers will increase the value of an organization. High-value customers have their monetary worth as individual customers to the organization quantified, whereas value of an organization quantifies the worth to its owners (stakeholders). On the other hand, customer value takes the perspective of an organization’s customers, “considering what they want and believe that they can get from buying and using a seller’s product” (Spiteri, & Dion, 2004: 678).

### 3.3 Sacrifice

Customer value is related not only to what customers can get, but also to what they have to give up; in otherwords, customer perceived sacrifice. For example, some researchers identify the key drivers of customer perceived value and clarifies sacrifice as one of the two key factors (the other is benefits). Sacrifice refers to what is given up or sacrificed to acquire a product or service. However, not only is price considered an element of sacrifice, but other non-monetary factors are also believed to be closely related to sacrifice. In fact, many customers count time rather than dollar cost as their most precious asset. Therefore, generally speaking, it is clear that there are two broad kinds of sacrifice: monetary costs and non-monetary costs. The former can be assessed by a direct measure of the dollar price of the service or product and the latter can be defined as the time, effort, energy, distance and conflict invested by customers to obtain products or services or to establish a relationship with a supplier (Wang, Lo, & Yang, 2004: 329).

Sacrifice is defined as what is given up or sacrificed to acquire a service. The measurement of the sacrifice construct is consistent with the multidimensional conceptualization advanced in the literature. Specifically, items that represent customers’ perceptions of the monetary and the non-monetary price associated with the acquisition and use of a service can be used as indicators of the sacrifice construct (Cronin, Brady, & Hult, 2000: 201).

### 3.4 Customer Satisfaction

Customer satisfaction is fundamental to the practice of customer sovereignty (Choi, Cho, Lee, Lee, & Kim, 2004: 914).

Because of its potential influence on customer behavioral intentions and customer retention, customer satisfaction has been the subject of much attention in the literature. Satisfaction is described as “an evaluation of an emotion”, suggesting that it reflects the degree to which a customer believes that the possession and/or use of a service evokes positive feelings (Cronin, Brady, & Hult, 2000: 204).

Satisfaction is a customer's post-purchase evaluation and affective response to the overall product or service experience. It is considered a strong predictor for behavioral variables such as repurchase intentions, word-of-mouth recommendations, or loyalty (Lin, & Wang, 2005: 3).

High customer satisfaction leads to greater customer loyalty, which, in turn, leads to future revenue. This set of relationships has been termed the "service profit chain". Increased customer satisfaction leads to decreased customer complaints and increased customer loyalty. Investors are attracted to companies that excel at satisfying their customers. It is not possible to increase business prosperity without increasing customer satisfaction. It is not the amount of goods and services a company can produce that leads to its success as much as how well it satisfies its customers so they will return and keep the business growing. The quality of what is produced is tied not only to a business, but to the viability of its industry and national standard of living. It should be measured systematically and uniformly. Customer satisfaction is a great complement to other, more traditional measures of economic viability such as a growing stock market, corporate earnings growth, trade deficit, customer and business debt, unemployment, and gross domestic product. As satisfied loyal customers, their continued patronage is assured on a global basis (Gilbert, Veloutsou, Goode, & Moutinho, 2004: 371).

Because of the important linkages between customer service quality, customer satisfaction and long-term business success, considerable effort has been made to develop measures of them and their relationships. Of particular note is the creation of the American Customer Satisfaction Index (ACSI) and the European Customer Service Index (ECSI). These two customer satisfaction indices (CSIs) function as intangible economic indicators used to monitor the financial viability of companies, industries, and international trade unions. Today, the ACSI conducts annual analyses of customer service quality in 35 separate industries, 190 companies, and government agencies. It has been reported to meet rigorous standards of precision, validity, reliability and predictive power with regard to financial returns. As the CSIs become more uniformly established across international economies, a global network of CSIs will likely be created from which organizations and industries can be compared across borders. The predictive models of the ACSI and ECSI comprise prior customer expectations, perceived quality based on the customers' post service assessments, and the customers' perceived value (product versus price) which lead to the creation of a customer satisfaction index (CSI) score ranging from 0-100. The post service assessments are completed by telephone based on the customers' ratings on three criteria: overall quality, reliability, and meeting the customers' needs. The national CSIs measure the quality of goods and services as experienced by those who consume them. An individual firm's CSI represents its served market's (i.e. customers) overall evaluation of the total purchase and consumption experience, both actual and anticipated. The measurement of customer satisfaction varies, depending on the assumptions made as to what satisfaction means. There are several theories that merit review in this regard. In general, it is agreed that customer satisfaction measurement is a post-consumption assessment by the user about the product or service gained. Also, there is a general agreement that the closer the assessment is to the actual service encounter, the more accurate the assessment of the service quality itself (Gilbert, Veloutsou, Goode, & Moutinho, 2004: 372).

The ACSI (American Customer Satisfaction Index) model in Fornell et al.'s (1996) study demonstrated that "customer satisfaction is more quality-driven than value-driven or price-driven"; nevertheless, perceived value also affects customer satisfaction. Later, Cronin et al. (2000) reinforced this by showing that perceived value is a "significant predictor of satisfaction" (Lai, 2004: 355).

### 3.5 Customer Loyalty

The concepts of quality, brand and/or company equity, customer satisfaction, and customer value are interrelated. Customer satisfaction is one of the most important criteria for customer loyalty. Several studies discuss and/or observe a strong link between customer satisfaction and loyalty. Some researchers discuss why increasing customer loyalty should lead to higher profitability. However, recent studies have demonstrated mixed results in analyzing the relationship between satisfaction and loyalty. These studies suggest that satisfied customers may not be sufficient to create loyal customers (Spiteri, & Dion, 2004: 679).

Brand loyalty is defined as "a deeply held commitment to re-buy or re-patronize a preferred product/service consistently in the future, thereby causing repetitive same-brand or same brand-set purchasing, despite situational influences and marketing efforts having the potential to cause switching behavior". This emphasizes the two different aspects of loyalty described in prior studies-behavioral and attitudinal. Some researchers suggested that behavioral, or purchase, loyalty consisted of repeated purchases of the brand, whereas attitudinal loyalty included a degree of dispositional commitment, in terms of some unique value associated with the brand. Thus, customer loyalty here was considered bidimensional, including both attitudinal commitment and behavioral re-purchase intention. Based on prior studies, customer loyalty was defined as the customer's favorable attitude toward an m-commerce website, resulting in repeat purchasing behavior (Lin, & Wang, 2005: 2).

## 4. A Proposed Model

Service quality can be defined as a customer's overall impression of the relative efficiency of the organization and its services. Customer satisfaction can be defined as a judgement made on the basis of a specific service encounter (Park, Robertson, & Wu, 2004: 435).

In reviewing the lessons learned over the last decade from service quality research there is a strong indication that improvement in service provides improved profit due to increasing the customer base through new and repeat purchases from more loyal customers. In addition the previous sstudies, it is realized lowering customer defection rate can be profitable to airlines (Gilbert, & Wong, 2003: 519).

To improve our understanding of air passengers' decision-making processes, a model that considers service quality with expectation and perception, sacrifice, service value, passenger satisfaction, and passenger loyalty simultaneously is established. The conceptual model (Fig. 2) is based on five variables such as service quality, sacrifice, service value, customer satisfaction, and customer loyalty.

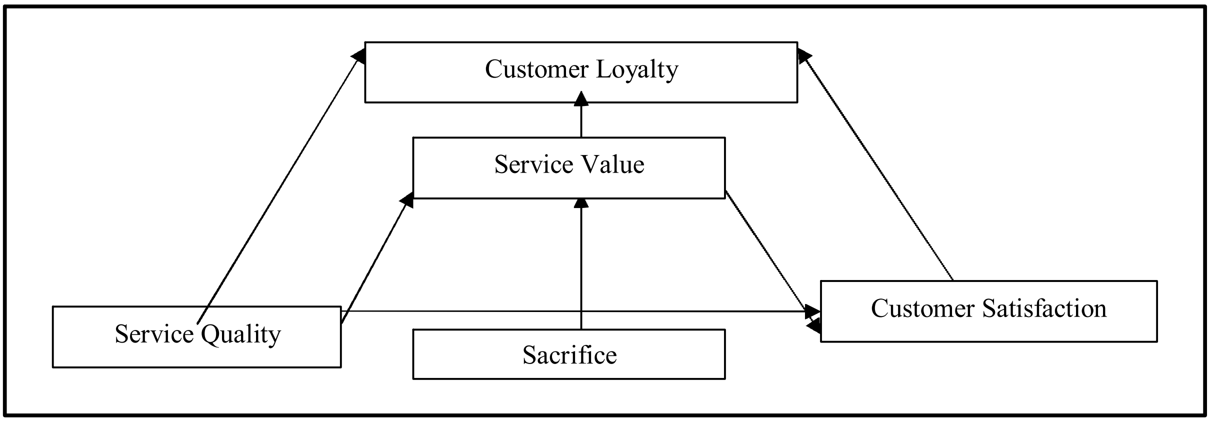


Figure 2. A Proposed Conceptual Model

4.1 Hypotheses

For this conceptual model we can develop seven different hypotheses.

The service customer compares the quality of the services received to the sacrifice required to obtain said service. Service quality is defined as the relative excellence or superiority of a service offering obtain service. Thus, service value is defined as a tradeoff between sacrifice and service quality (Brady, Robertson, & Cronin, 2001: 132). This leads to the first two hypotheses:

H1 Sacrifice has a direct effect on service value.

H2 Service quality has a direct effect on service value.

The cognitively oriented service quality and service value evaluations lead to the emotive satisfaction assessment. This maintains the cognitive-emotive causal order and suggests that service quality and service value vie for explanatory variance in the satisfaction judgment. This also reflects the findings reported in the literature as to the relationship between value and satisfaction (Brady, Robertson, & Cronin, 2001: 133). This leads our third and fourth hypotheses:

H3 Service quality has a direct effect on customer satisfaction.

H4 Service value has a direct effect on customer satisfaction.

In the quality–value–satisfaction–loyalty chain that emerged from literature review service value is an effective factor on customer loyalty. The relationship between service value and customer loyalty is represented as the fifth hypothesis:

H5 Service value has a direct effect on customer loyalty.

Specifically, the question is whether service quality perceptions have a significant indirect influence on customer loyalty through value attributions and customer satisfaction. In addition, the indirect effect of service value assessments on customers' customer loyalty through their influence on customer satisfaction should be of similar interest and also service quality has a direct effect on customer loyalty. This direct relationship is represented as the sixth hypothesis:

H6 Service quality has a direct effect on customer loyalty.

Because of the literature rewiev customer satisfaction has a positive effect effect on customer loyalty, that's why our seventh hypothesis is about customer satisfaction and customer loyalty. We are going to analyze that if customer satisfaction has a direct effect on customer loyalty:

H7 Customer satisfaction has a direct effect on customer loyalty.

For assessment of our model in future research we can use questionnaires which includes five section about our variables (service quality, sacrifice, service value, customer satisfaction, and cusotmer loyalty). On the other hand, for evaluation of the model reliability we can use LISREL packet programme. This programme is used for structural equation models. In structural equation models, we can analyze how the data fits to our model and also we can analyze the relationships between the variables.

In future research, the researcher can add the demographic features of the respondents to their model as a sixth variable.

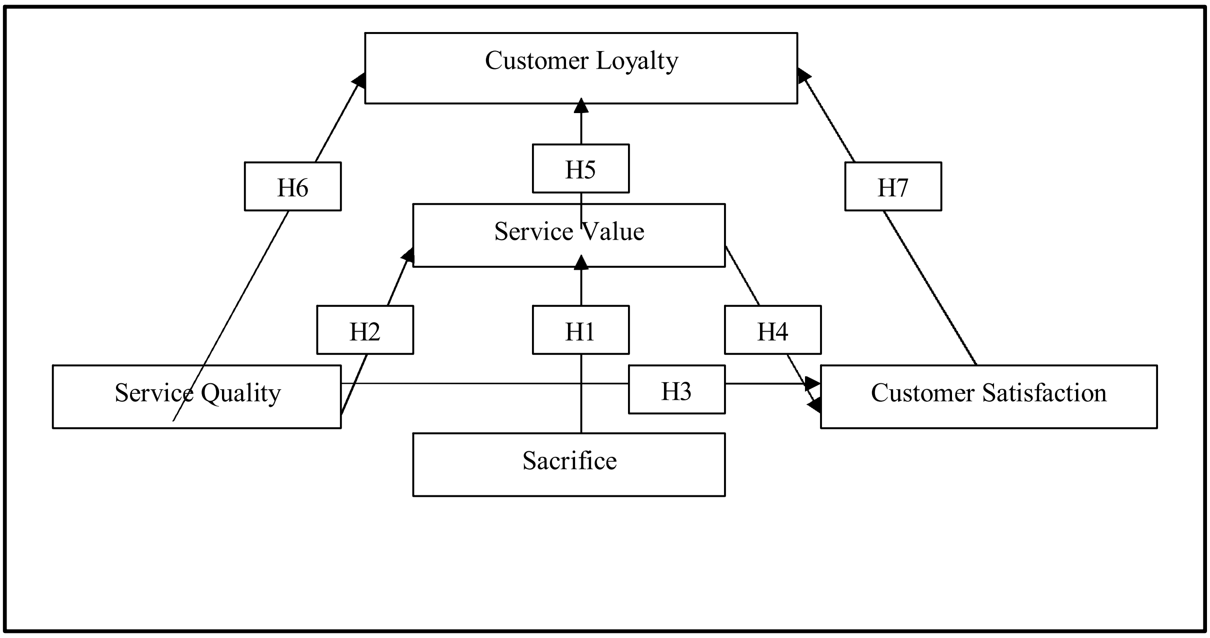


Figure 3. The Hypotheses of Relationships between Model Variables

## 5. Conclusion

To help airlines better understand how the customer views their services relative to their competitors, a customer-driven evaluation approach's model of service quality has been presented.

Airlines should recognize what their target customers want in order to maximize customer satisfaction. Factors that matter most to passengers are the type of services offered between their origin and the destination, time involved in making the trip, value of the service, and baggage concerns (Gursoy, Chen, & Kim, 2005: 64).

Concerning the quality–value–satisfaction–loyalty chain (inter-variable approach), the study indicates a clear pattern: quality is an antecedent of service value, passenger satisfaction, and customer loyalty is the behavioural consequence of service value, customer loyalty attitude being the final outcome.

In conclusion, we proposed a model which measures service quality in passenger transportation. Our study both synthesizes and builds on the efforts to conceptualize the effects of service quality, service value and customer satisfaction on customers' behavioral intentions.

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# IMPLEMENTATION FACTORS EVALUATION FOR SUCCESS OF DATA WAREHOUSING

Bersam Bolat[1] and Cenker Çakın[2]

## Abstract

*Data warehousing are being implemented due to the business need for tools within companies today to analyze the increasing amounts of data being collected and it helps companies gain competitive advantages in supply chain environment. The success of warehousing projects is getting have more and more importance in this manner. The study aims to determine whether there exists measurable relationship between the implementation factors and the success criteria of data warehousing through multiple regression analysis. In this pursuit, necessary data was gathered through a field survey of the people who are responsible for an application that uses data from the warehouse in Turkish companies. As a result of the analyses, "Project Implementation Plan (PIP)" has the highest score as an implementation factor and also it has an explanatory effect on Overall Success alone.*

Keywords: Data Warehousing, Implementation Factors, Success Criteria, Multiple Regression Analysis, Turkey.

## 1. Introduction

In today's competitive business environment companies should improve customer responsiveness, customer satisfaction, and increase flexibility for rapidly changing market trends. In order to get success in such an environment, either manufacturing or service organizations have to manage their supply chain effectively with new strategic tools. Effective supply chain management requires integration, optimization and collaboration among all participants in the value chain. The firms cannot optimize their operations unless do not understand changing needs of participants of supply chain. However, collaboration and information sharing in supply chain demand new technological infrastructure that can store and release large quantities of data from many sources. This kind of storage enables decision makers to make fast and accurate decisions.

In the mid-to-late 1990s, organizations around the world invested the new enterprise technologies such an Enterprise Resources Planning (ERP), Supply Chain Management (SCM) and Customer Relationship Management (CRM) to provide an excellence in their supply chain capabilities. However, it has been quickly realized that such technologies inappropriate to prepare and analyze the data especially for long-term planning and decision making. Moreover, some research and practices have proposed an approach that merges their ERP and Data Warehousing (DW) projects implementations. Thus, the ERP systems or SCM systems become much more interesting as DW capabilities are added (Zeng et al., 2003; Sammon and Adam, 2005). Together, DW have been implemented due to the business need for tools within companies today to analyze the increasing amounts of data being collected from different sources. According to the research of Gartner Inc., organizations will be confronted with the challenges of managing over 30 times more data by 2005 to meet the demands associated with electronic business and supply chain applications (Payton and Zahay, 2005). DW around the world is used for many purposes including CRM, performance management, risk management, resource allocation, connecting suppliers and customers along the supply chain, e-commerce and more (Watson and Swift, 2002). The success of DW projects is getting had more and more importance in this manner and it helps to companies gain competitive advantages in supply chain environment. This study investigates the relationships between implementation factors and success of DW that are being implemented at early adaptation stage in Turkey. In this pursuit, a research model was developed from a literature survey and multiple regression analysis is conducted to examine the relationships.

## 2. An Overview of Data Warehousing

A Data warehouse is a repository into which are placed all data relevant to the management of organization. It emerges from the need of information and knowledge to manage the organizations effectively in supply chains. Information Technologies such as computer-aided design (CAD), computer integrated manufacturing (CAM), electronic data interchange (EDI) and customer relationship management (CRM) can play significant role in both processes of decision support system (DSS) and DW. DW is a method of using the data as strategic and also it is considered as a collection of DSS technologies, aimed at enabling the manager to make better decisions (Chaudhuri and Dayal, 1997). However it is very important to distinguish the DW from DSS. DSS focus on the process labeled Manage on the other hand DW focuses on the labeled information (March and Hevner, 2005).

Although various definitions of DW in the literature are similar, each one has different aspects:

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- DW can be defined as the establishment and maintenance of a large data storage facility containing data on all aspects of an organization (Hwang and Cappel, 2002).
- DW facilitates the aggregation of data from different platforms n one repository and provision of a rapid access to quality information for analysis (Boakye, 1999).
- A DW (or smaller-scale data mart) is a specially prepared repository of data created to support decision making (Vixom and Watson, 2001).
- According to Chaudry and Dayal (1997); a DW is a large, accessible and reliable collection of data used by companies for analytical processing and decision support. This technology encompasses a set of procedures for cleaning, organizing, storing and integrating existing data from multiple sources (Chaudhuri and Dayal, 1997; Friedman and Pliskin, 2002).

A DW project is an expensive and risky undertaking. The typical project costs over $1Million in the first year alone (Wixom and Watson, 2001). In developing countries such as Turkey in the world, technological developments having good returns on investment such as data warehousing doesn't take precedence because of their cost and risk. However, data warehousing is expected to benefit the company enormously. For example, substantial reduction of process overlap alone is enough justification for the multimillion dollar effort. The other benefits of DW are facilitating business process re-engineering at an organization through a single-source data (Shin, 2002). In addition to this, if DW is used aiming at customer-focused; the benefits are many including but not limited to customer loyalty and retention, better marketing and sales coordination and increased organizational efficiency (Nemati and Barko, 2003).

## 3. The Research Framework

In recent years organizations have realized the value of data warehousing and its essential role supporting decision making in strategic supply chain management. Current literature on DW contains many anecdotal successes that are written by practitioners, and also descriptive and conceptual studies (Chaudhuri and Dayal, 1997; Boakye, 1999; Hwang and Cappel, 2002; Watson and Swift, 2002; Tan et al., 2003; March and Hevner, 2005). However, there are few articles investigates the implementations of DW empirically (Wixom and Watson, 2001; Park, 2005; Payton and Zahay, 2005). Many of the variables related to implementation factors and success criteria in the study which are questioned in the second part of the questionnaire have been determined through the review of the literature concerning empirical studies of DW, data-mining and IT projects. The steps followed in the research are in the below:

- Determination of the research objective
- Developing the research model, identifying the variables and producing the regression equation
- Preparing the questionnaire form and modifying the questions by discussing with specialist in DW
- Collecting the data
- Analyzing the data

### 3.1. Implementation Factors of DW Projects

To develop the research model, literature related with implementations factors and success criteria were reviewed firstly. DW is not an application; it is rather an enabler of many current infrastructure projects such as ERP systems. Yet, there are many aspects of it that are similar to application level IT implementations (Wixom and Watson, 2001). In the research model five implementation factors are identified and they are expected have positive effect on DW success. The explanations about the development of the criteria and the related literature search are presented below:

Management Support (MS): Management support is identified as one of the most important factors for success of projects and also many IT implementations (Nemati and Barko, 2003). This support may lead the organization to accept the new technology by means of high motivation (Vixom ve Watson, 2001; Kimball and Ross, 2002). Also, in order to adopt and use DW effectively, top management must have a good understanding of its potential (Watson and Swift, 2002). The first lesson emphasized in the study of Shin (2001) was the vital role of process involvement from business units. Especially, active involvement from business users was viable only when top management was behind the project. Three questions were asked to measure this construct.

Sufficient Resources (SR): In order to get success in DW, the other factor is to supply the resources that used in organization as just at the right time, to the right position and at the right quantity. The resources that mentioned above are; human capital, technological and financial resources (Nemati ve Barko, 2003). Resources are very important to DW projects because DW is an expensive, time consuming and resource-based implementations. Also the time is identified as another important resource used to complete the DW projects successfully (Vixom ve Watson (2002). Six questions relevant with human, financial and technological resources were asked to measure this construct.

IT specialist and end-users skills (ITS-EUS): People are important when implementing a system and can directly affect the system success or failure. The team or staffs who perform all the tasks in a project should have the skill which includes both technical and interpersonal abilities. This mix of skills helps success of DW projects (Vixom and Watson (2002). There are two types of staff in the IT projects as IT specialist and business end-users. It is important that the two types of staff should be worked in coordination especially in a DW project. (Kimball and Ross, 2002). According to Gertosio and Dussauchoy (2004), the client (business user) should have a clear and focused view of the problem. In task discovery, the analyst in IT projects has to spend time with client to be sure of the goal of the IT study. In the case study of Hirji (2001), the key implementation factor was the experience and skills of data mining specialist who also experienced as facilitator. Also training the business end-user well in advance is an implementation key because one can also use this experience to confirm additional patterns that may not have been identified (Solomon, 2005). In the former, business end-users impart domain knowledge the analyst and then wait for the analyses of the data and results. Because of this type of situation is time consuming, today most of business users are expected to analyze the data and present the extracted information (Kohavi et al., 2002). This construct included questions that asked perfection and knowledge of users and IT team and also communication between the team and end-users.

Project Implementation Plan (PIP): Because DW is not a product but a process; establishing measurable and achievable project goal and than planning the stages of a DW project are the very essential management activities. Success will depend on having clear and agreed upon plan and having a formal DW process to implement the plan (Boakye, 1999). The importance of project planning stages, clarifying responsibilities and goal alignment to provide focus and clarity was also emphasized in the study of Hirji (2001). The stages stated by Solomon (2005) may be used while planning the tasks of a DW project. These stages are; 1. Service level agreements, 2. Source system identification, 3.Data quality planning, 4. Designing the data model, 5. Tool selection, 6. Database software and platform selection, 7. Data conversion, 8. Purge and Archive planning. Eight questions were asked relevant with these items.

Information Requirements (IR): Determination of information requirements in DW projects is the one of the essential management task. The system could be unsuccessful technological investment that is aimless and expensive when the DW systems developed based on an incomplete or inconsistent set of information needs such as identification of dominant or targeted users (Winter and Strauch, 2004). The critical information requirements for business decision making and their diverse sources both internal and external present a challenge to development of DW and DSS. Executive information requirements demands significant integration efforts. Joint application design could be used to bring stakeholders together to identify the needs from different business units. In the meetings questions must address the problems, critical success problems, goals and alternatives (March and Hevner 2005). Winter and Strauch (2004) also proposed the different engineering approach that supports the entire process of determining information requirements for DW projects. This approach supports the end-user involvement by using business question for requirements documentation and discussion. This construct was measured with four questions in the questionnaire form by asking if the information requirements of end -user were determined or not.

### 3.2. Data Warehousing Success

Success criteria in this study were extracted from the literature that examines the success of DM and DW projects. Nemati and Barko (2003) used success criteria based on the framework proposed by Atkinson to reveal the factors influencing the success of DM projects. In their studies these criteria were identified as iron triangle (cost, quality and time), information system quality (maintainability, validity, reliability), organizational benefits (profits, efficiency) and the stakeholder benefits (satisfied users, social and environmental impact and personnel development). The DW system success was developed as data quality, system quality and perceived net benefits in the empirical research of Vixom and Watson (2001). Data quality has defined as the accuracy, comprehensiveness, consistency and completeness of data provided by warehouse. In addition to this; flexibility and integration have been shown to be important dimension of system quality. On the other hand, perceived net benefits have been measured as the reduction of time and effort to support decision making (Vixom and Watson, 2001). Also, a successful DW should provide information that enables managers to identify situations requiring action. They must be understandable, adaptable and include experience-based organizational knowledge (March and Hevner, 2005). Thirteen questions were asked in the study in order to measure DW success.

### 3.3. Methodology of the Research

A field study using the survey instrument was considered to be appropriate to obtain the necessary data. A survey instrument based on the concepts extracted from DW and IT literature was used in this study. The resulting instrument was then pre-tested and refined in a series of interviews with pilot participants who are most familiar with the DW project implementation. In the same way, the managers who were involved with existing DW implementation (e.g., information system manager, data-base manager, data-mining experts and DW project leader) and business end-users who were specialized in DW were selected as target respondents for responding to the questions. The survey instrument sent out by surface mail and internet to the target respondents. The target respondents involved the survey were chosen from the companies that have DW implementations and they were determined through the help of vendor contacts, web interest and personal contacts due to lack of complete database contains warehousing companies in Turkey. Data were collected from the respondents that have different tasks at the same company. Out of 43 companies (125 respondents); 23 (41 respondents) usable questionnaires were received and analyzed; indicating a response rate of 53,4 %. In the questionnaire; the respondents were asked to rate the research questions according to a 5-point Likert scale, 1 being strongly disagree and 5 the strongly agree. The variables related to firm characteristics are questioned in the first part of the questionnaire. A SPSS 11.0 for

Windows program is used to process the collected data and descriptive statistical techniques are employed to evaluate it. Arithmetic mean as central tendency measure, standard deviation as dispersion measure, and relative frequencies are utilized. The basic sample characteristics of the firms and the data warehouses that utilized are illustrated in the Table 1.

Table 1. Basic sample characteristics of the companies and the data warehouses

| A. Industry Mix | N | Sample % | B. Employees Range | N | Sample % |
|---|---|---|---|---|---|
| Finance | 4 | 17,4 | 0-500 | 6 | 26,0 |
| Retail | 3 | 13,0 | 500-5000 | 12 | 52,0 |
| Automobile | 3 | 13,0 | > 5000 | 5 | 22,0 |
| Energy | 2 | 8,7 | C. Operational Time of DW | N | Sample % |
| Electrical/electronics/ white durables | 5 | 22,0 | Less than one year | 4 | 17,0 |
| Transportation | 1 | 4,3 | One Year-Five Year | 16 | 70,0 |
| Tourism | 1 | 4,3 | More than five year | 3 | 13,0 |
| Communication | 3 | 13,0 | D. Tasks of DW users | Respondents from the companies | Sample % |
| Construction | 1 | 4,3 | Specialist of Information Sys. | 15 | 37,5 |
| | | | Manager of Information Sys. | 11 | 27,5 |
| TOTAL: | 23 | 100,0 | Business end-user | 8 | 20,0 |
| | | | Manager of Functional Department | 7 | 17,0 |
| | | | TOTAL: | 41 | 100,0 |

### 3.4. Findings of the Research

In the research, a principal component factor analysis was performed using varimax rotation to determine if the scales that measures dependent and independent variables comprised sub-dimensions. In the analyses, the items, possessing a factor loading smaller than 0.5 were eliminated. As a result of the factor analysis, for only the dependent variables related to DW success, the rotated solution revealed three significant components with an eigenvalue of 1 or greater (K.M.O=0.730, Bartlett's test, p=0.000). The sub-criteria are referred to as "Satisfaction of End-User" (SEU), "Speed" (S) and "Continuity (C)". The factors explain 35.9%, 19.2% and 17.57% of the variance, respectively. After the factors were obtained a multiple regression analyses was contacted to examine relationship between the implementation factors and the success criteria of DW. The following regression equation is estimated, defining success as a dependent variable and implementation factors as independent variables:

Success of DW=B0 + B1 (MS) +B2 (SR) +B3 (ITS-EUS) +B4 (PIP) + B5 (IR)

The descriptive statistics and correlation matrix are illustrated in Table 2. As seen in the table, "Project Implementation Plan (PIP)" has the highest score among implementation factor. The respondents ranked "Information Requirements" second and "IT specialist and end-users skills" third. On the other hand; "Sufficient Resources" has the lowest mean as an implementation factors for DW success although the DW projects are resource-based implementations as stated in the literature.

Table 2. Descriptive Statistics and Correlation Analyses

| | Descriptive Statistics | | Correlation Coefficient | | | |
|---|---|---|---|---|---|---|
| | Mean | S.D | Overall Success | (SEU) | (S) | (C) |
| MS | 3.88 | 0.71 | 0.132 | 0.485*** | 0.118 | 0.123 |
| SR | 3.71 | 0.70 | 0.165 | 0.414*** | 0.218 | 0.133 |
| ITS-EUS | 3.91 | 0.65 | 0.332** | 0.695*** | 0.039 | 0.120 |
| PIP | 4.06 | 0.66 | 0.535*** | 0.702*** | 0.314* | 0.286 |
| IR | 4.00 | 0.64 | 0.333** | 0.624*** | 0.026 | 0.201 |
| PSE | 3.86 | 0.63 | | | | |
| S | 3.37 | 0.80 | | | | |
| C | 3.69 | 0.85 | | | | |

*: p < 0,10; **: p < 0,05; ***: p < 0,01

As seen in the Table 2, there is positive and significant correlation between Overall Success (the average of the sub-criteria of success) and three implementation factors (ITS-EUS, PIP and IR). Additionally, Satisfaction of End-User which is the sub-criterion of Overall Success correlated with all independent variables and "PIP" is the most significant implementation factor. On the other hand; there is no significant relationship between Continuity and implementation factors.

The results of multiple regression analysis between implementation factors and the DW success are shown in the Table 3. Beta weights are calculated which are coefficient of the independent variables in the research.

Table 3. Multiple Regression Analyses

| | Overall Success | (SEU) | (S) | (C) |
|---|---|---|---|---|
| MS | 0.158 | 0.197 | 0.047 | 0.258 |
| SR | 0.015 | 0.017 | 0.036 | 0.070 |
| ITS-EUS | 0.098 | $0.438^{***}$ | 0.078 | 0.270 |
| PIP | $0.545^{***}$ | $0.344^{**}$ | $0.460^{**}$ | 0.301 |
| IR | 0.225 | $0.308^{*}$ | 0.102 | 0.096 |
| F | $5.70^{***}$ | $12.97^{***}$ | $2.17^{*}$ | 0.676 |
| $R^2$ adj. | 0.251 | 0.600 | 0.188 | 0.042 |

*: p < 0,10; **: p < 0,05; ***: p < 0,01

As seen in the Table 3; the Beta coefficient of the independent variables with respect to Overall Success is positive. The F test shows that there is linear relationship between Overall Success and implementation factors (F: 5.70, p: 0.009). The five independent variables explain 25.1of the variance % of Overall Success in the sample. Although there is positive and significant correlation between Overall Success and the two independent variables (ITS-EUS and IR); it appears that they have no explanatory effect on Overall Success. Only, the "Project Implementation Plan (PIP) has an explanatory effect on Overall Success. On the other hand, these two variables have explanatory effect on the success criterion that is Satisfaction of End-User (SEU). However, "ITS-EUS" is the most significant variable that affects the "SEU". Additionally, there is positive relationship between speed which is the other success criterion and independent variables (F: 2.17, p: 0.08) although only the PIP is explanatory variable on DW speed. The F test also shows that there is no useful relationship between implementation factors and Continuity as seen in the correlation analyses (Table 2).

## 4. Conclusion

Data Warehousing is a need of business and also it is seen as technological advances in supply chain environment. Evaluating the implementation factors for the success is considered to be an important issue because the adaptation of DW in Turkey is at the early stage. The study presented the research model that investigates the relationship between the implementation factors and success criteria of DW. To measure the success of DW, questions are asked regarding satisfaction of DW users and system quality or technical success of DW.

The analyses show that respondents consider the project implementation plan as an important implementation factor for DW projects. This construct is consist of the questions relevant with different planning stage of DW projects such as clarifying responsibilities, service level agreements, source system identification, data quality planning. This result could be explained by the consulting usage of the companies in the sample in their DW project implementations (87.5%). Because most of the organizations at an implementation stage in Turkey unfamiliar to DW systems, outsourcing strategy for the DW system supports clarifying the responsibilities and planning the stages. In addition to this; the results obtained from the correlation and regression analyses indicate that the implementation factors except "project implementation plan" do not affect the sub-criterion (S, C) which shows the "system quality". Existence of project implementation plan is the only and most significant variable accounts for the speed. System quality or data quality requires strong technical infrastructure. Further research may include the implementation factors that reflect technical background of the companies to understand DW system quality. On the other hand; all implementation factors, which could be characterized as social factors, are correlated with satisfaction of DW users. Especially, the well-skilled IT specialist and end-users (technical and interpersonal abilities) in the implementation process affect the satisfaction of end-users significantly strongly. Only a high quality, competent team can identify the requirement of complex projects (Vixom and Watson, 2001). The other significant implementation factor is determination of information requirements in DW process. Communication with users' expectations will help to understand what the DW will provide. Thus, users could be more satisfied when the warehouse is delivered.

Additionally, the result of the regression analysis reflects that neither management support nor the sufficient resources do appear to affect DW success. This is an unexpected result because the variables are identified as important factors in DW literature. As a result; well-organized and well-planned DW process will improve the overall success of DW projects. Further extensive research may be required that investigate the social and technical problems that arise and cause failure of the DW implementation process in the Turkish companies.

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# CLASSIFICATION OF IT SYSTEMS USED IN LOGISTICS SECTOR AND IDENTIFICATION OF NEW NEEDS IN THIS AREA

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## Abstract

*Due to its structure and functions, logistics sector intensively utilizes and invests on Information Technology (IT) and Information Systems (IS). IS and IT are vital for any logistics company to make fast and accurate decisions, to manage complex and time-sensitive operations and mobile resources, to accomplish tactical, managerial, and strategic plans. All these objectives require intensive support from IS and IT.*

*Thus, this study has 3 main purposes:*

1) *An extensive literature search on IT and IS developed for and used in logistics sector,*
2) *Determining IT and IS utilization profile of Turkish logistics companies,*
3) *Making analysis and drawing conclusions as well as proposing suggestions based on findings of the study.*

*In order to achieve these objectives detailed analysis with 6 logistics companies in Turkey were made. A questionnaire was adapted, adjusted, and used to collect data and information and to make analysis. Findings are presented as 6 case studies. The 6 cases give an understanding of IS and IT utilization by Turkish logistics companies. Further conclusions are made based on analysis of 6 cases.*

*Keywords: logistics, information and communication technologies, information systems, logistics information systems*

## 1. Introduction

The changing business life, changing customer needs, technological developments, increasing competition and the stress of all these factors on firms result in a need of better and faster information management in the logistics sector as it does in many other industries. This trend makes Information Technology (IT) and Information Systems (IS) utilization more important. The firms which aim to be more competitive in the dynamic market conditions must improve the flow of data and information, must produce better information and knowledge to support decision makers, and maintain a good IS network to achieve this. This will lead to success in operational, tactical and strategical level decisions in that organisation. In the first part of this study, logistics, processes and management are defined. In the second part, available literature about IT/IS currently used in logictics sector and its' effects are presented. The third part explains the survey which is used to determine the profile of Turkish logistics firms' IT/IS use and presents 6 case studies conducted with six logistics firms. The last part points some discussions about weak points in the IT/IS usage of Turkish Firms and draws some conclusions from this study.

## 2. The Concepts of Logistics and Logistics Management

Logictics is defined as the planning, applying and controlling of cost-effective and efficient flow of all processes for goods, services and information in the firm beginning with purchasing of raw materials and semi-finished goods, processing them and manufacturing, distributing finished goods to consumption areas (Council of Logistics Management). Rabinovich, Windle, Dresner and Corsi (1999) define logistics as a functional system. Parallel to these definitions, logistics is considered as a part of supply chain management. Logistics enables companies to get the right goods to the right place at the right time in the right condition and at the right cost.

Chen, Huang, Chen and Wu (2005) claim that logistics activities mainly consist of transportation, inventory management, order fulfillment and warehousing. According to Rabinovich, Windle, Dresner and Corsi (1999) a system of logistics functions can be divided into five broad areas: 1) facility location; 2) transportation; 3) inventory; 4) communication; and 5) material movement. Pokharel (2005) classifies transportation related activities as route and mode planning, picking and delivering, electronic identification, mobile communication, physical automation, managing claims, and tracking and tracing. When all the activities like purchasing, stock, control, transportation, import, export are considered logistics include many complex processes. Logistics as a holistic approach to the management of material and information flows plays a significant role in satisfying the customers' needs and requirements (Korpela & Tuominen, 1996). Therefore high level of information flow is as much important as physical flow in these operations. Today in the business world, this information and physical flow's effective management is of great importance for the internal and external functional integration and the firms accomplish all

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these via Information and Communication Technologies (ICT). ICT can be considered as combination of Information Systems and Information Technology. ICT help companies with internal and external functional integration (Daugherty, Ellinger & Gustin, 1996). Today IS and IT technologies focus heavily on integration and integrated systems such as ERP (Enterprise Resource Planning Systems, CRM (Customer Relationship Management Systems), and SCM (Supply Chain Management Systems). The meaning of internal functional integration is coordination and communication among all departments in an organization (such as marketing, accounting, finance, purchasing, transportation, warehousing etc.) and this can be accomplished by ERP utilization. The meaning of external functional integration is coordination and communication among the firm and other firms and this can be accomplished by SCM. Integration results with effective supply chain management, achieving cycle time compression, developing alliances/ partnerships (Towill 1996, La Londe, Masters 1994), more efficient logistics operations (Bowersox and Daugherty, 1991). Daugherty et al. (1996) found that managers of logistics companies believe that integrated logistics can be associated with IS more than organizational structure.

## 3. Literature Search

### 3.1. Logistics Information Systems

A Logistics Information System (LIS) can be defined as a system providing management with relevant and timely information (Wattiau & Akoka, 1996). LIS is an interacting structure of people, equipment, and procedures which together make relevant information available to the logistics manager for the purposes of planning, implementation, and control (Stefansson, 2002). The primary reasons for logistics changes in growing companies are new requests from customers, ongoing improvement in internal processes, and re-evaluation of company logistics strategies (Lattmann, 2000). These changes demand integrated logistics in terms of IS. IT had a substantial impact on the functionality of integrated logistics IS and made system integration possible (Barut, Faisst & Kanet, 2002).

Disappearing physical boundries in commerce, globalisation, the need for quick response to changing demands of customer are all forcing logistics sector to restructure itself and to effectively use IS. Increasing diversification of product portfolio, more complex supply chain, use of different ways of transportation at the same time are the factors that make business inevitable to use IS for effective planning, applying, following and managing. By this way firms can reduce logistics costs, increase efficiency and service quality, increase efficiency of warehouse management, increase use of information, update immediately all plans, save time, senkronization of information and good flow, increasing customer satisfaction.

Some of the LIS related studies that we have encountered in the review of literature are:

Pokharel (2005) tries to assess the perception of logistics companies towards information and communication technologies in Singapore. This study found that most logistics companies use ICT but their level and type depend on the size of the company and availabilty of technology. According to this study ICT helps with better efficiency, cost savings, reduced data entry errors, and increased customer satisfactions level. One of the most important finding is that ICT utilization is directly related with the size of company.

Prindezis and Kiranoudis (2005) discussed an internet based logistics management system that helps solving vehicle routing problem and presented automatically generated vehicle routing plans such that all customers' demands were met, no constraints were violated and a combination of vehicle costs and distance travelled was minimized.

Muffatto and Payaro (2004) analysed the procurement and fulfillment processes carried out using information and communication technologies to be able to identify which stages of the procurement and distribution processes can be digitized. The authors' proposed model defined fulfillment as controlling and managing transactions, warehouses, transportations and reverse logistics. The stages of the model go from the use of ICT simply as instruments of communication to the improvement of coordination processes.

Another paper by Davies, Mason and Lalwani (2006) focused on the road freight transport industry using the UK as a case study. It examines the extent to which internet freight exchanges and the use of ICT processes are affecting general haulage.

The survey of Rutner, Gibson and Williams (2003) highlighted an icreasing use of LIS and its ability to link functional areas of e-commerce. This study detailed in ERP as ERP sytems provide a mechanism for collecting, managing and sharing organizational data across business functions, including the data needed to support the integration of logistics operations.

Based on the results of our literature review, this study classifies LIS based on planning and execution, storage, transportation and tracking functions.

#### 3.1.1. Planning and Execution:

*Yard Management Systems(YMS):* This system is used in operational level. It is used to define the firm's all types of transportation vehicles held in a specified area and follow of these vehicles. The yard supply chain includes all the inbound and outbound activities generated by the distribution, warehousing, and replenishment of goods to satisfy orders from the regional stores (Mason, Ribera, Farris, & Kirk, 2003). *Functions of a YMS are:* Demand planning (How many vehicles, and what size of vehicles will be needed are the questions to be answered), Order management (It is the management of customer orders). some sample questions to be answered with A YMS are what type of vehicle should be used for a customer given specification like the vehicle with or without air-condition and to which destination this load will be transported are

*Import/Export Management Systems:* This system is used in operational level. It defines the IS used for import / export. Because logistics mean transportation of goods most of the logistics companies transport freight or producst between countries. In order to create necessary custom documents and paperwork imprt/export management systems have been developed and they are being utilized by logistics companies which works internationally to fasten the customs processing and to fulfill legal requirements.

3.1.2. Storage:

In warehousing, information on inbound and outbound flows, weight and volume of stored products by type and cost of inventory are necessary. In addition, information on product design, assembly, packaging, electronic tagging would also be needed if warehouse functions include packing, kitting and consolidation (Pokharel, 2005). Warehouse Management Information Systems permit the movement of goods within transport hubs and terminals to be largely automated, minimizing both handling costs and errors (Capineri & Leinbach, 2006). If WMS is wireless capable, then it can further enhance inventory utilization, customer support and value addition. In addition, availability of automated guided vehicles, sorting devices and automated storage and retrieval system would be of greater advantage for easy loading and unloading in the warehouse (Pokharel, 2005). Internet technology allows warehouse managers to receive orders more expeditiously and allows them to track the inventory connected with those orders (Mason, Ribera, Farris, & Kirk, 2003).

Warehouse Management Systems (WMS) are used for warehousing functios which are also operational level. Functions of a WMS are: Inventory deployment (It defines stock management where stock means the transported load), Real-time control( It defines the real time record of data for inputs and outputs to the warehouse), Label printing (It defines a technology that is currently in use. By this technology, all the goods transported are labelled), Bar coding(It defines the technology used for barcoding), RFID ( defines the technology used for identification by the help of radio frequencies, Voice data entry ( defines the technology used for recording voices.The operator who controls the stock enters via voice instead of entering via keyboard or barcoding).

3.1.3. Transportation and Tracking:

Transportation Management Systems (TMS): It is in operational level. Functions are: Routing and scheduling(It defines routing and scheduling of vehicles used in transportation. When does the vehicle leave? When does it arrive? Which route does the driver use? Are the questions to be answered), Carrier selection (If the firm does business with a carrier company, the selection of this carrier company is the scope of this system), Load tendering (It is about the load to be transported. What will be the final status of the load? Which type of vehicle will be selected for this load? (a container or a truck?)).

TMS are typically used as decision support tools in two areas: planning and optimization and transportation execution. During planning and optimization efforts, TMSs determine the transportation mode(s) and also manage freight consolidation operations and coordinate company shipments, including continious freight moves. When used in execution or operations mode, TMSs are either directly or indirectly responsible for carrier load tendering, routing, and scheduling, shipment tracking and tracing, and freight payment and auditing (Mason, Ribera, Farris, & Kirk, 2003). In transportation, ICT can be used for functions such as information transfer, route and mode planning, picking and delivering, electronic identification, mobile communication, physical automation, managing claims, and tracking and tracing. TMS, through wireless technology and communication network, can also assist in fleet visibility, dispatcher productivity by decreasing the paperwork, reduction in turnaround time through efficient communications with the warehouses, and finally providing real time data for the use by management (Pokharel, 2005).

The order pass to the WMS to manage the planning needed for the packing process including preparing the boxes and containers that will be needed to fill the orders in the warehouse. At the same time, the TMS analyzes the best way to source and ship the orders thereby saving the time that would be lost by sequential and segregated WMS and TMS operation. The TMS can also examine real-time inventory levels at multiple facilities and, based on optimum transportation costs and customer service, identify which facility should be used to fill the order (Mason, Ribera, Farris, & Kirk, 2003).

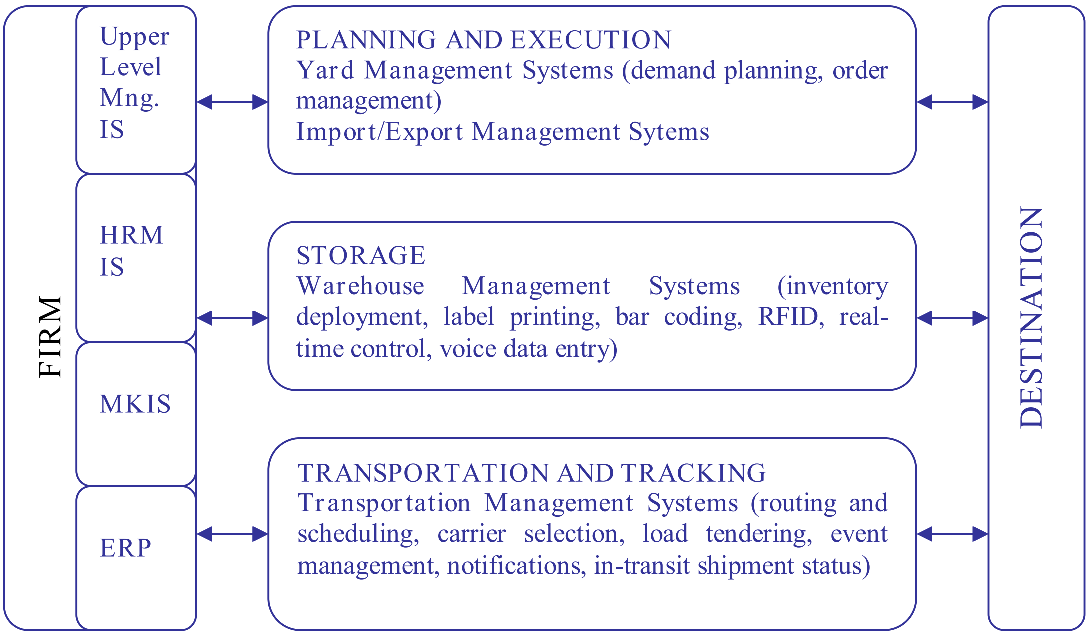


Figure 1. Information Systems Framework for Logistics Companies

After the above classification of LIS, information systems framework for logistics companies is presented in Figure 1. System given in figure 1 covers some of the main IS functions which are used in most companies and not specific to logistics sector such as Upper Level Management IS (ULMIS), Human Resources IS (HRIS), Marketing IS (MKIS), and Enterprise Resource Planning (ERP), as well as systems specifically designed and implemented to help with logistics needs such as Warehouse Management Systems (WMS), Transportation Management Systems (TMS), Yard Management Systems (YMS), and Import/Export Management Systems. Figure 1 shows different levels of ICT and IS utilization by logistics companies. As with all other organizations a logistics company also has an internal structure and departments such as marketing, finance, human resources, upper level managers, operationals managers, etc. In addition to this they may also have unique departments such as order picking, warehousing, route and mode planning, transportaion, yard and vehicle management departments. All these internal departments and activities can utilize ICT and IS. More specifically upper level managers can make strategic long term decisions by using ULMIS, mid level managers can use MKIS for routine daily or short term activities. HR department can keep track of employees and employee related activities by using HRIS. In addition all these, ERP system can be used company wide to follow and to manage activities and movement of materials, money, resources and information.

### 3.2. Impacts Of IT Utilization on Firm Performance in Logistics Sector

Speed and agility are critical for todays businesses. Therefore it is now a necessity for the firms to follow up the technological changes. As in other sectors, logistics will surely use and benefit from IT and will see the impacts of it. Traditionally logistics has been fed information on customer requirements from log-range forecasts that drove the production cycles of firms. Firms now require current and immediate information about the location of productive activities as well as information linking the locations with available transport opportunities (Capineri & Leinbach, 2006).

The development of ICT has increased the possibility of being cost-efficient and competitive while meeting with customer needs and making them happy. It is possible to track-and-trace shipments from suppliers to the final destination. With the advent of new ICT, it is becoming increasingly possible for companies to co-ordinate more closely and couple their logistics planning activities (Barut, Faisst & Kanet, 2002). ICT helps to execute activities faster, support autonomous decision-making processes, and enable distributive operations in order to achieve higher logistics efficiency (Pokharel, 2005). Other benefits of ICT are also in the context of our case studies.

The use of IT has permitted the development of faster, more reliable, more precisely time logistics strategies (Capineri & Leinbach, 2006). IT allows the firm to learn and respond to market changes better and quicker than competitors (Wu, Yeniyurt, Kim & Cavusgil, 2006). The increased pressure on time-to-market and order-to-delivery requires firms to be in close proximity to their customers, not necessarily in terms of physical distance, but in terms of time (Lemoine, 2004). This is all happening because companies have learned that they cannot meet the challenges of the speed-driven, globally networked economy without dramatic changes in how they organize their flows of information, materials and finished goods (Kasarda, 2000).

The use of IT has also enabled firms to more closely track-and-trace shipments from suppliers, through production, and to the final destination so that the time embodied in a production process in not merely sped up but is also more carefully managed (Lemoine, 2004; Capineri&Leinbach, 2006). In addition, the real-time transportation information generated by the system may also be used for post-shipment analysis of the carrier's performance (Mason, Ribera, Farris, & Kirk, 2003). IT use in logistics operations enables the company to divert its performance and energy to the demands of customers, suppliers and the market better. The company will use all the data and translate these data into information much more efficiently.

Looking at the point that we arrive today, the efficient use of IT/IS in logistics allow and ease companies to have changes in the way of doing business with suppliers, smaller but more frequent party shipments, more various types of deliveries to different customers and customer orders with shorter delivery cycles.

# 4. Research

## 4.1. Methodology and Approach

### 4.1.1. Participants:

A questionnaire was used in this study. 30 respondents representing large sizes from turkish logistics companies were chosen. First of all an informative mail was sent to 30 firms' managers. In 3 weeks a very small number of responses were received. We followed up with phone and mails to increase number of participant companies. As a final result 6 firms responded. Although this number seems very low to draw general conclusions, it is acceptable when the support of Turkish firms to such academical surveys are considered. In the future we are in the hope of having higher numbers as managers will be much more aware of the importance of such surveys.

### 4.1.2. Survey

The questionnaire used in this survey was originally developed by Balaban, Cilan and Coskun (2006) for tourism sector to analyse the ICT utilization profile in tourism sector. It is then adapted to logistics sector. The questionnaire has 5 main sections and total of 53 questions. Section A collects personal information about the respondent profile, Section B collects company information, Section C includes company ICT information related questions, Section D asks for company LIS information, and finally Section E measures impacts of ICT on these firms.

## 4.2. Company profiles and ICT utilization details

### *4.2.1 Company A*

This is a large scale firm with 220 employees and in logistics industry for 14 years. Primarily this company serves to food and automotive industries. In addition to these service is provided to chemical and heavy industries. They provide transportation, storage and customs service. The company has 175 – 200 vehicles. In terms of ICT infrastructure, the company has 80 computers which are used for daily operations and connected to internet. The company has a separate ICT department reporting to general manager and employing 2 specialists who deal mainly with hardware and software development. The general ICT strategy of the company is seeking from professionals outside the company. Nevertheless, they do not make use of an interactive web site. Most of their annual investment budget is spent to software (40%) and hardware (30%). Less percentage is given to training (5%) and ICT personnel (5%). The company is aware of the all mentioned ICT systems in this study and uses all except top management ICT systems throughout the company for 8 years. All these ICT systems are the modules of the current available automation software. The managers think that ERP use is more important for customer satisfaction and cost savings whereas marketing ICT system is more important for competitive advantage. The other modules (vehicle, transportation, and warehouse and import/export management) are important for mainly customer satisfaction as well as better service. Beside all of these systems the company purchased and uses vehicle satellite tracking system. The company is capable of providing all software and hardware in-house. Not surprisingly, ICT use effects on every components are considered as 5 in likert scale of 5.

### 4.2.2 Company B

This firm is owned by 51% foreign capital and is one of the large-scale companies in logistics industry. It has 103 employees and is operating in storage, stock management, and international transportation organization for 10 years. Most of the services provided to textile, manufavcturing and automotive industries. The company provides very seldom service to electrical and electronics industry as well. All the vehicles are outsourced.

IT system infrastructure is explained with 78 personal computers that are connected to internet for daily operations. All ICT services are outsourced. Receiving the order and customer response are possible via interactive company web site. A high percentage (44%) of annual investment budget is allocated for ICT. Out of this share, 40% is reserved for software and 40% for hardware. No investment is planned for ICT personnel. Customer visits, e-mails, telephone/fax are used for getting customer orders in spite of the available interactive web site. For the last 2 years marketing ICT system is used aiming better customer satisfaction and secondly better service and competitive advantage.

Likert scale 5 is used for measuring effects of ICT systems on various performance items. Most answers are marked as 3s and 4s. But company finds ICT systems insufficient for getting competitors' news, developing better relationships with customers, service sale, customer satisfaction, training, warehouse management and flow of knowledge.

### 4.2.3 Company C

This company is in the business of transportation for 20 years. It owns 60-80 vehicles and is classified as a large-scale company in the industry. With its 100 employees ICT serves to mainly automotive and textile industries and less to heavy industry and even less to electrical industry. Customer orders with flammable chemicals are transported with special precautions. IT infrastructure is explained by 15 computers which all have internet connections for daily operations. For 10 years the organization has ICT department and prefers to work with professionals as a general strategy. The employees in this department have hardware, software, network, automation programming tasks as main responsibilities. Some of these are partially outsourced. The available and partially interactive website allows for customer orders and inquiries. Out of the annual investment budget a small percentage (10%) is allocated for ICT. This 10% is divided as 40% for hardware, 20% for ICT personnel, 20% for maintenance and %10 for training. Rather than web site use, customer orders are handled mainly via e-mail.

The management is aware of all of the mentioned 8 ICT systems. They currently use 6 of them and intend to use 1. The human resources management system is developed in-house and in usage for 2 years. Marketing, vehicle management modules and ERP are used for 5 years. All these modules are considered as important tools for the business. The company aims competitive advantage with ERP, better service with vehicle management, better customer satisfaction with marketing. Import/export management system is regarded as very important and in use for 15 years. The warehouse management system is developed in-house aiming cost saving and is in use for 2 years. Other available programs are listed as quality system, maintenance and finance. The management cares for ICT effects on performance very much and replies as 5 to all items given in Likert scale of 5. But on the other hand according to them these systems require more investment on technology, decreases profits and customer number.

#### 4.2.4 Company D

It serves in logistics industry by transportation, storage, stock management, foreign commerce and customs operations areas and regarded as one of the 10 biggest companies in this field with 1486 employees. They serve more frequently to heavy industry, chemical, textile industries and less frequently to drugs, automotive and food industries. Shortly they serve to all types of industries. The company owns around 500 vehicles and outsources some when needed.

The ICT infrastructure consists of 200 computers through which daily operations are performed and all computers connected to internet. ICT department reports to general manager and employs 10 software specialists, 5 hardware specialists, 3 web site specialists, 2 database specialists and 1 system analyst. 80% of their workforce focuses on software area. They state their general strategy as being leader in the application of new technologies and systems. Online customer orders, import/export follow-up, on-line vehicle follow-up are all processed through the interactive web site. 60% of all customer orders are processed via e-mail. The largest amount of the annual investment budget is allocated for ICT personnel and least for training.

The company is aware of all mentioned ICT systems and uses them. These systems are all developed in-house and regarded as “highly important” except human resources and web site. These 2 are regarded as “important”. Top management, marketing and ERP are in implementation stage but vehicle management, warehouse, transportation, import/export management are all in application for 8 – 10 years. The main advantage of these systems are stated as cost saving. Other advantages are customer satisfaction and competitive advantages. When managers are asked to reply to effects of ICT on various performance parameters their answers are very positive. Nevertheless these systems do not decrease technology investment, do not increase customer portfolio.

#### 4.2.5 Company E

This is a medium-scale firm with 25 personnel and 35 drivers operating especially in open bulge load transportation with its 40-60 vehicles.

IT infrastructure does not employ an ICT department but instead outsources software and hardware services. Interactive web site is used effectively for online payments, import/export follow-up, pricing, flow of goods and services, vehicle follow-up and customer inquiries. But the percentage allocated to ICT systems (3%) out of annual investment budget is quite low. Out of this 3%, largest share is given to ICT personnel. Customer orders are received only by means of e-mail and telephone/fax. The managers are aware of most of the mentioned ICT systems and currently using human resources, marketing, vehicle, import/export management and ERP and regard these ICT systems as “very important”. The company aim to save costs as well as satisfy the customers. They consider especially marketing and warehouse management as a competition tool and use them. Customer satisfaction is also important. All the mentioned systems are modules of the current automation program. A disadvantage of these ICT systems is thought to be technology dependency. Other than this, impacts of ICT systems are found to be quite positive.

#### 4.2.6 Company F

This company considers itself as being one of the largest 10 in logistics industry with over 1000 employees. They serve primarily to heavy industry, consumable goods and less to automotive industry. The company is serving in the areas of transportation, stock management and warehousing operations via mainly its own vehicles and outsources some as needed. The ICT infrastructure is listed as over 200 personal computers ( ¾ of these have internet connection), and a separate ICT department. Following the latest technology, working with professionals, and being leader are stated as the general ICT business strategy. The interactive web site allows all customer contacts such as online inquiries, orders, payments, follow-ups, vehicle follows and pricing. But surprisingly online customer orders do not exceed %20. Rather the orders are received via e-mail (40%) actively. Almost a half of ICT budget is allocated for hardware. 30% is allocated to software. Relatively less percentage (10%) is reserved for ICT personnel. The company utilizes ICT systems common in all industries such as top management support systems, human resources, marketing and ERP systems. Other ICT systems which are much more specific to logistics industry such as vehicle management, transportation, warehouse management are also effectively and widely used in the operations of this company for last 5 years. Most of the ICT systems are developed in-house and partially outsourced. All these ICT systems provide better customer service, and increase competitiveness. Less benefits are declared as cost savings and personnel satisfaction. Most of the answers to questions about the effects of ICT systems show that in this company ICT systems are perceived to have very positive effects on business operations and performances.

### 4.3 General Overview of Results

A total of 6 firms operating in the logistics industry were identified and participated in this study. The small number of responses makes it difficult to generalize our results and to uncover all the details of ICT use profile of Turkish logistics firms. But neverthless we draw our own conclusions as :

All of the companies use ICT but their level and type depend mainly on the size of the company.

All the companies define themselves as logistics companies whereas most of them are solely transportation companies. We are uncertain and can not say that these definitions are done consciously. We think that difference of logictics and transportation is not known. As we only aimed to take realistic picture of the current situation we did not change or correct this common view and kept them original.

In the last part of the survey the companies were asked to define in what ways and how ICT effects them. Consequently their attitude was measured on a scale from 1 (negative attitude) to 5 (very positive attitude). Generally, a relatively positive attitude (on average 4) was reported.

But to some certain questions the companies emphasize negative attitude. They say that ICT does not reduce their technology investments, does not reduce their technology dependency, does not increase customer number or profits. These results seem not consistent with finding from other parts suggesting that the companies expect from ICT to benefit higher customer satisfaction and cost reduction. This paradox is common for most previous studies too. Companies want to see the results of IT and IS implementation immediately, but information systems literature emphesizes that the positive impacts of IT and IS can be seen after 3 to 5 years. So, companies who are serious about getting good results from IT and IS must be patient and must believe that their investment will result with better performance not immediately but in the mid and long run.

The companies provide services to more than 1 industry type and in most cases 1 company provide multiple functions. They consider cost reduction, increased customer service level, efficiency and data reliability as opportunities from ICT. The use of ICT increases with the size of the company but is indifferent regarding the type of the industry covered and type of the function offered by the company. For example, customers from various industries use internet technology to simplfy certain processes. ICT allows people to easily communicate and to accurately transmit information. The increased outsourcing of logistics activities to third party logistics is an important trend seen in our study.

## 5. Conclusions

Besides the physical development in logistic sector, the integrated logistic service and integrated logistic information system will take place of the concept of traditional forwarding. Integrated logistics information system is a comprehensive concept involving the management of all activities among all supply chain members both upstream and downstream (Barut, Faisst & Kanet, 2002). The information supplied by these systems help the managers to give decisions quicker in a more reliable fashion, to follow and manage the operations easier and to apply the operational, tactical and strategical plans of all organizational levels as desired.

Within the last decade the structure of transportation growth in Turkey has changed in several ways, the most important being the growth in logistical distance. As cited from Nielsen, Jespersen, Petersen and Hansen (2003) transport is seen as a necessary precondition of economic growth and inevitable consequence of the development. Today most of the Turkish Companies operate and compete in global markets. The change effects everyone in the supply chain. It effects customers who want to give orders via e-mail or online and want to be able to follow his shipment in every stage, truck drivers who wants to find his way by using satellite systems or to communicate with headquarters in case of an emergency or change in plans, suppliers who want to know how much or how many to ship and when that shipment will arrive. Therefore they all must use IT and IS.

Turkish companies are just in the process of transition. They would like to use all these systems and they would like to be competitive in global market. But still, there is a need to make lot of investment in field of people, process and technology. The most important thing is that upper level managers (company owners mostly for logistics sector) must believe in IS and IT. Without their support these systems and technologies cannot be implemented and utilized successfully. Some companies see IS or IT as a cost increasing investment. It is true that IS and IT requires a big initial investment as well as yearly maintenance and upgrade costs. And their benefits will be seen in 2-5 years. For some managers 2-5 years is too long and they see IT or IS investment unnecessary.

IS and IT utilization requires educated and computer friendly employees. This is another area Turkish logistics companies must improve. This can be achieved through training and through explaining them that these systems will help them with increasing their efficiency. Most of the companies in this sector prefer to outsource IT and IS related services. Literature has huge number of studies which show pros and cons of outsourcing IS and IT functions. Companies especially logistics companies which deal with large volume of data can not fully depend on outsourcing. They may outsource some basic functions or some functions which require expensive expertise, but especially for strategic advantage they must establish and function IS and IT departments inside their organization.

According to Davies, Mason and Lalwani (2006) while many of the smaller haulage operators remain dependent upon traditional communication and process systems, the larger logistics companies, who control the majority of vehicles and freight movements, are progressively developing new ways of working supported by ICT adoption. Our study is confirmed this findings. In logistics sector, IT outsourcing became widespread especially at last years can enable to reach technology of small companies. Finally, as with all other sectors, logistics sector will depend on internet based IT and IS in the future, so they must start thinking about them and they must start with planning of them. Otherwise their competitive power will be decreased and they will need to do business in a more restricted area.

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# IMPROVEMENT OF PORT INFORMATION SYSTEMS FOR TCDD PORTS

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## Abstract

*In today's world of globalization, utilization of information technology in transport and port industry is rapidly gaining importance. After Turkish government decided to privatize the operation of Turkish ports, the efficiency issues became more seriously important. When the privatization of Mersin, Izmir and Iskenderun Ports will be over, the companies to operate these terminals will intend to implement their operating systems and these systems should be integrated to Turkish State Railways (TCDD) and Turkish Customs Office. If the efficiency level of the port administration and the customs office will be far below that of the terminal operating systems, it will be a bottleneck for the ports' overall efficiency.*

*In this research, future port information systems development strategy and corresponding administrative precautions for Turkish government are discussed, under the light of past system development projects for the ports. First, the information systems utilized in the world's leading ports are reviewed. Then past attempts to implement information systems to TCDD ports and the current situation of the ports are reviewed and problems in front of information system improvements are stated. Finally, under the light of previous studies and actual applications in world's leading ports, some recommendations to overcome these problems using information technology are proposed.*

*Keywords: ports, Turkey, TCDD ports, information systems*

## 1. Introduction:

It is for sure that ports are one of the most important elements of a country's economy. They are not only the intersection points of different modes of transport, but also focal points of economic activity. Due to various factors, such as increasing amount of international trade, increasing capacity of vessels, decreasing cost of inland transport, introduction of new technology to ports and containerization, the competition between ports has become severe and efficiency issues has become a major point of concern in the last few decades.

Recent developments in information technology have deeply affected almost every field of industry. Ports are no exception. Since ports are places where various tasks must be carried on in harmony by various bodies, utilization of information technology is inevitable to coordinate and harmonize these activities, ranging from basic tasks like cargo handling to auxiliary tasks such as communication between port-related bodies.

On the other hand, for the case of Turkish ports, utilization of information technology has been delayed for such a long time that inefficiency is severely affecting Turkish economy (Mersin Chamber of Commerce and Industry, 2003). Due to undeveloped transport infrastructure, international cargo routes between Europe and Asia is being shifted beyond the borders of Turkey (The Undersecretariat of the Prime Ministry for Foreign Trade, 2001). On the other hand, Turkey is holding negotiations with European Union, and – if the negotiations are successful- is expected to be a member of it within the next decade. This will certainly cause an increase in the amount of import and export cargo due to expected foreign investment drawn to the country, because of low land and labor costs compared to European countries. Moreover, the strategic value of Turkish ports, especially Mersin Port, will increase due to reconstruction of Iraq after the war and the port is competing with Tartus and Lazkiye ports of Syria. Therefore, low efficiency of Turkish ports will be a bottleneck for such improvements.

In this research, first of all, the current sophisticated port information systems utilized in the world's major ports are overviewed. Then the past projects to develop port information systems for Turkish ports are summarized and the present situation and problems of Turkish ports are described. Finally, based on the past experiences, applications in the world's advanced ports and the implications suggested by previous studies; some basic characteristics of the of the information system that should be implemented to solve these problems are suggested.

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## 2. Current Situation of World Ports According to Information Technology:

The term "port information system" is used for every kind of information technology –hardware or software– that is used in port operations, and further explanation will be given within this chapter. Such a system can be extremely diversified according to the functions of the system and the tasks that are carried out within the port.

In this section, information technology utilized in some leading ports of the world will be reviewed in order to seize the scope of information systems utilized in ports.

### 2.1 Port of Singapore:

Port of Singapore is a good example for one of the best usage and application of information technology in port terminal operations. Port of Singapore Authority (PSA) runs one of the most technologically advanced ports in the world and information technology is the key to become the most efficient port in the world (Lee-Partridge, Teo, & Lim, 2000:86). Since the country is in severe lack of land, the efficient utilization of existing land is crucial for the Port of Singapore, and this was achieved by the sophisticated technology used in the port. This can be a good example of overcoming physical limitations by the proper utilization of information technologies.

The information system in the Port of Singapore is separated into three levels (Applegate, Dustin, & McFarlan, 2003:325). In the first level, main operations are streamlined, synchronized and integrated by a program called Computer Integrated Terminal Operating System (CITOS). In the second level, real-time management, coordination and control of the operations are offered by PSA staff. In the third level, another proprietary software, called PORTNET, connects the port with other organizations, including shipping lines, haulers, truckers, customs, marine service providers etc.

CITOS is defined as "a comprehensive Enterprise Resource Planning (ERP) system specializing in real-time command and control of information and resources for container terminals" (http://www.portnet.com/03products/citos.htm). It supports all planning requirements, including berth allocation, yard planning, ship planning, rail planning and resource allocation. It keeps track of all activities related to terminal operations and movements in the yard, regulates gate operations, and enables real-time terminal operation through connections with control centers. It also contains modules for equipment maintenance, performance reporting, invoicing and container number recognition. On the other hand, operation of break-bulk terminals is carried out by another system, called Computer Integrated Conventional Operations System (CICOS).

PSA offers integrated services to shipping lines, haulers, freight forwarders, shippers and local government agencies operating in Singapore, through Portnet, via internet environment. The system enables online ordering of services, such as berth application, stevedoring services, yard crane booking, ordering pilot, tug or waterboat. Document submission, like electronic bay plan (EBP), vessel itenary or required information for pre-gate activities can be fulfilled through Portnet. The system also allows the customers to track and trace the location and the status of their cargo and orders. Legal or regulatory documentation, such as electronic delivery order (EDO), container store & release order, hauler's job lists and subcontract functions, and government permits applications seamlessly flow through the system. It offers an easy-access data repository to share critical coordination data, such as detailed schedules, ship planning data, reefer containers temperature and dangerous goods containers condition. The system also offers financial functions such as online charges and billing. On-line connection with custom services is supplied through Tradenet (http://www.portnet.com/03products/ portnet.htm).

Such investments in information system infrastructure returned back to the Port of Singapore as performance increase and high efficiency. For example, the world record in vessel loading and unloading (243 containers in an hour) was broken in April 25, 2000 (Applegate et al., 2003:328). And in March 2000, the port handled 1.5 million TEUs in a single month, which is still an unreachable record in anywhere else in the world (Lee-Partridge, Teo, & Lim, 2000). On the other hand, this success depends on not only the IT system but also modern management strategies of the government and the port authority. In fact, absence of such awareness can be a major obstacle in front of Turkish ports.

### 2.2 Port of Hamburg:

Port of Hamburg is one of the most modern ports in Europe. Its highly automated terminals, such as Container Terminal Altenwerder (CTA) operates 24 hours a day, almost totally automated. The terminal has 14 semi-automated container cranes to load the containers onto "driverless" container carriers, called Automated Guided Vehicles (AGV). On the yard, two automated gantry cranes operate in each block by one passing over the other to ensure high handling rates and avoid time losses due to system failure (Engelhardt, 2006).

The system is coordinated by software called Container Terminal Information System (CTIS). The system enables real-time data overviews, supports EDI Electronic Data Interchange. If the container data, e.g. from customers and agents, is pre-advised, it will reduce the manual input to a minimum. It also offers Windows-based Graphic User Interface to provide the user with a real-world environment, helping manage the container yard, equipment and resources more efficiently. An overview on the CTIS modules is as follows (http://www.hamburgportconsulting.de/s2_engl.html):

- Gate- und Truck Monitoring
- Vessel Call and Berth Planning
- Yard Planning

- Ship Stowage Planning
- CFS Container Packing Station
- Customs Access
- EDI (Electronic Data Interchange)
- Report Generator
- Connectable devices/systems
- Radio Data Terminals
- Internet
- Invoicing/Tariffing

On the other hand, Hamburg's Data Communications System (Dakosy) networks port operations and logistics companies within the port. It was established in 1982 and was selected as the world's top transport related EDI system by International Federation of Port Cargo Distributors.

Dakosy provides a data interchange interface that enables information flow among the companies along the whole transport chain. It offers customized software packages for specific segments in the transport chain that not only complement the existing software but also provide new solutions, such as monitoring dangerous goods or steering railway traffic.

The container information system, called COAST (Container Authorization System) offers online information about status, location and condition of container. It transfers general communication requirements from phone or fax to user friendly internet (Keith, 2003:22-24).

2.3 Busan Port:

Busan Port is the biggest port in Korea, which is located at the southeastern end of the Korean Peninsular and serving as the gateway connecting the Pacific Ocean and the continent of Asia. Although the port facilities are managed by Busan Port Authority (BPA), container terminals are operated by different companies. BPA utilizes PORT-MIS, which is originally developed by Busan Regional Maritime Affairs and Fisheries Office, to manage and control port activities, whereas every terminal operating company has its own terminal operating system.

PORT-MIS has the following functions:

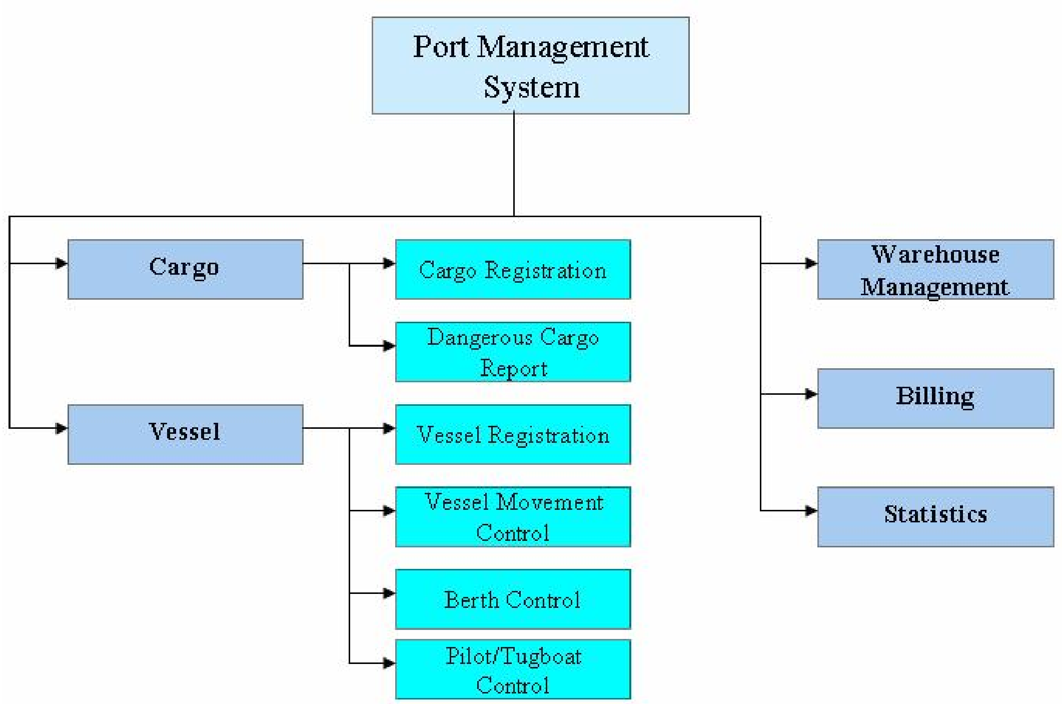


Figure 1. Main functions of PORT-MIS (http://www.klnet.co.kr/)

On the other hand, terminal operating systems differ slightly since terminals are operated by different corporations. As as example, the In-House System of Korea Hutchinson Terminal Co., Ltd. covers all terminal operations including gate, yard, vessel, sales and related statistics operations. It supports connections with CFS, EDI and customs. It also has modules for human resource management, financial system, equipment maintenance and repair, web page service and electronic mailing for team members. The system is also interfaced with a purchased ship planning system.

The communications and EDI is provided by a private network company called KL-Net. Kl-Net offers various B2G solutions through which companies can make online applications and service requests, such as booking for port facilities, custom clearance, immigration application for ship crew, railroad transport, request for inspection (fishery products, dangerous goods etc) and a financial module that enables online payment for taxes and port services.

KL-Net's Port Logistics' Integrated System for Maritime Business (PLISM) connects carriers, hauliers, terminal operators, checking companies and forwarders to support colloborative business. The system covers generation of precise logistics information, automated handling of compared data, maximization of information pooling, access to "job-site" information, standardization of requests and orders to minimize information dublication. The system runs on internet-base client/server system. KL-Net also provides various B2B solutions to support shippers, transporters, terminal operators. port logistics and electronic tax invoicing. (http://www.klnet.co.kr/)

### 2.4 Port of Hong Kong:

Terminal operating system utilized in Hong Kong International Terminals (HIT), uses BETA TUXEDO middleware that ties the elements of the system. HIT's award winning terminal management system, so called Plus Productivity Programmme (3P), is a fully- integrated solution to handle HIT's business requirements ans enhance and support yard operations. It includes capital, civil works and a large amount of process re-engineering, in order to achieve improved stacking capacity, improved handling capacity and improved yard operations (3P Brochure, http://www.hit.com.hk/facilities/3p.pdf).

All necessary information is transferred to the terminal for pre-planning process that ship planning and yard planning systems decide the method of deploying containers. For the yard operations, all necessary information about container movements and inventory control is exchanged between the system and the terminal mounted in the crane cabinet via radio frequency or fiber-optic network. After loading onto the truck, the crane operator sends a message to the system that regulates the entrance and the exit of the truck through the driver's identification card. Every component of the system works fully integrated to share information (Forward, 2003:43).

Based on 3P, the system called PIONEER allows terminal operators to automate their operations and achieve higher levels of efficiency and customer satisfaction (PIONEER Brochure, http://www.hph.com.hk/downloads/pdf/Pioneer.pdf). PIONEER System offers IT solutions not only for terminal operations, but also depot management, freight management and barge management. The functions of the terminal operation system includes vessel operations (container registrations, bay-plan and confirmations, vessel planning), gate operations, yard operations (yard crane and movement monitoring, automatic assignment for ground location), inventory management, operation management and billing.

Not only the terminal operations, HIT also invested in port community systems. In 1998, it launched Customer Plus Programme that enables exchange of electronic messages between HIT and shipping lines. Also, in 2003, it a new joint venture called OnePort Limited. The main purpose of OnePort is to improve business processes at the Port of Hong Kong by providing port community with value-added services and electronic information exchange between all port users. The system provides services such as on-line custom declaration, paperless container exchange services, paperless container collection and delivery for truckers and services for shipping documentation. HIT also offers EDI for invoicing and container related information through cellular phones.

### 2.5 Port of Rotterdam:

Rotterdam is one of the most modern ports in Europe. Europe Container Terminals (ECT) utilizes unmanned AGV's to transfer containers from berth to yard, and unmanned yard cranes operate in the yard to minimize waiting times. ECT plans to launch a new terminal system, called Total System Solution, in order to integrate the information systems in its Delta Terminals (http://www.ect.nl/).

All available information concerning the port is accessible via one central access point, PortofRotterdam.com. The port authority intended to provide a secure platform for engaging all manners of financial transactions, through a port-wide application of e-business. The site also provides an index of available e-commerce companies. The system is supported by various applications. For example Virtual Port: Rotterdam program provides a fast secure and reliable portal platform which enables easy access to electronic message exchange. This enables small companies within the port community to utilize EDI. Gigaport at Rotterdam program provides services including electronic verification of financial transactions, paperless transfer of commercial documents and web application for customs clearance. And WebJonas program, launched by Roterdam Municipal Port Management allows ship brokers to announce electronically the arrival of cargo and ships and settle their port dues (Forward, 2003:24-30).

### 2.6 Summary:

Utilization of advanced technology is common in almost every application of a port. Since the ports consist of various activities with different characteristics, a well-designed port management information system should supply information, goals, timing and frequencies to enable decision making for efficient port management. The system can differ depending on the characteristics of the task done.

On the basis of the above examples, information systems can be divided into three broad categories. *Terminal operating systems (TOS)* are "computer systems available for organizing the container terminal itself" (Jeffrey, 1999:39).

Terminal operating systems:

- Manage the flow of containers through the terminal by relocating the containers in the right places in the most efficient manner;

- Plan loading/unloading schedule and yard transfer operation by receiving information from shipping companies, describing position of containers on vessel coming into the port and which ones need to be taken off at the terminal;
- Process the containers transported into the terminal by rail or road, receiving notification from shipping companies and trucking companies about them; and
- Notify shipping companies and trucking companies about the locations of containers. (Choi, Kim, Park, Park, & Lee, 2003)

On the other hand port authorities may need systems to monitor and control the overall port activities and to accept official requests for vessel arrivals or using port facilities, called *Port Management Information Systems* [1]. Such systems can be distinct in the ports that don't operate its own terminals (such as PORT-MIS of Busan Port Authority) or such functions can be embedded in an integrated system (such as PORTNET of Port of Singapore Authority).

Moreover, *Port Community Systems* are "computer networks which link up the port with all the companies that use it, including hauliers, rail companies, shipping lines, feeder ports, shippers and customs officers" (Forward, 2003:14).

Although the configuration of the information system can differ depending on the port, an ideal port information system encloses all these functions under the umbrella of a totally integrated system.

## 3. Information Systems in TCDD Ports:

### 3.1 Information System Development Process for Turkish Ports:

TCDD ports started to build container terminals in 1985 to catch up the rapid changes of container transport in the world. Among these, Mersin, Haydarpasa and Izmir Ports were the ones with busiest container traffic.Increased traffic in these ports caused congession due to Turkish custom regime that is not flexible enough to develop regulations to easy such transport and the lack of sufficent control of the port operations with computerized systems.

In order to supply compter support to container terminals of Mersin, Haydarpasa and Izmir Ports, Ports Branch and Data Procesing Branch of TCDD prepared "TCDD Port Services Telecommunication Project", abbreviated as DELIMTEL. The analysis tasks were started in August of 1990. This had a wide range of purposes, including analysing container terminal activities and needs, developing a management information system for a selected pilot port and implementing the system to other ports.The project was estimated to be finished by the second half of 1992.

Meanwhile European Union (EU) carried out a project called MEDITEL, in order to develop a computer application program to ease the services the ports that face Mediterranean Sea and to form an information network that enables information transfer about ship and cargo traffic between these ports. The software package called ESCALE that was developed by Port of Marseille Authority was to be used in this project. TCDD declared to be involved in this project in 1991. Haydarpasa Port was chosen as the pilot port. According to the agreements, EU would finance the cost for software, and $70,000 of the hardware cost would be compensated by PMA.

The port officials examined both the software and the hardware to be used in the project and it was agreed that Haydarpasa Port is suitable for the project. On the other hand the modifications to be made on ESCALE package in order to fit the differences in management technique and infrastructure couldn't be finished on time by the French officials. Instead, the second ESCALE package was offered because of being better for problem handling. But even the second package couldn't fit the existing system. Negotiations with French officials and EU did not end in any result, and the project was clogged. So, in August of 1995, the technical committee declared to EU officials that developing a new application program for this port would be more suitable.

After four years, TCDD project group added "fare services", which was missing in the original project, to the application program of DELIMTEL and MEDITEL Projects and finished the new program called "Computerized Tracking of Port Operations Project" in the beginning of 1999. For the time being, this program is in service except for "services offered to the ship" (i.e. pilotage, fuel supply and so on) interface.

In 1995, another project was developed by using C programming language under UNIX operating system, in Izmir Port. This program was activated in Izmir Port after testing phase. But because of the problems about real-time operation of this application program with manually offered services, usage of this program was cancelled in 1999.

In order to ensure effective terminal and port management for TCDD ports through the application of "fully automated terminal operations", a technical committee was formed within TCDD and this committee started to compose required technical specifications in the beginning of 2000's. On the other hand, in the beginning of 2005, High Council of Privatization Administration decided that all services except transfer of ownership in all TCDD ports except Haydarpasa Port, would be privatized. This decision resulted in the cancellation of the project.

Meanwhile, server and computer parks provided to Mersin and Izmir Ports in 2004 and the application program developed by Haydarpasa Port's IS staff is still in use as an out-of-project application[2].

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[1] These systems are also referred as "Port Administration Support Systems" in Park, Choi, Lee, Kang, & Yang, 2005.

[2] Obtained directly form TCDD Headquarters, according to the Freedom of Information Act Law.

### 3.2 Current Situation in Turkish Ports:

Today, most of the basic operations are still carried out on paper. All applications for port services are taken by fax for the terminal operation tasks and even berth planning is done on paper. The situation is not so different in the case of port management tasks and custom declerations.

To make the present situation clearer, an interview survey was carried out in Mersin Port about the present condition of the port information systems[1]. Based on this survey, the problems of information systems of Turkish ports can be summarized as follows:

- Since the previous projects to implement information technology did not end in a success output, there is still no information system utilized in TCDD ports.
- Almost every operation is carried out by paper-based methods; computers are just used for in-office purposes.
- Electronic data interchange (EDI) technology is not utilized at all.
- There isn't a portal site for the ports that inform the users about up-to-date information about the ports.
- There isn't enough academic research on port information systems.

Based on literature survey, basic administrational and structural problems seen on TCDD ports are stated briefly as follows:

#### 3.2.1 Administrational Problems:

Port management couldn't be converted to an autonomous port authority system, so it suffers severe bureaucratic and regulative inefficiency. Port management must be flexible enough to deal with severe competition in the region, to meet the market demands and to be able to manage the port activities with low cost and high service standards. But such requirements are not likely to be realized by the current public administration (Lokmanoglu, 2003). Free Trade Zone in Mersin Region is a good example that same workers in the same port area are working more efficiently, due to the autonomous management

Since these ports are operated by government organs, port revenues are used for supporting other public services such as railroad expenses (Yucel, 1997), thus capital needed for port infrastructure investments is distributed over those services. As a result of this, required projects for infrastructure cannot be finished as predicted.

Port services are expensive. Turkish ports are indicated as the most expensive ports among the North Europe and Mediterranean ports and this situation is affecting international competitiveness of the ports (Undersecretariat, 2006).

Since most of the tasks are carried out by paper-based manual methods, speed of port and custom services fall behind the commercial activities. Information flow and coordination between port-related parties are inefficient.

The public ports suffer from insufficient human resources. The managers lack modern business management knowledge and trained operational staff, such as crane operators, is scarce.

Other administrational problems cover issues related to insufficient advertising and marketing of the ports, unregistered port land, and insurance policy that does not cover damages given to ships and cargo.

#### 3.2.2 Structural Problems:

Structural problems of the TCDD ports are about insufficient physical resources of the ports such as quays and wharves, lengths and drafts, equipments and vehicles that serve the hinterland, stacking and storage places and vehicle parking lots.

Provided that private ports in Turkey do not have railway connection, 95% of the cargo handled in the ports is transferred by trucks, indicating that connection of railway and ports couldn't be realized for inter-modal combined transport. Other structural problems about railway transport –such as lack of easy access cargo tracking system and container land terminals, etc- are affecting Turkey's international competitiveness and the cargo route between Europe and Asia is being shifted beyond the borders of Turkey.

Old equipments frequently break down. Maintenance and repair of the equipment cannot be handled in an efficient way because of bureaucratic problems. On the other hand, cranes also break down due to overloading (Gulenc, 2004).

Traffic within the ports is not well-regulated and frequently congests. This is due to insufficient sign tables, lack of control, and uncontrolled and irregular usage of yard area (Gulenc, 2004).

General administrational and structural problems of TCDD ports are summarized in Table 1.

## 4. Contribution of Information Systems to the Problems of TCDD Ports:

In this section, contributions of information systems to solution of the problems stated above are discussed. Most of these problems can be solved, or at least reduced by effective utilization of information technology.

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[1] The main reason for selection of Mersin Port is that in the study of Yucel (1997)it is stated that TCDD operates all the ports in the same way. So the results of Mersin Port are assumed to be applicable to other ports that are operated by TCDD.

Table 1. General administrational and structural problems of TCDD ports.

| | Problems | Source |
|---|---|---|
| Administrational problems | Port management couldn't be converted to an autonomous port authority system, so port management suffers severe bureaucratic and regulative inefficiency. | Yucel (1997), Undersecretariat (2001), Gulenc (2004) |
| | Speed of port and custom services fall behind the commercial activities. | Yucel (1997), Cubukcu (1998) |
| | Port services are expansive and are not based on cost-analysis. | Yucel (1997), Undersecretariat (2001), Gulenc (2004) |
| | Long-term planning cannot be made and investments cannot be realized as predicted. | Yucel (1997), Cubukcu (1998) |
| | Information flow and coordination between port-related parties are inefficient. | Yucel (1997) |
| | Human resources are insufficient and managers lack modern business management knowledge. | Yucel (1997), Gulenc (2004) |
| | Trained operational personnel (i.e. crane operators, etc.) are scarce. | Gulenc (2004) |
| | Tasks are carried out by paper-based manual methods. | Yucel (1997), Cubukcu (1998) |
| | Advertising and marketing of the ports are insufficient. | Yucel (1997) |
| | Port revenues are used for supporting other public services. | Yucel (1997) |
| | Damage given to ships and cargo are not compensated by insurance. | Yucel (1997) |
| | Maintenance and repair of the equipment cannot be done properly due to regulation problems and heavy bureaucracy. | Gulenc (2004) |
| Structural problems | Land is insufficient; there isn't enough land for containers and truck parking. | Yucel (1997), Undersecretariat (2001), Gulenc (2004) |
| | Handling technology is old and equipment is out-of-date. | Yucel (1997), Undersecretariat (2001) Gulenc (2004) |
| | Berth lengths and depths are insufficient to accommodate large container vessels. | Yucel (1997), Undersecretariat (2001) |
| | Special facilities for dangerous cargo are either insufficient or do not exist. | Yucel (1997) |
| | Equipment and facilities to prevent pollution are insufficient | Yucel (1997) |
| | Traffic and physical distribution within the port is frequently congested. | Yucel (1997), Gulenc (2004) |
| | Combined transport between maritime and rail transport cannot be realized, therefore 95 percent of the cargo is carried from the port by trucks. | Undersecretariat (2001) |
| | Gantry cranes broke down frequently due to overload. | Gulenc (2004) |

### 4.1 Contribution of Information Systems to Administrational Problems:

In order to solve the regulative and bureaucratic problems privatization was a necessary (UNCTAD, 1982) but late move. The most important contribution of information systems to flexible port management is that it is generally accompanied by its peculiar management method, referred as business process re-engineering (Hammer, 1990). When information systems are designed, corresponding business processes are to be transformed in order to ensure flexible management and maximized efficiency of the system utilization. If the business processes do not accompany information system deployment, the gaps and contradictions between the system and the on-going processes may cause failure of the system, just as in the case of previous system development efforts in TCDD ports.

Real-time information exchange between the port administration and other port related parties is one of the most important features of the port information systems and it provides coordination and efficient control of the operations. Through electronic data interchange (EDI) technology, all traditional paper documents can be converted to electronic documents and exchanged between related parties thus the service speed is increased and error rates are decreased.

Another problem stated above is the port service fees. Although determination of port fees is a complex procedure, information systems can help the costs to go down by the efficient utilization of existing resources. Moreover, information systems decrease the need for human resources, thus decrease labor costs.

The contribution of information systems to human resources problem is that it makes the operations and tasks more human-independent. In most of the advanced ports, even container handling is done by unmanned, automated cranes and transfer vehicles, thus the need for trained and experienced operators is reduced. Even office work can be done by less number of staff, due to reduced paperwork. On the other hand, when a new system is introduced, the staff must be educated about the new system, and it must be considered separately.

As the information systems increase the operational efficiency, they certainly contribute to the competitive power of the port, contributing its marketing and commercial activity within the port.

### 4.2 Contribution of Information Systems to Structural Problems:

For most of the time, deployment of new infrastructure and equipment, or expansion of the yard area would be very expensive, or sometimes impossible for certain restrictions. Instead, port administrations should maximize the utilization of available resources. From this point of view information systems play a crucial role. All the tasks performed in the terminal area can be planned, organized and coordinated by corresponding modules. Moreover, information systems can coordinate the operations of different parties, resulting in more efficient operational performance and less wastes of time and resources. For example, due to its terminal operating system, CITOS, the Port of Singapore can stack containers up to nine high in order make a good use of its very limited land (Applegate, 2003:315).

It is a fact that the equipments used in the ports are old and need to be renewed. Despite, maintenance and repair of the equipment can be controlled efficiently by the help of information systems. An ideal terminal operating system should contain an equipment management module (Choi, Kim, Park, Park, & Lee, 2003).

On the other hand, cranes do break down due to overloading (Gulenc, 2004). Again, information systems can help equipment management by controlling time schedules for each crane and vehicle, regulate task dispatching for each equipment and allocate operator to cranes and transfer vehicles. By doing so, the system not only ensures the efficient utilization of port resources, such as equipment as well as human operators, but also avoids overloading.

To reduce congestions within the terminal area, information systems can allocate each container in the yard in the most efficient manner, and send instructions to trucks and trailers for container movement. The order of tasks can be coordinated by the system in order to minimize equipment moves and time wastes and thus the traffic not only within the yard but also during entry/exit through gates is regulated efficiently.

The effect of information systems will be enhanced if they are connected to other systems. Integrated information systems, enabling cargo tracking and information exchange between various related parties, should accompany other infrastructural investments for port and rail developments in the future. Such developments will certainly help Turkey to regain its strategic position for cargo flow between Europe, Asia and the Middle East.

These contributions are summarized in Table 2.

Table 2. Summary of the results.

| Problems | | Contribution of IS |
|---|---|---|
| Administrational | 1. Expensive fees | 1. decrease cost by efficient use of resources<br>2. decrease labor cost |
| | 2. Severe bureaucratic and regulative inefficiency. | 1. accompany changes in business processes |
| | 3. Manual, paper-based management, inefficient information flow and coordination. | 1. enable real-time information exchange<br>2. paperless work environment with EDI |
| | 4. Insufficient human resources. | 1. tasks become more human-independent<br>2. less labor needed for same amount of work |
| | 5. Insufficient advertising and marketing. | 1. increase competitiveness |
| Strucural | 1. Insufficient land, equipment and facilities. | 1. more efficient utilization of existing resources |
| | 2. Old equipments, frequent breakdowns, inefficient equipment maintenance and repair. | 1. optimize work instructions to avoid overloads<br>2. online control of equipment M&R |
| | 3. Frequent traffic congestions within the ports. | 1. optimize work instructions and yard allocation |
| | 4. Inefficient connection between the marine and railway infrastructure. | 1. information exchange between parties<br>2. on-line cargo tracking |

## 5. Conclusion

In the preceding chapter, on the basis of world's advanced ports and previous academic studies, how information technology can contribute to solve the general structural and administrational problems of the public ports in Turkey was discussed. If they are added up, the basic level of information system that needs to be built in Turkish ports should include the following properties.

Terminal Operating System (TOS) :

- planning
- yard allocation for containers
- job dispatching for equipment and operators
- work load optimization
- equipment M&R

Port Management Information System (PMIS) :

- paperless work environment
- real-time monitoring and control of operations
- better marketing through increased competitiveness

Port Community System (PCS) :

- real-time information exchange
- coordination between transport modes

On the other hand, a well-designed information system may not always guarantee successful results. The system must be supported with other precautions to ensure efficiency. These are the problems that cannot be solved by information systems directly, and have significant effect on the success of the system. These factors can be summarized as follows:

- Legal regulations should be amended to ensure a flexible business environment within the port.
- Information planning must be well-established before the implementation project to avoid future operational failures and user dissatisfactions
- Out-of-date business processes within the ports should be improved to be in consistence with information systems
- Old equipment should be replaced by high-performance equipment that can operate in harmony with the new system.
- Both operational personnel and managerial staff should be trained about the new system, since they are the ones who are supposed use the system

It must be noted that logistics activities are like links of a chain, strength of which depends on the strength of the weakest link. Each and every of the factors above can be a bottleneck for the development of the new system. The failure of the projects in the past can be seen as evidence, so the success of the future projects, especially after privatization, depends on these precautions.

## 6. Acknowledgements

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# STANDARDS, SECURITY & PRIVACY ISSUES ABOUT RADIO FEQUENCY IDENTIFICATION (RFID)

Evsen Korkmaz[1], Alp Ustundag[2] and Mehmet Tanyas[3]

## Abstract

*There is no doubt that managing the flow of goods depends on monitoring the real flow in the physical world meanwhile in the digital world. Today automatic identification (auto-ID) technologies are used to close the gap between these two different environments by online updating of databases as the materials flow in the chain. From this point of view, we can say that auto-ID technologies are core components of automated inventory control systems on all echelons of supply chain. As being a novel sub-component of auto-ID, RFID innovates important features. Although developments in RFID technology begun nearly 50 years ago, recent advances provided new opportunities improving commerce and everyday life. New applications and obligations (like the obligations that are put forward by Wal-Mart to its suppliers) bring forth different aspects. Due to the fact that RFID is a recently developed technology, there exist some deficiencies, like the lack of standardization and the lack of legislation regulations, that cause questions about privacy and security in society. In this study, we reviewed the standardization studies of related organizations like EPCglobal and ISO, compare these and find the gaps. We also classify the risks that threaten the privacy of individuals and organizations. Finally, regarding the standardization studies and existing risks towards the privacy of individuals and organizations, security proposals and policy suggestions are introduced.*

*Keywords: Automatic Identification (auto-ID), Radio Frequency Identification (RFID), Security, Privacy, Standardization, Supply Chain Management (SCM)*

## 1. Introduction

RFID (Radio Frequency Identification) technology is the latest Auto-ID technology that is anticipated to supersede the barcode technology. As its name implies, RFID uses radio signals to communicate. There are three main components of RFID systems. These are tag, reader and back-end database (Weis, 2003). The communication between these components is provided by radio waves like the other wireless technologies as Bluetooth. RFID represents several distinctions over barcodes in terms of (1) non optical proximity communication, (2) information density, (3) two way communication ability and (4) multiple simultaneous reading (read more than one item at once) (Roberts, 2006). These features provide RFID the advantage of expanding all echelons of the supply chain. While the manufacturing of RFID tag technology is evolving, it is planned to develop tiny tags that are invisible to the human eye. The microscopic beads (RFID tags) can be embedded in inks to track banknotes and other important documents. The microscopic tags can also be added to the materials like automobile paint, explosives, or other products that law enforcement officers or retailers have a strong interest in tracking. According to researchers, this technology could be ready for commercial use in three to six years (http://epic.org/privacy/rfid). The other constraint that lays in the future proliferation of RFID tags is cost of tags. A barcode label can be produced at a cost of less than 1 cent per label. So the main drawback of RFID against the barcode is cost of tags. According to the RFID tag classes, the cost also differentiates. Whereas some RFID tags can cost several dollars, the cost of cheapest ones decreases day by day. It is expected that the cost of Class 1 RFID tags to go down to 15 cents within the next two years. EPCglobal classifies the RFID tags into five main groups such as Class 0, 1, 2, 3, 4 according to its functionality (Roberts, 2006). The classification is shown in

Table 6, Class 1 type is the discussed one for global supply chain adoption due to its cost. Manufacturers of RFID tags achieved to produce a tag at 30 cents cost for these class 1 tags (Hou, 2003). Such improvements in cost and size will ensure speedy expansion of RFID technology into many areas of use. For instance to this incredible development of RFID technology, retailers insist on expanding the use of tags from pallet-level to item level (Flint, 2006).

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Table 6: Tag Classes according to EPCglobal.

| Class | Nickname | Power Source | Memory | Features |
|---|---|---|---|---|
| 0 | Anti-Shoplifting Tags (EAS) | Passive | None | Article Surveillance |
| 1 | EPC | Any | Read-Only | Identification Only |
| 2 | EPC | Any | Read-Write | Data Logging |
| 3 | Sensor Tags | Semi-Passive or Active | Read-Write | Environmental Sensors |
| 4 | Smart Dust | Active | Read-Write | Ad Hoc Networking |

Beside the utilities provided by RFID, there are also drawbacks. The great efficiency gains offered by RFID systems may come at cost of inadequacy of privacy, security and standardization issues.

The risk of being read of insecure tags by unauthorized readers is the main concern about privacy and security. Physical attacks, traffic analysis, eavesdropping, counterfeiting, spoofing, replay attacks and denial of service are threats of RFID systems in privacy and security respect (Henrici & Müller, 2004). Each of these risks may affect the privacy and security of both individuals and organizations. When we consider the risks towards individuals, the main risk about privacy is insecure tagging of individual items. Unfortunately, the universal deployment of low-cost RFID tags in consumer items increases day by day. Clothing, shoe and accessory makers have all started embedding RFID tags in their products (http://www.rfidjournal.com/article/articleview/272, 2002). There are some protests against the item level tagging without informing the consumers (http://www.spychips.com). One of the largest clothing manufacturers of the world had to retreat because of boycotts from its customers (Roberti, 2004). Consumers may not even be aware that they are carrying RFID tags. In response to this unawareness, some regulations such as "Bill of Rights" are proposed (Garfinkel, S. 2002). Due to the possibility of being everywhere, RFID tags have the capability of monitoring every detail that you do, what you buy, pretty soon where you go. Retail markets can come to learn the buying patterns of consumers. There are several retail projects being developed nowadays. The concern of these projects happens to be simply tagging store loyalty cards, in order to develop on-line and one-to-one advertisement in retail shops. Another purpose is to determine which parts of the store are being visited most often (or not at all) (Flint, 2006). By means of these studies, digital maps of retail markets can be drown with CRM studies.

Insecure tag threats are not limited to violation of individual privacy. It also threatens organizations. Corporate spies could monitor insecurely tagged inventory of a retail store, a warehouse or a cross-dock. Through periodical monitoring, they can get the sales data or promotions data easily.

Standardization is an important issue as much as privacy on RFID technology. One of the obstacles laying in the future enhancement of RFID is lack of standardization. There exist organizations that have studies on standardization issues such as ISO and EPCglobal. Standardization is important for an enhanced use of RFID through the global supply chain for three main reasons (Yu et al., 2005). First of all, provided that RFID technology has international standards, interoperability across national borders will be achieved (appropriate to global supply chain adoption). Harmonization of standardized tags and readers manufactured by different vendors can be obtained. The other reason for getting the advantage of developing international standards is bringing the costs of exchangeability down. Finally an internationally accepted RFID standard will facilitate the growth of the worldwide RFID market. In spite of all progress on paving the way for RFID usage throughout the global supply chain, there still exist gaps on standardization. As it will later be explained in detail, just after arriving a compromise on an air interface protocol proposed by EPCglobal (called Generation 2), new debates are about its insufficiency. It has been claimed that Gen 2 can not meet the requirements of item-level tracking: Gen 3 is on its way (Ashton, 2006).

In the following chapter, after determining fields of standardization studies such as air interface, application areas, etc., we discuss the recent standardization studies. In Chapter 3, we go into details in privacy issues, then classify the privacy proposals according to some attributes. Finally, Chapter 4 offers a conclusion and suggestions about the standardization, privacy and security.

## 2. Standardization for RFID Adoption

As we mentioned previously, standardization is an important issue for proliferation of RFID technology throughout the global supply chain for three main reasons. In summary by courtesy of standardization studies, the interoperability of tags manufactured by different vendors can be provided, the costs of exchangeability get down and also world-wide standardization make RFID usage more common. International Standards Organization (ISO) and EPCglobal are working to develop international standards for RFID technologies especially in UHF spectrum. Even though it is commonly defended that there are no standards or there is no harmonization between existing ones, there are currently many well-established standards. But the completion of all standards can not be achieved up to now. The lack of a complete and unified RFID standard has caused many companies to hesitate in adopting the RFID systems; some companies did not dare to make a commitment to a not standardized technology, by fear of finding one day the whole investment worthless. After mentioning well-established standards, emerging standards such as Gen 3 protocol are also discussed below.

## 2.1. Fields of Standardization

Standardization studies deal with the description of data link, physical and application layers (Knopse & Pohl, 2004). Data link layer includes anti collision, initialization, data content and tag addressing protocols. One of the distinctive properties of RFID is multiple simultaneous reading of tags (mentioned in chapter 1). Related with this property, simultaneous transmissions on the same frequency may result interference that is called *collision*. Collisions may result in a failed transmission. A method that is employed by readers and tags needed to avoid collisions, referred as an *anti-collision algorithm*. Several attributes can be used to evaluate the quality of anti-collision algorithms (Weis, 2003). These are: performance, range, bandwidth requirements, implementation costs, noise and error tolerance and finally security of algorithms. Anti-collision algorithms may be either probabilistic or deterministic. The most common used deterministic algorithm is called "binary tree walking algorithm" and it is commonly used on UHF spectrum. ALOHA scheme is another well-known algorithm as a probabilistic anti-collision algorithm. Tags operating on highly regulated 13,56 MHz band tend to use probabilistic network. Data content determines how data is organized or formatted.

Physical layer includes air interface functions. Air interface protocol deals with how a transponder is activated and how the information stored in the transponder is transferred to a transceiver. Shortly, it shows the way tags and readers communicate (http://www.rfidjournal.com/article/articleview/1335/1/129/). Instead of anti-collision, air interface protocols have to be standardized.

Application layer organizes how standards are used on shipping labels. Conformance is another protocol of that layer; it deals with testing whether the products meet the standard or not.

## 2.2. Established Standards on RFID

As a long standing organization, ISO has created RFID standards for many areas like cattle tracking or payment systems (Knopse & Pohl, 2004). ISO 11784 that defines how the data structured on tag, ISO 11785 that defines the air interface protocol, ISO 14223 and ISO 18000-2 are all related with the standards of animal tracking. Only ISO 14223 becomes different from others with further allowance of read/write and write-protected data blocks. These standards are all related with each other and for animal identification in the frequency band below 135 kHz. ISO 14443 has been created for payment systems and contactless smart cards (proximity cards) and they can be operated at approximately 10 cm distance from the reader; ISO 15693 has been created for vicinity cards to define air interface, anti collision and transmission protocols. ISO 18092 defines the near fields communication protocol in the frequency band of 13,56 MHz. For testing the conformance of RFID tags and readers to a standard, ISO created ISO 18047, and ISO 18046 for measuring the performance of RFID tags and readers. ISO has also developed standards for item management. ISO 18000 defines the air interface, collision detection mechanisms and the communication protocol for item tags in different frequency bands. There exists seven parts in this item management standard. First part (ISO 18000-1) is related with the reference architecture. Other parts (2 to 7) specify the characteristics for different frequencies. ISO 18000-2 specifies low frequency tags (<135 kHz). ISO 18000-3 is for HF systems (13,56 MHz) that is compromised with ISO 15693 created for vicinity cards. ISO 18000-4 specifies 2,45 GHz systems; ISO 18000-5 specifies 5,8 GHz band. Part seven (ISO 18000-7) specifies an RFID system with active transponders and range in the 433 MHz band. ISO 18000-6 organized the air interface for 860 MHz to 930 MHz. This sixth part is the most common-known part for two reasons. First of all at this band level, there is no standardization between continents. The United States and Canada allocate the frequency band from 902 to 928 MHz for UHF RFID systems because their GSM bandwidths are not located within this band. The European Telecommunications Standards Institute (ETSI) has released a 2MHz band ranging from 865.6 to 867.6MHz for Europe's UHF RFID use in July 2004 (Word & Kranenburg, 2006). Japan has allocated a 2MHz UHF band ranging from 953 to 954MHz for RFID use in May 2005. The diversity in national spectrum allocation for RFID adds more barriers to the growth of RFID systems in the world market. RFID tagged goods traveling across borders, respond only to a specific UHF frequency range. So the tags cannot be read in countries where different spectrum bands are allocated for RFID use. Secondly EPCglobal's Gen 2 standard is related with ISO 18000-6 for addressing the same application level. The harmonization studies had gone on from December 2004 to July 2006.

EPCglobal is established by EAN International and Uniform Code Council (UCC) to commercialize EPC technology that is developed by MIT Auto-ID Center in November 2003. MIT Auto-ID Center was set up in 1999 to develop the Electronic Product Code and related technologies that could be used to identify products and track them through the supply chain. EPCglobal has the responsibility for commercialization and management of Electronic Product Code (EPC) system researched and developed by the MIT Auto-ID center. Auto-ID Center chose to create its own air interface (UHF) protocol for tracking goods through the international supply chain that is available royalty-free to manufacturers and end-users, instead of using ISO protocols as the standard for the air interface. The reason for rejecting ISO standards is its complexity: it increases the cost of the tag unnecessarily. Cost issue is extremely important for EPCglobal because of its mission, which is to develop a global RFID system that can be used on open supply chains. The tags must be disposable. So the developed RFID system must be a low-cost system. Consequently, Auto-ID Center standardized the air interface protocol at ultra-high frequency band. Only UHF band provides the read range needed for supply chain applications, such as reading pallets coming through a dock door.

In 2004, EPCglobal started to develop a second generation protocol, called Gen 2. The purpose of the studies is to create a single, global standard that would be more closely aligned with ISO standards. EPCglobal approved Gen 2 in December 2004. Afterwards, ISO required revising the protocol in accordance with ISO RFID standards. Unfortunately, the approval of ISO delayed for a disagreement on Application Family Identifier (AFI). EPCglobal finally announced that ISO incorporated its Generation 2 RFID air interface protocol into ISO 18000-6 standards on UHF in July 2006 (Elamin, 2006). Surely, this evidence is a significant milestone in the history of RFID adoption.

TOBB-GS1 is an organization aiming to standardize the national UHF bandwidth in Turkey. It is expected that The Turkish Telecommunications Standards Institute sets the national UHF bandwidth of Turkey as the same frequency band of Europe.

Figure 17: Established standards on different bandwidths (Knopse, H. & Pohl, H. 2004)

## 3. Privacy & Security

Defined as the ability of an individual or group to keep their lives and personal affairs out of public view, or to control the flow of information about themselves (http://en.wikipedia.org/wiki/Privacy), privacy is an important matter of modern community. According to some authors, improvements in technology are not all for the furtherance of public welfare. For instance, we are regularly filmed by CCTV cameras integrated with facial recognition software. Anyone could follow us through public areas by the help of this devices and software. This example may be considered as violation of individual privacy, to be more specific, a type of privacy called “location privacy”. As one might guess, there are different classifications of privacy categories. In this paper we present only two of them. As reported by Weis, the Electronic Privacy Information Center (http://www.epic.org.) categorized privacy into four separate but related groups:

1. *Information Privacy:* Involves rights regarding the handling of personal information such as tax, medical or purchase records. Also known as “data privacy”.
2. *Bodily Privacy:* Concerns the right not to be subjected to invasive bodily procedures such as cavity searches and blood, urine or genetic tests.
3. *Communication Privacy:* The right to communicate with others in secrecy.
4. *Territorial Privacy:* Rights limiting intrusion into domestic, workplace or public environments, including searches, identification checks and video surveillance.

According to the other classification type of privacy (http://en.wikipedia.org/wiki/Privacy) there are three main categories:

1. *Political privacy:* The right of keeping your political opinion secret for a variety of reasons - political groupings may be able to commit violence either when successful (using the powers of the state) or when defeated (using their own militias for example).
2. *Medical privacy:* The right of keeping your state of health secret. The reasons for keeping medical information private may include possible discrimination against people with a certain medical condition
3. *Genetic privacy:* The concept of “genetic discrimination” and the associated need for confidentiality of genetic information, or "genetic privacy constitutes this privacy title.

Up to here, we have mentioned the privacy issues and introduced how technology and privacy are related. Hereafter we can evaluate the RFID technology with that point of view. In some cases RFID threatens some of privacy rights. When we assess the risks according to the categorization of EPIC, we can list these threats. Monitoring a warehouse illegally by RFID readers and getting a company’s inventory data may violate the right of information privacy. Unauthorized tracking of a persons’ state of health by RFID readers also violate the bodily privacy. Tracking cars by RFID technology can also violate the territorial privacy. The government of UK is working on a project aiming to build a database of exactly where the 28 million vehicles on the road were at any time (http://www.e-plate.com).

### 3.1. Classification of Proposals on Privacy & Security Issues

*While RFID technology is spreading out, the number of studies on security and privacy is increasing. Although some approaches have been fixed in literature, newly developed schemes are being added day by day. Some fixed proposals are given in order:*

- Kill Command Approach: By sending a special "kill" command, a tag can be deactivated or killed. A killed tag can never be activated after sending this special command. It is the most straightforward approach for protecting end-consumer privacy. On the other hand it also limits the utilities that can be gained in home applications like smart oven or refrigerator. Major manufacturers of home appliances are working on R&D projects with huge budgets. From this point of view, kill command approach is not so favorable for mass usage.
- Faraday Cage Approach: Using containers made of metal mesh or foil that are impenetrable by radio signals is the general definition of this approach. As one might guess, this method can only be used for valuable goods.
- Active Jamming Approach: The consumer uses a radio frequency device that could create a noisy environment by broadcasting radio signals at random. For purpose of preventing unauthorized readers to get the tag data, this approach could also block other legitimate RFID readers. Because of the drawback, this method is somewhat crude.

*Beside these approaches more developed and detailed schemes appear in literature every day. Some of these studies build up on regulative proposals such as "Bill of Rights". Others stress on more technical proposals such as cryptography and authentication. In this study we classify related studies into two main groups: regulative and technical approaches.*

#### 3.1.1. Regulative Proposals

Item level tagging of goods increases and so does the possibility of monitoring individuals. The unawareness of consumers that they are carrying RFID tags runs a risk towards individuals. For example, one of the major tire manufacturers of the world announced that they are working on a project about embedding RFID tags in their products (http://www.rfidjournal.com). Most of the people purchasing these tires will never know, nor even suspect, that their car could be tracked by transponders in their tires. Consumers should have some options about buying RFID tagged ones or non RFID tagged ones. Beside the awareness rights, consumers should also have the right of removing or destroying tags on the goods that they purchased. Considering these issues, Garfinkel wrote a "RFID Bill of Rights" (2002) based on the US Department of Health and Education's Code of Fair Information Practices. According to Garfinkel's Bill of Rights:

Users of RFID systems and purchasers of products containing RFID tags have;

1. The right to know if a product contains an RFID tag.
2. The right to have embedded RFID tags removed, deactivated, or destroyed when a product is purchased.
3. The right to first class RFID alternatives: consumers should not lose other rights (e.g. the right to return a product or to travel on a particular road) if they decide to opt-out of RFID or exercise an RFID tag's "kill" feature.
4. The right to know what information is stored inside their RFID tags. If this information is incorrect, there must be a means to correct or amend it.
5. The right to know when, where and why an RFID tag is being read.

The first right may be satisfied using an industry standard logo on all consumer goods carrying an RFID device, such as other similar logos that exist for organic or genetically-modified products. This logo will simply state that the product has the RFID tag, offering consumers the possibility to make an informed decision and decide whether to disable the tag or purchase a non-tagged alternative. This makes the second and third rights practical.

Likely to "Bill of Rights" study, EU is also working on to provide secure environment with RFID usage. In January 2005, the EU Article 29 Working Party on Data Protection issued a "Working document on data protection issues related to RFID technology" and invited comments, the summary of which was published on 28 September 2005 (Flint, 2006).

#### 3.1.2 Technical Proposals

In general there are two technical approaches aiming to provide data security on the RFID tag (Hui, Wong, Chan, 2005). Encryption of the data that is stored on RFID tags is one approach. Authentication between the RFID readers and tags is the other.

##### 3.1.2.1 Cryptographic proposals

Cryptography is defined as a process associated with scrambling plaintext (ordinary text, or clear text) into a cipher text (a process called encryption), then back again (known as decryption) (http://www.stallion.com.au). In this approach, by the encryption of the data stored on the RFID tag, the data can be protected in cipher text format instead of clear text format. By means of this, the data retrieved by unauthorized readers will be meaningless, unless they are able to decrypt all the information they received.

There exist different cryptographic approaches for RFID security issue. The most common-known cryptographic approaches are public key, hash function (lock) and randomized hash function approaches. In public key approach, each tag should carry a particular vendor type of readers' public key and its unique private key. During reading, readers and tags may mutually authenticate each other with these embedded keys. Authentication between readers and tags can be achieved by a challenge–response technique. Eavesdropping can be prevented unless attackers find out the actual private key of each tag, but this is unlikely in a short period of time. In hash lock approach, a tag may be locked so that it refuses to reveal its ID until it is unlocked. In the simplest scenario, when the tag is locked it is given a value (or meta-ID) y, and it is only unlocked by presentation of a key or PIN value x such that y = h(x) for a standard one-way hash function h. Randomized hash function approach is an extension of hash lock approach. The main difference is based on pseudo random functions. An additional pseudo-random number generator is required to embed into tags for this approach. Presently, tags respond to reader queries by a pair of values (r, hash(IDk || r)) where r is the random number generated by a tag, $ID_k$ is the ID of the $k^{th}$ tag among a number of tags in $ID_1$, $ID_2$, ..., $ID_k$, ..., $ID_n$. When a reader inguire the tag, it gets two values: a random number and a computed hash value. Computed hash value is based on the concatenation (||) on its own $ID_k$ and r. If the reader is an authorized one, it can check all registered ID values on its backend database and finally reach the $ID_k$ value for that specific tag . Thanks to this process, tag authentication can be provided. After sending the $ID_k$ to the tag, tag will be unlocked and send its EPC data.

After introducing these three major cryptographic approaches, we can compare these according to their drawbacks. Public key approach necessitates high computation power for RFID tags. Thus, the cost and also the size of RFID tags are greater for item-level tagging. The main disadvantage of hash function approach is the lack of mutual authentication. For example, a hacker can obtain the Meta-ID value of a tag, then with this value, he/she can counterfeit a tag and can get the specific random key from the authorized reader for this Meta-ID value. Therefore, the hacker can catch the chance to get the key to unlock the tag and obtain its EPC data. Besides the hacking possibility, hash function approach can not provide the location privacy due to the stable Meta-ID value broadcast by the tag. As one might guess, randomized hash function is more reliable for privacy and security respects but it is not practical or feasible for systems that have big numbers of tags. Because of the random number generator, the cost of tags is high.

#### 3.1.2.2 Authentication proposals

Normal information retrievals from the tags to the reader can be allowed to proceed, provided that authentication has been done before. Thus, both the reader and the tags identify they are the right parties to exchange information. In order to prevent illegal access to the memory segment of tag, there should be a procedural access control. In literature there exist studies on authentication proposals that are mentioned in the next part of this paper.

### 3.2 Summary of Proposals on Privacy & Security Issues

When the studies related with security/privacy issues are examined one by one, it can easily be seen that most of them focuses on EPC Class 1 RFID systems. The main reason is that it is targeted to use Class 1 tags for global supply chain adoption thanks to low costs. Related with this cost attribute other constraints exist on Class 1 tags. Their computational capacities, memories and read-write storages needed for cryptographic and authentication processes are limited. Class 2, 3 or 4 types of tags have the capability of supporting any complex cryptographic protocols. So it is easy for these systems to provide secure environments, but on the other hand these systems are too expensive for mass markets.

Henrici and Müller developed a simple hash based scheme to overcome limited tag resources (2004). They aimed to keep only short-term values in a tag. The main data storage work is loaded to back-end database system. Their scheme is based on a one-way, simple hash function and a key management process executed on backend system. Although the tag only performs hashing, location privacy can be provided by changing the Meta-ID of the tag in every read attempt. This means that the tag changes its identity on every query. A structure called reference database manage these procedure of identity changing. The database must provide a single random number to calculate the new tag identifier. In this scheme complex processing is required neither at the tag nor at the database. This proposal is favorable for its simplicity. It only requires implementation of a hash function in the tag and data management at the backend. It does not necessitate random number generation on tags. Location privacy is also provided. It is claimed about the scheme developed by Henrici and Müller that it can not resist to replay attacks (Chien & Chen, 2006).

Juels, Rivest, and Szydlo (2003) added a new approach for protecting consumer privacy to the conventional classification mentioned in 3.1. In addition to kill tag, faraday cage, active jamming approaches, they put forward "smart RFID tag" approach. They mixed hash-lock approach and re-encryption approach in this title. In addition to these, silent tree walking that is mentioned previously as an anti-collision algorithm is considered in smart RFID tag. The scheme developed by Juels et al. is the mixture of active jamming and tree-walking protocols. As mentioned before active jamming approach is a crude approach. It could cause severe disruption of all nearby RFID systems, even those in legitimate applications. However the proposed approach is akin to jamming, but it is more clever in its operations by interacting with the tree walking singulation algorithm. It aims selectively blocking. This approach uses tree-walking singulation algorithm for two reasons: tree walking algorithm is likely to be the most common anti-collision technique, and also it is supportive of the more flexible modes of blocking. As cited above, there is one more well-known singulation approach called ALOHA. However the proposed smart blocker tag technique does not work with ALOHA, since it is not possible to block certain subranges of IDs on a selective basis. Selective blocking can materialize by tree-walking algorithm with the feature of simulation of the full set of $2^k$ possible RFID-tag serial numbers conducted by blocker tag. The tree-walking singulation algorithm enables an RFID-tag reader (also enables the blocker tag) to identify the serial numbers of nearby tags individually by means of a bit-by-bit query process resembling a depth-first search of a binary tree.

For example, in Figure 18 a tree which is of depth 2 is shown. So it has $2^2 = 4$ tag serial numbers represented in its leaves. If only two of them are present, the others are only imitated two-bit serial numbers. This means they refer nothing. An unauthorized reader can not know which ones do really exist.

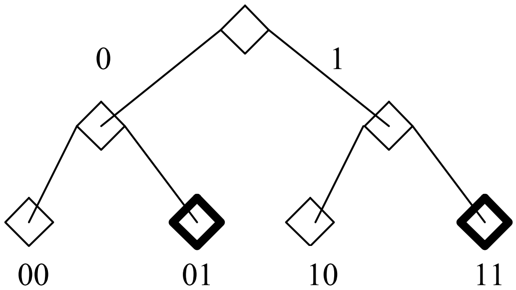


Figure 18: A depth-two binary tree. (01 and 11 tags are present)

Considering that an EPC code consists of 64 or 96 bits, it is hard for an unauthorized reader to inquire each $2^{64}$ or $2^{96}$ alternatives. In selective blocking tag approach, a blocker tag simulates the full spectrum of possible serial numbers for tags of a physical region that is aimed to keep private.

The approach developed by Juels et al. is feasible for its very low cost implementation. It is cheap to implement because the RFID tags which are in use in consumer goods may not to be modified at all, and the blocker tag also is cheap. It is a modified version of a standard tag with two antennas that is required to simultaneously broadcast both a "0" bit and a "1" bit.

As mentioned before the studies related with security/privacy issues mostly intensify on Class 1 tags. However a few of these studies are on Class 1 Gen 2 protocol. The main reason is that Gen 2 is approved by ISO recently (in July 2006). The scheme proposed by Chien and Chen is one of the three studies related with Gen 2 tags in literature (2006). The others are Karthikeyan-Nesterenko's scheme and Duc et al.'s scheme. After stating the reviews and weaknesses of these two studies, Chien and Chen present their new mutual authentication protocol. As mentioned by Chien and Chen, Gen 2 RFID tags cannot support any hash functions due to their limited resources. So the other proposals mostly cannot be implemented on Gen 2 RFID tags in security respect. The proposed scheme consists of two phases: initialization phase and authentication phase. Due to the challenge and response technology and the freshness of random numbers, proposed scheme is reliable. Only the randomized data is transmitted on the wireless channel between the reader and the tag, and the product information (EPC) is only transmitted from the server to the reader through the secure channel.

Ayoade recommend the scheme called Authentication Processing Framework (APF) as a feasible method to overcome privacy and security problem (2005). According to this method both readers and tags must be registered to APF database. This framework makes it compulsory for the readers to authenticate themselves with the APF database before they can access registered tags. The data stored in the tag is encrypted. To get the data from the tag, the reader needs to have the access (decryption) key of tags that is registered in APF database. It is difficult for any reader to have access to the memory segment of the tag without possessing the access key. Only authorized readers that were determined when they were registered to APF with their unique identification number reach the EPC data. This framework can not be suitable for global supply chain applications, due to the enormous data management load. It is not feasible to register all tags and readers to a database in a global supply chain. But in limited application areas it can be useful. Ayoade applied his framework on a particular area in a real world system. This area was patient confidential/personal information area. By the APF system the information about a patient stored in an RFID tag attached to his hospital card can only be seen by his doctor or related staff.

Hui et al. proposed a new approach in their study (2005). Their study differentiates from others and makes itself more reliable for having both real applications and also performance tests performed comparatively with a well-known cryptography scheme (DES algorithm). The proposed scheme consists of two phases. In the first phase the EPC data stored in the tag is encrypted by a heuristic Jigsaw encoding scheme. This helps to encrypt an EPC data into a pseudo-EPC code. An unauthorized reader can not reverse the pseudo-EPC code into a valid EPC code in a short period of time. The reader has to get the scattering way of Jigsaw Algorithm. Without the knowledge of the scattering way to a matrix, it is not possible for attackers to resolve it in a short time because it involves a permutation of 64 ways. In the next phase, a simple tag authentication scheme is proposed by using a one-way hash-lock function. By this step it will be realized that the tag is cloned or not. After developing the scheme, it is tested for implementation. Jigsaw algorithm is compared with DES algorithm which is the most well-known algorithm. Two hundred measurements were made to execute cipher operations on a 64-bit EPC tag. First comparison attribute is time for encryption and decryption. Jigsaw algorithm is obviously faster than DES. Jigsaw is more appropriate for ease of use and efficiency. These two algorithms are at the same operational reliability level. Even DES is more secure, Jigsaw is more feasible to apply according to all other criteria. The scheme is designed for the application on EPC Class 1 Gen 1 protocol and to be used with apparel products.

## 4. Conclusion

Important acquisitions in many application areas are gained by RFID technology. There are still R&D studies and debates going on in order to enhance the functionality of this technology. The main purpose of the studies is to provide international standards and find a solution for consumers' privacy and security problems. Due to the promises made by RFID technology on numerous fields and applications, the studies on RFID standardization and privacy issues vary. Whereas some security/privacy proposals are focused on providing consumer security in particular application areas such as hospitals, others also turn to global supply chain applications. Similarly, the differentiation can be related with tag classes. While new proposals for Class 1 Gen 2 tags are being introduced, schemes for Class 1 Gen 1 type tags are also being developed. From this point of view, one can easily say that no single proposal is likely to be completely satisfactory. For the purpose of finding the most appropriate scheme, there exist some criteria that must be considered, which are:

- Application area (open supply chain, or a more specific area such as a health facility),
- Type of tag (considering its capabilities such as computational load, memory capacity),
- The degree of desired operational reliability, performance, operation time and ease of use.

Performance tests must be conducted in order to find the best scheme for that specific application area. Sometimes combination of methods may prove to be the best.

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# MEASURING THE PERFORMANCE OF COLLABORATIVE RELATIONSHIPS IN SUPPLY CHAIN NETWORKS USING DATA ENVELOPMENT ANALYSIS: A CORPORATE GOVERNANCE PERSPECTIVE

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## Abstract

*Supply chain management (SCM) as a concept of functional integration of processes between firms in business partnerships is not new, yet has been invigorated by the prominence of modern information communication technologies (ICT). The end-to-end supply chain in the form of networks linking customers, manufacturers, suppliers and logistics providers is a virtual and physical reality which many believe can provide sustained competitiveness through added value to customers, operational efficiencies, and strategic capabilities in a global business arena. This scenario of a supply chain network provides an opportunity to develop models which explain i) the dynamics, complexities and processes of integration as supported by ICT and ii) the customised relationships necessary for a collaborative strategy to succeed. There is much literature on the former but a dearth on the later. This paper presents a development in performance measurement of some factors of corporate governance in a supply chain by using the Data Envelopment Analysis (DEA) algorithm. DEA is a non-parametric operations research technique, successfully used and widely applied in situations, which traditionally support qualitative study.*

*Keywords: Collaborative Relationships, Supply Chain Networks and Data Envelopment Analysis*

## 1. Introduction

### 1.1 Background

The end of the last century, and the last decade in particular, witnessed an unprecedented expansion of computing power and a rapid increase in information exchange through advances in information communication technologies. The impact on business is immediate, pervasive and unavoidable. Opportunities are global but threats are local. The firm that operates as an independent entity with loosely linked arrangements with suppliers and customers is facing the threat of becoming economically no longer viable, a small backwater business, or being taken over by more competitive and efficient predator companies. While in the past the pursuit of operational excellence may have kept the firm competitive against others that had a similar goal, it no longer succeeds with such a strategy when the others have tackled the goal of attaining greater efficiencies by challenging performances along the whole supply chain (SC). The business practices of the 20$^{th}$ century no longer serve the requirements of the 21$^{st}$ century (Bowersox et al, 2002, Lowson, 2003) resulting in the evolution of new supply chain management frameworks (Lambert et al, 2005, Cigolini et al, 2004). Furthermore, the rapid advance in information communication technologies has created a vacuum in knowledge that has often been addressed piecemeal as unilateral phenomena.

A current widely debated topic, with an arguably disappointing track record, is that of collaboration as the driving force behind effective supply chain management (Min et al, 2005). This paper attempts to provide a mechanism for the quantitative measurement of collaboration and trust as factors of organisation behaviour that enhance or impede SC efficiency. It thus contributes to an understanding of how SC performance can be improved.

The paper is introduced with the research questions that are currently being investigated in an Australian SC. These are being studied through the conceptual framework of performance measurement depicted by a performance pyramid (PP) founded on corporate governance. Since PP is common to all organisations this feature can be the vehicle for integrating the SC and for measuring the performance of partnerships through collaboration and trust. Measurement is conducted by using the optimization model of Data Envelopment Analysis (DEA), a non-parametric operations research technique based on linear programming. An application scenario is created and the significance of the results and implications of the findings are discussed. Limitations of the current work are recognised and planned to be addressed in ongoing research.

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1.2 Research questions

1 Does the Performance Pyramid, comprising customer relations, internal operations, and supply chain networks, founded on a corporate governance platform, provide partner firms in the supply chain network with a performance measurement framework that identifies failings in collaborative relationships?

2 Can the Performance Pyramid be applied to supply chain networks in Australian businesses to improve competitive strategies?

3. How can the DEA algorithm be further utilised in modelling supply chain partnering for corporate performance?

## 2. Performance measurement in organisations

Traditionally the field of operations management has been concerned with the effective planning, organising and controlling of the resources and activities necessary to produce goods/services for customers. The systems model reflecting this typically has an Input (resources) - Transformation – Output (goods/services) with feedback loop, framework. This effectively defines the organisation and establishes its operational imperative, that of converting and using resources to provide quality products to customers, as efficiently as possible. However, there are numerous aspects and various determinants of organisational performance and before focusing on the supply chain network it is necessary to describe the performance model on which this paper is based. The scores derived from the Performance Pyramid (PP) are the ultimate metric against which the performance of the firm is benchmarked. The PP forms part of the performance measurement conceptual framework shown in figure 1 and described below.

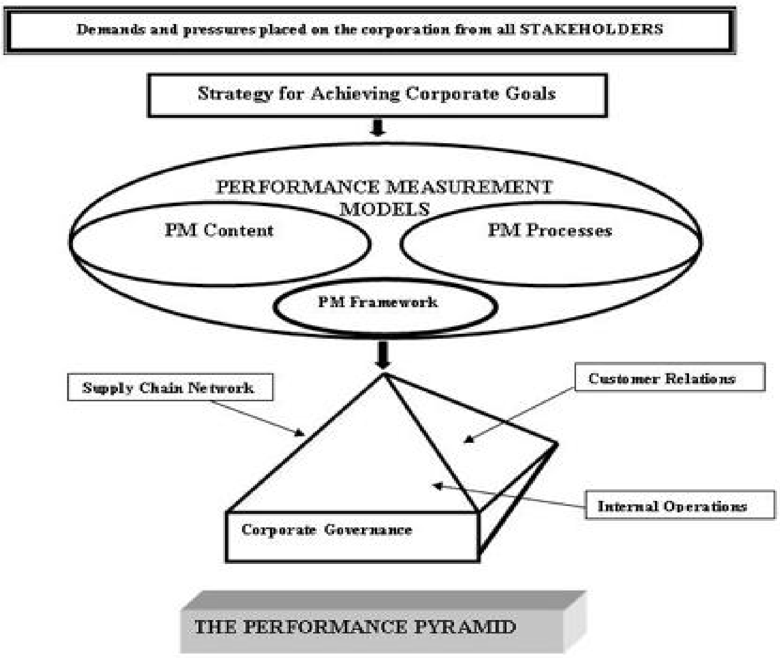


Figure 1. The Performance Measurement Conceptual Framework

The organisation faces constant pressures, internal and external, to be competitive and profitable. In response to these pressures, and with regard to their importance, management devises strategies for achieving corporate goals (Womack and Jones, 1994, Kaplan and Norton, 1996). To gauge performance against these goals the organisation implements procedures and practices which provide key indicators of achievement. This requires the adoption of a particular performance measurement framework within which the 'what to measure' content issues and the 'how to measure' process issues are established. Models such as the Balanced Scorecard (Kaplan and Norton, 1992, 1993) and the Performance Prism (Neely, Adams and Crowe, 2001) have been canvassed and widely used for this very reason, yet when it comes to SCM, Beamon (1998) claims there is little past work to draw on. The present authors contend that a further development of these models is the Performance Pyramid (PP). The PP, on a bedrock of corporate governance, provides a performance scorecard of composite metrics along the supply chain. The metrics are the scores for the performance dimensions of; internal operations, SC networks, and customer relations. Integral to performances along these dimensions is the role of 'relationships and collaboration' in the whole SC, while not dismissing the importance of technical and functional relationships that exist along side it. Lambert, Knemeyer and Gardiner, (2004) for example, demonstrate the development of a qualitative partnership model that can be adopted in attempts to achieve cost savings and reduce duplication of effort in collaborating firms, while Li, Kumar and Lim, (2002) claim that this can be done with scenario building, relational interdependencies, process and information mapping, and analysis using quantitative models. Chan and Qi (2003) go further with the development of an innovative approach to measure the holistic performance of the SC using fuzzy set theory.

## 3. The integrated supply chain with the organisation behaviour of collaboration and trust

### 3.1 The integrated supply chain model

In the integrated supply chain model there are generally three interrelated flow streams. The first is usually the *material flow* stream, which involves the purchase of materials, components and services from external suppliers. This is followed by the transformation of these supplies into manufactured and assembled (for services this is seen as conversion) finished goods. The final stage is the distribution of the finished product to customers. The SC network can be very complex with many suppliers and subcontractors, and even more customers. The network of the SC is the business-to-business (B2B) link and the relationships that ensue. The next flow stream is that of *information flow*, which operates to a great extent in reverse to the physical, flow. This B2B link is facilitated by electronic data interchange (EDI) and the Internet. It has become increasingly important because advances in the necessary technologies have provided expediency and economy. Communication channels have become 'information superhighways'. The third flow stream in the SC is *financial flow*. The payment to suppliers and subcontractors and the receipts of payment from retailers and customers, as well as internal financial flows have equally been affected by advances in the global EDI system. The integration of the SC and its study is provided by the discipline known as Supply Chain Management (SCM).

SCM provides a framework for businesses and their suppliers to bring goods, services and information efficiently and effectively to customers by firms collaborating to improve operational efficiencies and to leverage strategic positioning. For each SC member the B2B relationship represents a strategic choice of position in the supply channel, based on acknowledged dependency and the requirements of domestic and global customer accommodation. This SCM is heavily dependent on ICT/internet and the instantaneous and inexpensive transmittal of information which economizes the conduct of business. In concept SCM can be a highly efficient and effective network of business linkages which serve to improve efficiencies by eliminating duplication and non-productive, non value-adding work. In practice this is a challenge. The conceptual model for the SC (adapted from Bowersox *et al,* 2002) is shown in figure 2 where the tier networks of suppliers (SN) are represented by S and s, and the distribution networks (DN) are shown as D, and d. The integrated corporation (IC) displays the role of operations management through the functional areas of procurement, manufacturing and marketing. It should be noted that the interactions between IC and S, s, D, and d or any other supply chain party can become a 'relationship dyad' which is a Decision Making Unit in the DEA algorithm discussed later.

In the past SCM has not provided fully the benefits promised. Traditionally the B2B groups were linked loosely and independently with often multiple arrangements with many different firms. The greater the independence of the operation the greater the possibility the group had a 'fragmented supply chain'. A common approach to handling these multiple arrangements and containing any fragmentation was to establish specialised functions with specific roles in the SC. Relationships were maintained by incumbents of these specialised positions and it was implicit in their duties that their primary objective was to 'get the best deal' for their employer. Consequently, the adversarial nature of negotiations corrupted the possibility of collaborative relationships and the structure that they operated in. Different firms were treated discriminately, based on the nature of the relationship and the power base (Cox, 1999). Not uncommonly, issues that arose included questions of loyalty, confidentiality, and conflicts of interest. Another approach was to outsource non-core functions. Not only does this insulate the buying company from poor supplier behaviour and negate the responsibility for their egregious violations, it further fragments the supply chain by eroding any competitive operational advantage this strategy held.

Difficulties in achieving efficiencies in the SC were recognised. Lowson (2003) traces the lineage of supply systems operations strategies attributing this geneology to the current pursuit of competitiveness, flexibility and responsiveness as well as mass customisation. One approach used to overcome the difficulties was to vertically integrate the organisation so that SC members all belonged to the same corporation. Benefits of this arrangement are intuitive; functional responsiveness and accountability was kept within the corporation, financial sophistication, transfer pricing, and the ability to control and shift costs became available, and transfer of information could be conducted without loss of integrity. Additionally, the corporation was able to operate globally to achieve strategic advantage. However, practices such as stockpiling inventory to insure against unpredictable markets were maintained, and remained unchallenged because no viable alternatives existed. As consumer affluence increased, this long-standing passive acceptance of service changed to an expectation that there would be active involvement in design and delivery of products and services. This too was facilitated by the expediency of communication facilitated by the Internet. Nevertheless in spite of hindrances, an outcome of these technological developments meant that dimensions of responsiveness, flexibility and lean (Holweg, 2005) could be exploited for economic advantage.

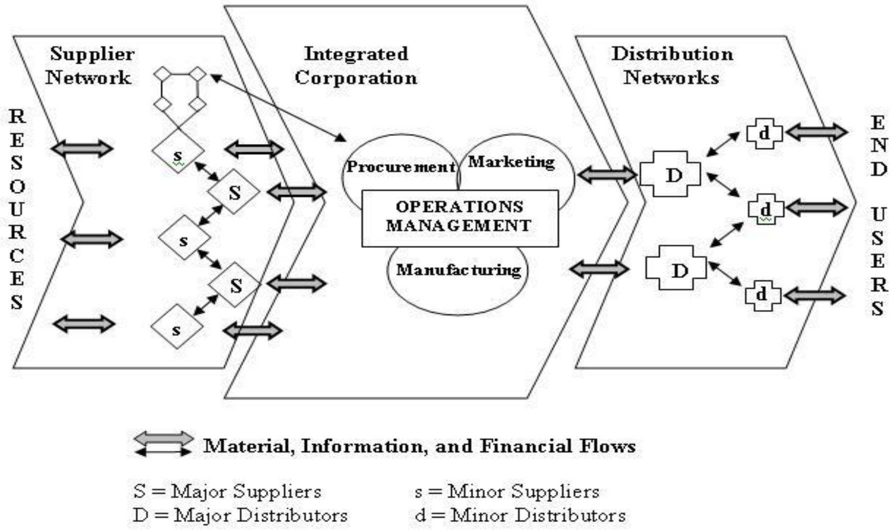


Figure 2. Generalized Model of The Supply Chain

In terms of operational performance of the supply chain the logic that prevailed assumed that if the individual members of the SC were efficient then the whole supply chain would benefit. Overall chain process efficiency was considered to be the sum of the individual efficiencies of members of the chain. Hence performance measurement focused on the individual components of the SC. For example, cost/unit to manufacture and cost/unit to transport were analysed independently and not as part of the complete SC. Sometimes this invited an accounting game where spreading and sharing of costs through overhead allocations and burden rates was used to diffuse the true costs of non-viable operations. This is contraindicative of the objective, which should be to achieve performances that provide the overall lowest cost for the total supply chain. It should also be noted however, that cost minimization should not be the over-riding goal. The authors maintain that the efficacy of the conceptual framework of the supply chain is subsumed in good corporate governance (CG). This is essential because overall corporate performance, and thus supply chain performance, is a reflection of the stewardship of the organisation by the Board of Directors. Many seemingly successful corporations have failed because of poor stewardship.

The quest for integrated supply chain management is to provide mechanisms where the cost of product is reduced, the quality maintained or exceeded, and the expectation of ultimate consumers satisfied. This can only be achieved by collaboration of partners within the supply chain network (SCN), extending the enterprise beyond traditional organisational boundaries, and integrating the services of all providers by the facilitation of ICT. It is this ICT that has manifested a paradigm shift in thinking about the possibilities; the move from a supply chain to a value chain to a network. It is more pragmatic to regard these chains as networks because of the myriad of complex structures that describe the direct and indirect elements of transactions in the interdependent relationships between firms. There are technical and social content in these relationships. The technical ones are the mechanisms that control supply functions and relate to everyday operational activities, which are undertaken by the supply chain partners. Cigolini, Cozzi and Perona (2004) describe these as the SC techniques which operate at the interface between companies and "relate to the hard configuration of the supply system (p13)" These are generally routine activities which have a social component simply because people do them and the development of any human relationship occurs only because the task requires some human interaction. These can be generically labelled as 'SC Processes' (SPC). The social content in the relationships that develop intentionally or otherwise in the inter-firm transactions are those that involve trust, commitment, collaboration and power, and may be generically labelled 'SC Relationships' (SCR).

### 3.2 The organisation behaviour of collaboration and trust

Many authors discuss the value of collaborative interaction within the supply chain but often without distinguishing between the process driven and relationship driven interactions. While the transactions occur simultaneously and in concert with each other, these two dimensions may present a juxtaposition, which hinders the analysis of SC performance. Some authors perhaps do not differentiate between these dimensions because they see process and relationship as unified and non-distinguishable factors that describe SC transactions. Alternately, some authors select factors from these dimensions intentionally to investigate particular aspects of the SC. Others may make the distinction and choose to investigate one or other of the dimensions or a selection from both. Irrespective of the stance of researchers it is axiomatic that people undertake SC processes and people interact with other people in the SC. Consequently, the organisation behaviours at all levels of the SC should not be marginalized. The dimension of relationships (SCR) in organisation behaviour can be used to categorize a sample number of studies. Min, Roath, Daugherty, Genchev, Chen, Arndt and Richey (2005) for example, propose a conceptual model of SC collaboration, which has three components; Antecedents, Collaboration, and Consequences. The antecedents to collaboration were identified as; strategic intent, internal alignments, relationship orientation, relationship-specific investment, free flow of information and heightened communication and finally formalization. The nature of collaboration was identified by three major constructs; behaviours, culture and relationship interaction, as descriptors of this condition. These displayed the features of; shared information, joint planning, joint problem solving, joint performance measurement, and leveraged resources and skills. The consequences of collaborations however, were outcomes specified as; mutual efficiency, effectiveness, profitability and, reinforcement and expansion of the relationship.

Cox (1999) on the other hand, argues that operational efficiency is best understood in terms of business strategy where the overriding factor is the role of usurper of power in the SC relationship. The company that possesses power has “the ability to appropriate value from the relationships with others-whether these are with customers, employees or suppliers (p172)”. Kidd, Richter and Strumm (2003), promote the role of trust in knowledge management and organisational learning in SC systems especially across national boundaries. This is particularly important with the advent of globalisation. Duffy and Fearne (2004) argue that with the introduction of Efficient Consumer Response, and its inherent dependence on relationships based on co-operation and trust, mutual benefits for the whole supply chain are achieved. ECR works because of a mutual sharing of information, risks and rewards. The test for whether the relationships are cooperative or adversarial is in the significant predictors, which lie in the constructs of trust, commitment, relational norms and conflict resolution methods. This is supported from a logistics perspective by Daugherty, Ellinger and Gustin (1996) who produce survey results, which promote the integration of logistics throughout the channel system with an acknowledgement of the benefits where it succeeds.

The overlap of the dimensions, as discussed above, is illustrated by Lambert, Garcia-Dastugue and Croxton (2005), when they evaluate the process oriented SC frameworks of the Global Supply Chain Forum (GSCF) and the Supply Chain Council (SCC). They quote the GSCF framework as having eight SCM processes, namely; customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, supplier relationship management, product development and commercialization, and returns management. It is interesting to note that they comment on process orientation yet quote relationships as particularly important to these processes. While they state that the purpose of SCM is to increase the value of a firm they recognise that the two dimensions (as is our contention) “are not mutually exclusive because transactional efficiency should be an outcome of good relationship management (p33)”. Finally, Min and Mentzer (2004) successfully tested a theoretical framework based on supply chain orientation (SCO) and supply chain management (SCM). Their framework bears a similarity to our two dimensions of process and relationships where SCM is analogous to the former and SCO to the latter. They define SCO as the systemic, strategic implications of tactical activities to relational factors such as trust and commitment to SC relationships and SCM as the coordination of traditional business functions within the business and across the SC to improve long-term performance of the individual company and the whole SC. A pool of 20 scale items for SCO and 30 items for SCM used in the test were statistically acceptable and the results produced a positive, significant regression coefficient for business performance.

Good relationships may be an asset because the time spent on activities of both parties can be optimized by minimizing pre-qualification and credential checking and process auditing, while accessing the pooled resources of both parties to allow a division of tasks and a reduction in duplication. Kanter (1994 p 100) identifies the “eight I’s” of collaborative advantage in such relationships with an emphasis on the integration of these by mutual trust. On the other hand, the disadvantage of this closeness is a restriction on company autonomy, resources to maintain the relationship and coordinate ongoing processes, and the real possibility of future indebtedness to the other. There is also the cost of termination of the relationship should it be unmanageable.

The relationships between firms that interconnect to form networks however, display common characteristics, summarised as:

- Reciprocity – each partner is expected to contribute some balanced share to the specific transactions. This may include different proportions at different periods of time and at different stages in the supply process.
- Interdependence – the parties are knowledgeable of each others’ capabilities and operations and may draw on these to help solve process problems.
- Loose coupling – while maintaining rudimentary legal formal obligations there is a reasonably stable framework for interaction and communication.
- Power – a supply chain has inherent power relations which can be exploited positively or negatively, but usually has an ‘orchestrating’ key partner
- Boundedness – boundaries of the network are defined by the perimeters of individual partners.

These characteristics highlight the necessity for communication and collaboration in the relationship with a commitment to trust, shared values and aligned goals.

The mechanistic model, which portrays only technical and functional relationships, can be displayed in the functional indicators of the performance pyramid diagram presented in figure 1. The proposal of this paper is that the efficient operation of the whole organism (the complete supply chain) is dependent on the effective operation of communication channels that are necessitated by these interactions as they are manifested in the relationships that go beyond simple communications and on to understandable collaborative agreements which are displayed by the levels of trust and collaboration between members of the SCN. It is the relationships fostered by collaboration and trust that integrates the SC and provides the competitive advantage in business operations. It is the rationale of this papers therefore, that collaboration and trust as subsets of organisation behaviour in the supply chain network are contributors to SC performance and warrant measurement. As the SCN is a conglomeration of B2B interactions, fundamentally between two partners, it is the contributions of these dyads that must be measured and compared. The authors believe that this approach of measuring SC performance is novel and provides a contribution to the study of SCM. But how can they be measured? Fortunately, a new application of the non-parametric technique of Data Envelopment Analysis may provide the mechanism (Ramanathan, 2003, Sengupta, 2003).

## 4. The data envelopment analysis method

The first DEA model of Charnes, Cooper and Rhodes (1978), referred to as the CCR ratio form (Cooper, Seiford and Tone, 2000) was based on their extension of Farrell's (1957) technical efficiency measure of performance expressed as a ratio of a single input and a single output. At this time the concept of efficiency as a productivity ratio was gaining credence world wide as it became an economic tool for the measurement and comparisons of productivity at international, national, and industrial levels, but surprisingly only to a minor degree at the company level (Sumanth, 1984). However, the obstacle to acceptance was the difficulty in arriving at total productivity as a ratio inclusive of all input resources and outputs. An index calculated from aggregated dollar values of inputs and outputs (revenue) was too abstract to allow a meaningful dissection of a firm's efficiency (productivity). Charnes et al (1978) were able to by-pass the shackles of financial metrics by devising a form of mathematical optimization to generalize from single outputs/inputs to multiple outputs/inputs.

They called these independent and discrete relationships 'decision making units' (DMUs) which could be assigned at the researcher discretion according to the output-input relationship that warranted investigation. In fact all DMUs are discretionary inputs and outputs assigned by the researcher. This is the subject of some debate in the academic literature.

In particular, the CCR model

"generalized the single-output/input ratio measure of efficiency for a single DMU in terms of a fractional linear-programming formulation transforming the multiple output/input characterization of each DMU to that of a single "virtual output and virtual input." (Charnes, Cooper, Lewin and Seiford, 1994 p 6)

DEA defines the efficiency of an arbitrary unit i as:

$$Efficiency \quad of \quad unit \quad i = \frac{\sum_{j=1}^{n_o} O_{ij} w_j}{\sum_{j=1}^{n_I} I_{ij} v_j} \qquad (1)$$

$$or: \quad Efficiency \quad of \quad unit \quad i = \frac{Weighted \quad sum \quad of \quad unit \quad i's \ outputs}{Weighted \quad sum \quad of \quad unit \quad i's \ inputs}$$

$O_{ij}$ represents the value of unit i on output j

$I_{ij}$ represents the value of unit i on input j

$w$ is the non-negative weight assigned to output j

$v$ is the non-negative weight assigned to input i

$n$ is the number of input and output variables

Unlike parametric approaches, which require a specific functional form expressing relationships between independent and dependent variables, DEA calculates the maximum performance of each DMU in relation to every other DMU in the population. It does this by establishing an 'external frontier' (which is similar to the boundaries of the feasible region in linear programming) which depicts the optimum performance perimeter where equally efficient DMUs occupy coordinates at different points of the efficiency line.

The relative technical efficiency (Cooper, Seiford, and Tone, 2000) of each DMU is expressed as a percentage matched against the best DMUs, which reveal the 'best practice production frontier', the maximum output empirically obtainable with a given amount of input.

Improvement for the lower performing units is possible by various manipulations of the productivity ratio, such as increasing the output while keeping input stable, decreasing input for an unchanged output or a range of options (Charnes, *et al*, 1994) depending on the appropriate improvement strategy for current economic conditions.

DEA has an attraction to researchers because of three main factors;

- each DMU has a single score to indicate relative efficiency
- potential improvement for each DMU is benchmarked against the best-practice referent (or base) DMU, and
- DEA obviates the need for alternate abstract inferential statistical models.

In addition, recent studies have demonstrated new use of DEA in areas of increasing academic interest, such as the relationship between proactive environmental policies and firm performance (Sarkis and Cordeiro, 2001) and impact of corporate social responsibility on organisational performance (Manzoni, forthcoming 2007). DEA is also increasingly used in conjunction with other techniques, such as analytical hierarchy process (Sarkis, 1999) and often used to quantify qualitative data as a prelude to further analysis (Avriel and Golany, 1996, Zhu, 2003)

In contrast to other descriptive and inferential calculations DEA focuses on individual observations as single efficiency measures rather than population averages or regression relationships. Multiple input and output measures using different units can be accommodated, as can the inclusion of dummy (categorical) variables, and while these factors are generally treated as value-free they can be weighted to include a priori knowledge from the judgements of experienced and knowledgeable mangers. Finally, DEA focuses on benchmarking against existing best practice rather than on measures of central tendency.

## 5. Application scenario

A simplified example chosen for illustrative purposes follows in Table 1 below where the DMUs are 'virtual entities' representing SC 'relationships dyads'. The DEA can be applied to intra- firm and inter-firm SC DMUs, as in say, a vertically integrated manufacturing enterprise with several plants, supplier and distributor subsidiaries, all under corporate control, as well as the horizontal SC of the external partners. For example, one Decision Making Unit may be the 'virtual entity' described by the relationship between the core firm CF and a supplier S while another could be the entity of the relationship between CF and a distributor D. Similarly other DMUs may be the virtual entities created between the relationships of various suppliers and distributors in the horizontal and vertical SCNs that exist. The various SC relationships that may exist could be, as those shown in figure 2, between the IC[1] and Tier 1 suppliers (S), between IC and Tier 2 suppliers (s) and between IC and the major distributors (D). Any other dyad that exists across chain partners as shown in figure 3, and warrants inclusion for benchmarking relationships, may be added to the DEA computations. All the 'relationship dyads' (RDs) become individually identified DMUs in the DEA algorithm.

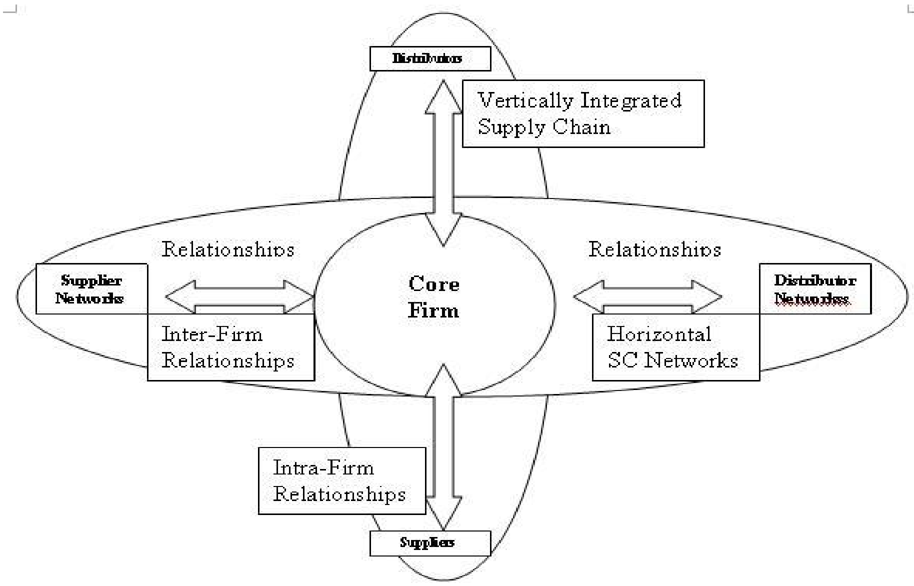


Figure 3. Relationship Inputs and Outputs for Virtual DMUs

Table 1 shows the RDs of intra-firms and inter-firms relationships in the SC, with sample identifiers labelled with subscript *i* for internal, *e* for external, *s* for supplier, and *d* for distributor. For example, $B_{is}$ is the virtual relationship between an internal supplier with the core firm while $G_{ed}$ is the DMU for an external distributor relationship and $L_{es}$ is that for an external supplier. Comparable input factors for all DMUs could be rated responses on scaled questionnaires for; strategic intent SI, informational alignments (IA), relational investments (RI), and communication flows (CF). Comparable outputs could be; joint planning (JP), joint KPIs (JJPI), Responsiveness (R), and Formalization (F). These input and output factors have been selected as examples of the variables that could be used in DEA and they come from studies such as Min and Mentzer, 2004, Min *et al* (2005) and Holweg (2005).

The computation of results (Ragsdale, 2004, Zhu, 2003, and Cooper *et al*, 2000) show that DMU's B, G and L are equally efficient SC relationship members with a score of 1.00 (100%) where intra and inter-firm partners could all be treated as equally discrete and comparable so long as the inputs and outputs are identical variables in the SCN.

[1] Note the distinction between the Integrated Corporation IC in figure 2 and the Core Firm CF in figure 3.

Table 1 Inputs, Outputs and Efficiency Results of Relationship Dyads

| DMUs (RDs) | Strategic Intent (SI) | Info Alignment (IA) | Relational Investment(RI) | Commn Flows ( CF) | Joint Planning (JP %) | Joint KPIs(JKPI) | Responsiveness (R) | Formalizaton (F) | Efficiency |
|---|---|---|---|---|---|---|---|---|---|
| A | 4.74 | 6.75 | 5.89 | 7.7 | 92 | 67 | 76 | 81 | 0.96 |
| $B_{is}$ | 6.38 | 7.42 | 7.18 | 9.7 | 99 | 76 | 86 | 88 | 1.00 |
| C | 5.04 | 6.35 | 4.97 | 9.3 | 98 | 66 | 46 | 77 | 0.83 |
| D | 3.61 | 6.34 | 5.32 | 7.7 | 87 | 71 | 61 | 43 | 1.00 |
| E | 3.45 | 4.43 | 3.39 | 7.8 | 94 | 54 | 59 | 76 | 0.84 |
| F | 5.25 | 6.31 | 4.95 | 7.9 | 88 | 45 | 91 | 58 | 0.82 |
| $G_{ed}$ | 2.36 | 3.23 | 2.89 | 8.6 | 90 | 91 | 93 | 72 | 1.00 |
| H | 7.09 | 8.69 | 6.40 | 9.1 | 100 | 78 | 71 | 88 | 0.77 |
| I | 6.49 | 7.28 | 6.01 | 7.3 | 89 | 81 | 61 | 68 | 0.85 |
| J | 7.36 | 9.07 | 6.94 | 8.8 | 89 | 66 | 51 | 57 | 0.79 |
| K | 5.46 | 6.69 | 5.86 | 8.2 | 93 | 92 | 58 | 77 | 0.91 |
| $L_{es}$ | 6.58 | 8.75 | 8.35 | 9.6 | 97 | 95 | 89 | 83 | 1.00 |

## 6. Results, significance and implications

When a benchmark is established and the parameters awarding this standard are recognised the stage is set for kaizen (continuous incremental improvement) in the SC. The above-illustrated example shows that the managers in non-performing DMUs (those RDs with less than 1.00 rating) have a challenge to improve[1]. In other words, there are relationships in the SCN that are performing better in terms of collaboration and trust than others. The significance of these is that the under performing RDs have a measure of their under-achievement enumerated. An analysis of the input and output factors against the same factors of the best performers can provide managers with strategies that should pave the way forward. This provides an opportunity for individual RD improvements with the result that the whole SC improves and benefits. Addressing the factors that require attention should not be unduly difficult since the benchmark performers display their constituent factor scores.

The limitation of the scenario presented in this paper is that it is illustrative and based on work currently being investigated elsewhere. Some of the difficulties in the methodological issues of that work would be expected here. Namely, the selection of the DMUs and the correct input and output factors would be crucial to the measurement outcome and to the effectiveness of DEA's ability to discriminate efficient from non-efficient DMUs. Nevertheless, these have been resolved in those other initial studies and could be here.

## 7. Conclusion and future research

Supply Chain Management invites many strategies espoused as the way to measure performances in the SCN. These can be segregated on the basis of functional SC Processes or social SC Relationships. If the adage that 'numbers speak louder than words' holds true for SCM then DEA provides an ideal tool for the quantification of performance. Its computation is mathematically irrefutable and unquestionable in its interpretation once the correct parameters have been established. While initial trials in a current investigation (elsewhere) are encouraging it has not yet been tested on all the performance metrics in the pyramid, including the SCN. This new challenge is to identify and apply those input-output factors for each pyramid dimension that will provide the efficiency computations for a performance scorecard.

Future research proposes to test the applicability of this approach in a myriad of organisational settings across a variety of commercial enterprises in the Australian economy. In particular, the attraction of a viable 'Performance Scorecard' lies in its ability to metricate the contribution and importance of each part of the whole supply chain. To date, some positive results have been achieved in initial studies of corporate governance performance in a SC within the banking industry.

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[1] In this instance the managers would be those from the two interacting firms in the RD

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# WHY DO SERVICE LOGISTICS NEED SELF-ORGANIZATION? – A COMPETENCE-BASED ANALYSIS OF GLOBAL SUPPLY CHAINS IN THE MOVIE PRODUCTION INDUSTRY

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## Abstract

*Service Logistics presently are confronted with challenges like increasing environmental complexity and dynamics. On the one hand service demands of customers are rapidly changing and on the other hand there are multiple business partners, disposing of different competencies, involved in Global Service Supply Chains. To cope with these conditions, the need for flexibility as well as stability in global logistic planning processes becomes evident. Therefore this paper shall examine if competence building and leveraging can be improved by a management approach such as self-organization. Furthermore, it will be questioned if this approach offers any potential of application in international co-productions of the movie industry, focusing on logistics management.*

Keywords: Global Service Logistics, Self-Organization, Competence Building & Leveraging, Movie Production

## 1. Introduction

In general, services can be defined as every kind of activity that contributes to the satisfaction of human needs (dimension of activity). Other characteristics are the capability to combine production factors (dimension of potential), the existence of a result or process benefit for a service consumer (dimension of result) and their process character, i.e. that services only develop through the participation of a service consumer as an external factor (dimension of process) (Meffert & Bruhn, 1995). A concrete managerial perspective in this understanding of services has to be seen in a globalized context. From such a perspective, service companies are involved in service supply chain networks, where they could be service consumer of another service producer themselves, and vice versa. “Activities, processes and structures of a number of organizations are interwoven worldwide, where the management has to deal with multiple interrelations between actors situated in distinctive economic, political and social environments.” (Hülsmann, Grapp & Li, 2006: 495) Organizations which are part of those structures are legally separate, but depend economically to a certain degree on each other (Hülsmann & Grapp, 2005). This perspective represents one possible interpretation of »Global Service Supply Chains« (=GSSC).

In the sector of »movie production logistics« (=MPL), service logistics feature typical needs which are increasingly globalizing, too. Often movie productions are planned and organized among international companies in so called co-productions (Thiermeyer, 1994; Kindem, 2000; Wirtz, 2003). That means that a certain movie production project is realized by combining different services which contribute to the same project (i.e. that competencies are exchanged and resources are shared or service companies procure them for the mainly responsible movie production company). Despite global linkages among service companies, from a network perspective, resources and competencies (e.g. actors, costumes, technical support) have to be delivered to the set (Haase, 2003) »just-in-time« (Wildemann, 1990), in order to ensure effectiveness as well as efficiency of the movie production process

This might lead to problems of complexity and dynamics which seem to be typical in GSSCs. A complex system could be considered as "the existence of many characteristics depending on one another in a section of reality [...]" (Dörner, 2001: 60). But not the quantity of elements is decisive for the complexity of a system. The existence of various inter-relations between the elements of a system and between a system and its environment determines the degree of its complexity (Dörner, 2001; Malik, 2000). In general, a logistic system such as GSSC is dynamic (Bäck, 1984), because its structure of elements, sub-systems etc. changes over time. For GSSC as a logistics system, institutions, persons and places as well as every resource or competence could be regarded as elements among which a spatial and temporal transfer takes place, e.g. between customers and service suppliers (Delfmann, 1998). In typical movie production logistic structures, there are existing many different and often rapidly changing service

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needs (e.g. technical, financial, and informational support), because of the temporal, project-based existence of such movie production systems (Picker, 2001), i.e. that different companies are involved. Therefore, by focusing especially on competencies in the movie production industry (=MPI), increasing complexity and dynamics in global service logistics planning processes can be assumed.

In consideration of the outlined problem context for GSSCs, different hypotheses shall be deduced: first, from the perspective of the competence-based view, there is a ubiquitous competence bundling and allocation takes place as an original logistic function in GSSC as well as in the MPI under complexity and dynamics (hypothesis no. 1). Therefore it should be asked how the ubiquitous competence bundling and allocation in the MPI is realized efficiently in service logistics management and how MPL-management is able to fulfill this task in a globalized context. Secondly, it assumed that a selected management approach could advance competence building and leveraging in global service logistics which in turn might contribute to increase efficiency of the original function competence bundling and allocation for the MPI, too (hypothesis no. 2).The first main question of this paper is, how far competencies are required in GSSCs (e.g. MPI). Therefore, in a first step the paper analyses increasing complexity and dynamics as overarching problems of GSSC from a competence-based perspective. In a second step, the aforementioned problems will be illustrated from an MPI view. The second main question asks, if self-organization as one possible competence-orientated management approach can serve to deal with the occurring problems in GSSC. Therefore, the idea of self-organization, will be presented. The third main question is, how far a self-organized competence building and competence leveraging in GSSCs (here focusing on MPI as field of application) could be achieved efficiently. Therefore possible theoretical contributions of self-organization as an approach to cope with the mentioned difficulties will be described.

## 2. The Need of Balancing Flexibility and Stability in Global Service Supply Chains

### 2.1. Changing Challenges for Global Service Supply Chains

From the perspective of an interacting symbiotic eco-system, organizational structures such as GSSCs constantly have to adapt to changing and diverse environmental conditions in order to acquire necessary resources (e.g. information) and opportunities (e.g. consumer demands) to ensure their existence in a long-term perspective (Hicks & Gullett, 1975). For MPL-management this could lead to the necessity of exclusive cooperation with adequate partners that offer the needed services for a specific movie production project (e.g. to monitor the quantity and quality of service companies) and look for potentially successful movie projects (e.g. to produce corresponding to the demands of the viewer). However, access to resources and opportunities of the environment is limited (Sanchez and Heene, 1997) which is for example reflected by limited purchasing power because MPL-management is facing budget restrictions according to the individual movie budget.

Currently, GSSCs are facing hyper-competition (D'Aveni, 1995; Thomas, 1996). This describes a phenomenon under which businesses have to act proactively or react immediately on changing environments to compete in the fields of price-quality positioning or creation of knew knowledge to build up services etc. (D'Aveni, 1995). Further phenomena influencing GSSCs are hyper-linking (i.e. that many different service partners are involved in the global service logistic chain) and hyper-turbulence (e.g. a current change of market demands for services) (D´Aveni & Gunther, 1994; Monge, 1995; D´Aveni, 1998; Xiao Li & Chuang, 2001). The mentioned phenomena lead to increasing complexity and dynamics in GSSCs. The consequence for the GSSC-management seems to be dilemmatic because on the one hand it should follow a strategy of rationalism. But on the other hand while there is an expanding complexity of its highly dynamic environment (e.g. pressure to develop and offer new services) it has to cope with rational decisions for single strategic alternatives that cannot be logically substantiated (Hülsmann & Berry, 2004). Especially in MPL-management a relatively long planning period is followed by a shorter production period. As a consequence, whatever has been strategically planned beforehand concerning the optimal coordination of its logistic service processes might lead to ad-hoc decisions of MPL-management during the production process if unexpected situations occur (e.g. a service partner, actor or crew member cannot participate in the specific movie production project). Presumably such ad-hoc decisions are less effective. That happens as reaction time for MPL-management is shorter and in consequence endangers a sustainable strategic MPL-management which has to decide based upon a limited quantity of information (Bronner, 1999).

To cope with this kind of increasing complexity and dynamics as problems, GSSCs have to focus on their system flexibility which from a social system perspective is needed for processes of integration (i.e. absorbing environmental complexity by opening the system's boundaries) and stability to preserve the system's identity (i.e. coping with internal complexity and differentiating from its environment) (Luhmann, 1973). Flexibility in GSSCs could mean to absorb for example service demands from the environment which can be understood as complexity, but in turn to gain stability and to end up with the absorption at the point in time when the maximum of processable service demands is reached. One possible alternative which relates to this kind of flexibilization and stabilization of companies (e.g. GSSC) could be the idea of competence management. In the competence-based concept, on the one hand flexibility is a requirement for competence management as well as its result and then represents a competence itself. It represents a basic requirement for GSSCs as systems and permits the system to build and leverage competencies, such as networking competence (Zadek, 2004) or complexity absorption competence (Froschmayer, 2004). At the same time, flexibility is required to endow the system with the necessary adaptiveness to secure a sustainable existence of the system in a complex and dynamic environment (Hülsmann & Wycisk, 2005). Following this assumption, the competence-based perspective may offer a concept for GSSCs to integrate flexibility into its organizational structures. But in order to do so, organizational flexibility first of all must be generated. Three main aspects seem to be necessary for a system to increase its adaptivity: "flexibility as a basic requirement", "stability as a basic requirement" and "the need of a balancing between flexibility and stability".

But which is the competence-orientated background to focus on flexibility as well as stability as basic requirements for GSSCs? Both requirements are assumed to contribute to competence building and leveraging (Hülsmann & Wycisk, 2005). Considering flexibility as a basic requirement is necessary for every organization to adequately respond to potentially changing and diverse environmental conditions (Sanchez, 1993, 1995), e.g. new service logistic demands. An adaptation of corporate strategies is required, if circumstances are changing (Sanchez, 1997). A competence can be understood as „[…] the ability to sustain the coordinated deployment of assets in ways that help a firm achieve its goals" (Sanchez & Heene, 1996: 8; Sanchez, 2004: 521). From a GSSC perspective, strategic competence-based management could be one application of the competence-based theory. In a general meaning, competence-based management includes the identification, evaluation, arrangement, building and leveraging of the competencies of a company (e.g. Barney, 1996; Thiele, 1997, Hamel & Prahalad, 1997). Regarding the required flexibility, adequate (service orientated) competencies have to be built and leveraged (Volberda 1998) for GSSCs which ensure the existence and survival in a global competitive environment. In this context, Sanchez differentiates five "modes" of competencies: 1) cognitive flexibility to imagine alternative strategic logics (i.e. depending from the GSSC-management's ability to perceive service market needs); 2) cognitive flexibility to imagine alternative management processes (i.e. creation of effective service organization designs as well as the definition of appropriate controls and incentives for monitoring and motivating the service-value creating processes); 3) coordination flexibility to identify, configure, and deploy resources (i.e. ability of GSSC-management to acquire or access, configure, and deploy chains of service-relevant resources); 4) resource flexibility to be used in alternative operations (i.e. range of benefits a service-relevant resource could have) and 5) operating flexibility in applying skills and capabilities to available resources (i.e. ability to make efficient and effective use of the system's service resources) (Sanchez 2004).

Regarding general implications of the competence-orientated perspective, it has to be stated that a GSSC-management has to realize a strategic "fit" between the different modes of competencies and its environment. That in turn requires in the first place flexibility of the management itself. Management has to identify which modes have to be improved to finally optimize skill profiles of individuals as well as capabilities of work groups (e.g. capabilities in achieving logistic goals more efficiently) (Sanchez 2004). However, in an ideal case every key success factor should be considered, and a set of interrelating and balanced success factors has to be developed. This is necessary as it is assumed on the basis of the present status of research on competence management that only through a strategic "fit" organizational competencies could be improved for the whole organization (Bove et al., 2000) (i.e. for all service partners involved in the GSSC).

### 2.2. Transfer of Competence-Orientation from Global Service Supply Chains to the Movie Production Sector

How could the problem of balancing flexibility and stability in GSSCs from a competence-based view be interpreted for the MPI? Additionally it should be asked which competencies are needed by MPL-management to fulfill its logistic task efficiently, facing changing challenges of complexity and dynamics. Adapting this management perspective to the MPI regarding its logistic structures, a "dual competence-understanding" for MPL can be deduced. On the one hand, service competencies (e.g. technical support, transportation services) can be considered as a part of MPL. Such service competencies are needed for the realization of movie production processes. On the other hand, MPL-management must have an organizational competence as meta-competence (Bouncken, 2003), i.e. a competence to coordinate other competencies. It is necessary to plan (allocate) and arrange (bundle) the mentioned service competencies optimally (Purcell & Gregory, 2000). This demand for competencies has to be satisfied to fulfill logistic service goals efficiently (i.e. to ensure service quality, quantity, time, costs) (Arnold, 2002). In the following, this understanding of competencies in MPI shall be linked to the general requirement to GSSCs to build and leverage competencies by balancing flexibility and stability of the respective system. Competence building in general for GSSCs could be assumed as the acquisition and integration of competencies as well as the generation of required service knowledge, skills, and technology. Competence leveraging could be considered as the application of GSSC's existing competence pool to market opportunities (Bellini, Capaldo, Raffa & Zollo, 2000; Purcell & Gregory, 2000). Analysing the original logistic function of MPL in the view of a strategic competence-based management, the focus seems to go beyond a perspective of a simple competence allocation and bundling. MPL-management so far focuses on generating a portfolio of competencies which is needed for the coordination of requirements for one specific movie production project, and arranges them individually (Gaitanides, 2001). Probably, this is the case because of the mostly temporarily limited existence (short-term perspective) of a MPL-system (Picker, 2001) which in turn only allows a temporarily limited bundling and allocation, changing from project to project (Keil, 1999; Jones & Walsh, 1997). However, GSSCs from a competence-based view have the opportunity to build up a portfolio and even optimize the acquired, integrated competence pool in order to be adaptive, e.g. to logistic service market challenges (long-term perspective). Competencies of the involved GSSC-companies are part of a strategic competence management process (Purcell & Gregory, 2000). In a social system perspective, the status quo of MPL-management mainly seems to be based on a focus of flexibility to cope with its environmental complexity and dynamics in a short-term view (i.e. to cope with unexpected loss of service competencies). But problems might occur if MPL-management will not consider – as a regular GSSC-management – the stability of its service logistic processes (i.e. that needed services might not be available in an emergency case, if nobody is in charge of managing the competence pool). Following this line of argumentation, the question arises if there couldn't be any service logistic orientated potential for MPL-management from a competence-based perspective to widen its view. Should MPL-management maybe not only plan or bundle its set of competencies, but also leverage it for future demands for service competencies and thereby balance between flexibility and stability?

The decisive problem in the transferability of the idea of competence building and leveraging from GSSCs to MPL is that competencies are bundled for only one movie production logistic process. But even during the production (i.e. in pre-production, production, post-production), the quantity of service partners´ competencies varies during different production phases (Picker, 2001; Wirtz, 2003, Lange, 1999). Service partners in this regard could be often seen as critical resources or competencies (Sydow & Manning, 2004) in "temporary systems" (Goodman, 1981). The changes in the competence pool and therefore also the structures of an MPL-system finally even seem to increase the above stated problems of complexity and dynamics. Except from bigger movie production firms (e.g. Warner Bros. or Bavaria Film) most competencies are not bundled for a long period of time in the MPI, and firms mainly focus on their core competencies (Wirtz 2003; Picker, 2001). From a general GSSC-perspective, the main risk is that effectiveness as well as efficiency are endangered as it could be just too expensive to permanently hold competencies as for example actors (Gaitanides, 2001). This is why especially inefficient service logistic planning seems to lower service quality (i.e. if specific service competencies are not available) as well as quantity (i.e. if the needed set of service competencies is not available), time (i.e. if service competencies are not available when needed) and place (i.e. if service competencies are not available where needed), originating from a lack in competence-orientation. Two questions finally seem to become evident: 1) How can GSSC leverage and build competencies more efficiently? 2) And furthermore, transferring the potential competence-oriented contributions to MPL, how MPL-management in a globalized context could be capable to fulfill competence bundling and allocation referring to the outlined competence building and leveraging effects?

## 3. Self-Organization as a Management Approach

Building and leveraging competencies in GSSCs is assumed to be one opportunity to cope with the problems of complexity and dynamics. However, how can the identified need for balancing flexibility and stability as a prerequisite of a service-oriented global competence-management of logistics be generated? Self-organization could be a concept to create the desired effects – a point to be examined later. Now, the concept of self-organization shall be presented briefly concerning its origins, main statements, and regarding its development as a management approach.

Self-organization emerged from multiple sources. Its historical roots are spread over various academic fields, e.g. natural science, philosophy, and sociology, and goes back to at least 500 BC to Heraklit and Aritstoteles who identified self-organized processes in natural phenomena (Paslack & Knost, 1990; Paslack, 1991). All studies of self-organization had one thing in common: they aimed to identify and to explain general principles concerning the question of how complex systems autonomously create ordered structures, e.g. the research of Von Foerster (1960) (cybernetics), Prigogine and Glansdorff (1971) (chemistry), Haken and Graham (1971) (physics), Maturana and Varela (1980) (biology). The approach of autopoiesis of Maturana and Varela (1987) for example analyses and describes the self-organizing processes of living systems, diffused into various scientific fields, such as sociology with reference to Luhmann's systems theory (Luhmann, 1994) or as well as to business science (Probst, 1987; Kirsch, 1992; Malik, 2000; Hülsmann, Grapp & Li, 2006).

The main statement showing the convergence between the different research fields is that all studies equally deal with dynamic and complex systems, no matter if such phenomena are natural or social, but the focus of study is rather the complexity of their internal and external relationships, comprising and constituting their behaviour (Dörner, 2001; Malik, 2000). In the present discussion, the terminological differentiation into self-management, self-organization and autonomous cooperation shows the variety in the understanding of this approach. Self-management is considered to be the most extensive understanding. It could be regarded as the completely autonomous design of a system by itself: autonomous goal, planning, organizational, and resource decisions (Manz & Siems, 1980). Self-organization as part of management describes the way of creating ordered structures in a system out of itself, i.e. the process and structure design of a system based upon its own capability (Probst, 1992; Bea & Göbel, 1999). From the basic idea of self-organization, the specified understanding of autonomous cooperation evolved. Autonomous cooperation in a general sense means the capability of a system to form itself with its own facilities. Whereas autonomous cooperation in a narrow sense describes decisions of system members in externally organized processes based upon specific situative parameters (Herzog et al., 2003).

One current definition of this approach, developed in an interdisciplinary research center, is that "autonomous co-operation describes processes of decentralized decision-making in heterarchical structures. It presumes interacting elements in non-deterministic systems which possess the capability and possibility to render decisions independently. The objective of autonomous cooperation is the achievement of increased robustness and positive emergence of the total system due to a distributed and flexible coping with dynamics and complexity." (Hülsmann & Windt, 2006). In the concept of self-organization there are attributes such as autonomy, interaction, redundancy and non-determinism as overarching characteristics which can be derived from the perception of the concept of self-organization, the origin of autonomous cooperation.

What do these attributes mean referring to their origins? *Autonomy* describes structures that evolve on their own, e.g. that they autonomously arrange themselves from a chaotic state to a profoundly structured state (Haken, 1987) and are named autonomous patterns (Prigogine & Glansdorff, 1971). In the context of business science, this attribute is characterized by processes of delegation and decentralization. Consequently, autonomy can be understood as the degree of autonomous decision-making processes among the company's employees (Kappler, 1992).The development of a self-organized order within a system can be seen as the result of *interactions* of different system elements (Haken, 1987), e.g. between employees, departments etc. It is expected that these are not related to individual system components. However, researchers emphasise that their interactive behaviour is the result of synergistic effects. Through self-organization, an increased level of quality can be gained which can be measured by an improved ability to cope with complexity and in turn by a better fit of system structures and environmental challenges (Hülsmann & Wycisk, 2005). The characteristic of *redundancy* describes that each element or subsystem in the whole system is equipped with the same assets and abilities (e.g. individual qualifications of the employees). Whether the function of ordering in the process of self-organization is taken over by a specific element mainly depends on the quantity of information it has (Probst, 1987) and the possibilty to render decisions. *Non-determinism* can also be found in all self-organizing systems. This characteristic means that the system behaviour cannot be causally predetermined (Haken, 1983; Prigogine, 1996). However, in a social self-organized system, general rules of decision-making have to be predetermined (Hülsmann & Windt, 2006) so that the system reaches the desired state (e.g. attaining its goals).

What could this understanding of self-organization mean in a theoretical management context? From a social system perspective, this concept means shifting operative decision-making to its sub-systems, -units, and -elements while the individual system components operate independently from centralized decision-making structures (Probst, 1987). Intelligent systems with adaptive capabilities on a local level a required which however follow global goals such as service levels. The application of this management approach results in positive as well as negative effects which show some possible theoretical contributions to management. One positive effect among others could be that higher flexibility and stability could be achieved by shifting the responsibility of decision-making and coordination to smaller organizational units as well as their relation to other units inside or outside the respective system. Thereby, especially managing capacities will be improved as less coordination of a central planning is needed. One negative effect among others could be that risks evolve. For example, the total stability of a system could decrease due to a diminished identity of the system as a whole caused by sub-system egoism (Hülsmann & Grapp, 2005). That means for single systems that their individual degree of autonomous cooperation is probably too high so that they might misuse the freedom for decision-making (i.e. to render decisions which do not serve the system's global goal of service orientation).

## 4. Possible Contributions of Self-Organization to Competence Building & Leveraging in Global Service Supply Chains

### 4.1. Effects of Self-Organization to Global Service Logistics

After having presented self-organization as one possible management approach to allow competence building and leveraging, it is the aim of the following chapter to show some theoretical contributions of self-organized processes to competence building and leveraging in GSSC on a first level of analysis, i.e. it is intended to analyse how GSSC leverage and build competencies more efficiently by the application of self-organization ($1^{st}$ level of analysis). On a second level of analysis, the potential competence-orientated contributions shall be transferred to MPL, i.e. how MPL-management could be capable in a globalized context to fulfill competence bundling and allocation referring to the outlined competence building and leveraging ($2^{nd}$ level of analysis). In this section, some possible contributions of self-organization to build and leverage competencies in GSSC shall be shown and illustrated for MPI by examples. To analyse effects of self-organization, it is intended to use the dimensions of quality, quantity, space, and time as general analytical criteria of business science contexts. As flexibilization of GSSC is supposed to represent the counterpart of the system's stabilization, a trade-off between both poles always has to be assumed. That means a positive effect of self-organization on flexibility implies a negative effect on stability, and vice-versa (Hülsmann & Wycisk, 2005). The main focus of analysis will be on flexibility, because the creation of flexibility always seems to be the first step for coping with environmental challenges by opening the system's borders before they have to be closed again to stabilize the system in the second step.

#### 4.1.1. Qualitative Aspects

For example, regarding the characteristic of autonomy, self-organization contributes to develop various patterns of competencies along with constantly changing environmental conditions because GSSCs as systems as well as their sub-units attain the required flexibility to let evolutionary processes regarding competencies take place (Hülsmann & Wycisk, 2005). Whenever e.g. service competencies are needed in a GSSC, they could be autonomously formed exactly fitting to the respective needs of the system as well as to the service partners involved or to the affected customers' demands. This adaptivity of GSSC implies a higher quality of its competencies which need to be build up in the ideal case whenever it is required (e.g. MPL-management might be burdened with less risk for its logistic planning: quality of competence bundling as well as allocation as in the case of an unexpected situation such as unavailable resources on the set could be covered because a flexible reaction is possible, i.e. that problem solution could be managed by professionally educated movie production staff with fundamental knowledge in service logistic management).

#### 4.1.2. Quantitative Aspects

In terms of quantitative aspects, self-organized GSSC could improve competence building and leveraging through processes of decentralization, e.g. by a heterarchically organized structure, all the absorbed complexity is distributed among its diverse sub-units and elements (Kappler, 1992), e.g. local service partners which are globally situated. This means that the total complexity is reduced to a partial one for GSSC-management. GSSCs seem to gain flexibility and act flexible as competencies do not have to be planned and designed for every involved service partner individually anymore. But it is possible to hand over the competence for decision-making on competence-building and leveraging to a certain degree to the responsibility of companies involved in GSSC (e.g. MPL-management could set up a pool consisting of specific core competencies from logistics service providers: bundling and allocation depends on the specific movie production project (e.g. small movie or block buster) but could be optimized by systematically building and leveraging a pool of competencies out of which the needed ones can be integrated into the specific movie production logistic process).

#### 4.1.3. Spatial Aspects

A spatial closeness to the operational level of work could be assumed if service companies in GSSCs are empowered to make autonomous decisions through delegation (Mullins, 2005). Only the specific service partners in GSSCs know which competencies are needed at which point of time as they operate at the direct point of action and therefore get the relevant information how to leverage competencies for necessary decisions for the production logistic process. Therefore a high degree of interaction among the employees in a self-organized GSSC, provided by the spatial closeness of the service partners, is important. They exchange information directly and not via a centralized planning unit (GSSC-Top-management level). This could mean that processes of delegation and decentralization in GSSC require a higher degree of interaction between the involved service companies (Laux & Liermann, 1993). It could be assumed that self-organization especially contributes to leverage existing competencies in GSSC. For example, if certain employees are talented in communicating they should be further educated and supported so that they can be installed in interface management between the different companies of GSSC (e.g. MPL-management needs a relationship management: leveraging its competencies in terms of spatial aspects of self-organization goes beyond the bundling and allocation and emphasizes the need to install long-term relationships among its service partners, i.e. to be always well informed about the capabilities of each specific company that could be potentially part of the next movie production project; this ensures an up-to-date competence pool from the perspective of an MPL-management, but also gives service partners the opportunity to constantly adapt their logistic competencies which are needed in movie production).

#### 4.1.4. Temporal Aspects

Because of the existing context of a temporal effect of flexibility in autonomous cooperating structures and spatial closeness of autonomous decision-making, it can be stated on the one hand that the process of decision-making becomes less time-intensive and on the other hand easier to handle as the information flow among GSSC-companies becomes faster. For example, improved personal customer services can be immediately generated. This means required information can be made available in the right place and at the right point of time. Thereby, GSSC could flexibly react towards environmental changes (Hülsmann & Wycisk, 2005). Furthermore, with a high degree of interaction and exchanged information, the elements learn increasingly more about each other’s capabilities and know-how, e.g. realized by job rotation or job enlargement (Schreyögg, 1998; Mullins, 2005). Referring to the characteristic of redundancy, every GSSC-company or -employee could fulfill the same logistic task. By such processes of competence building and leveraging there would be no delays anymore because a flexible reaction is possible at any time (e.g. MPL-management has the opportunity to react faster: even though a certain set of competencies has been bundled and chosen for a specific movie production project, it will be possible to react to the many different changes and challenges during one production logistical process, i.e. that it should be the goal for MPL-management to employ crew members who are all equipped and educated on the same needed level to cope with whatever situation might occur).

### 4.2. Implications of a Self-organized Movie Production Logistics Management

As it has been shown, flexibility as prerequisite and competence as well as stability could be partially generated by the application of self-organization and in turn be enabler for competence building and leveraging processes. In the section above it was stated that flexibility and stability are both needed to cope with complexity and dynamics in GSSC-structures as well as in the MPI. In consequence, the question arises what from a competence-based perspective the most important implications for the MPI that should be reminded by a MPL-management are? Therefore now possible results of a competence-based orientation enabled by self-organization in MPI will be outlined and the main effects for MPL-management will be sketched in a brief overview. This will be explained systematically for the two general levels of management from an operational (i.e. short-term, specific, and concrete) and strategic (i.e. long-term, general, and abstract) perspective. In MPL-management, the operative management perspective has to be understood as situation-related realization of the strategic logistic goals (Remer, 2004).

From an operational perspective in MPL-management, especially flexibility seems to be necessary for the movie production process as a project, if it takes place in an unpredictable, changing and uncertain environment. In contrary, a strategic perspective MPL-management is mainly based on stability because it refers on production from the view of a movie production studio, e.g. representing a more stable environment with fewer changes. Coming from a resource-based management approach which emphasizes the differences in effectiveness for property-based (e.g. long-term contracts with actors) and knowledge-based (e.g. the development of particular technical or creative skills) resources (Miller & Shamsie, 1996) in this paper a perspective on competence building and leveraging in the MPI has been developed. The main implication of a self-organized MPL-management on the operational level seems to be that a fast reaction will be possible regarding its arrangement of competencies, if unexpected situations lead to a competence loss. As a short-term effect, single competencies are always available and could potentially satisfy the competence demand for a movie production project which is realized among global partners. This in turn is closely linked to the strategic management perspective of MPL-management. In such a strategic view imponderabilities lead to less risk for a movie production, as competence building and leveraging in MPI could be managed by a competence portfolio which contains the relevant competencies for providing its operative management with the needed competence input. This implies that MPL-management has to take care for its portfolio and systematically build and leverage its competence pool that should always contain strategic logistic management competencies. Thereby, operational management gains the opportunity to act more flexible but also needs to give a feedback to strategic management. This is necessary, if the installed competencies cannot be adequately integrated into the logistic process of a movie production (e.g. because of missing knowledge about movie production business). By this feedback system MPL-management could maybe adapt its future competence building and leveraging based on direct information out of movie production processes.

## 5. Prospective Research on Service Logistics in the Movie Production Industry

In theory, it is expected that there are positive effects on competence-building and leveraging for GSSC as well as in the MPI which can improve its basic logistic function of competence bundling and allocation through self-organized processes. However, these mainly theoretical contributions still bear realization problems regarding the application of the theory of self-organization. Such limitations regarding its realization can be identified, coming from the characteristics of GSSC and the MPI. A general criticism on competence-based management in MPI has been presented focusing the fact that movie production is a more or less project based enterprise. But to develop and leverage competencies is assumed to be a process over a long period of time (DeFillippi & Arthur, 1998). This section will reflect about some possible realization problems in GSSC and illustrate the existing problems for MPL-management, which represent a potential for prospective research questions. As a starting point, the characteristics of service logistic structures such as GSSC (introduced in the 1st chapter) will be taken as criteria for a possible realization of the thoughts developed in this paper. In GSSC, service partners can be considered as globally dispersed. Does the statement "think global, act local" (Sjurts, 2004) not bear realization problems for competence building and leveraging in movie production companies? It could happen that egoistic behaviour of those service partners who only pursue their own competence needs evolves. For MPL-management in an international co-production, this could lead to difficulties in monitoring, if preparations of service partners (e.g. during pre-production phase) are done properly. In consequence, the risk could evolve that certain competencies are not leveraged the way the MPL-management wants them to be. A further characteristic is the service hybridization between service consumer and provider in GSSC. The question for GSSC then always is, if services should be made or bought (Walter, 2003). In MPL-management, depending on the size of the respective movie production project (i.e. regarding its budget), it could be risky besides the question of costs to shift responsibility for competence-based management to an unknown partner because of insecurity concerning the quality of the service partner's competence building and leveraging. Another characteristic of GSSC describes the multiple interrelations between service partners. But how can long-term relationships among service partners be established, while many different interests and changing service demands have to be considered? As a realization problem for MPL-management, not every service partner will be available for specific projects, e.g. a relationship management is needed (Paul & Kleingartner, 1994) for a constant improvement of service partners' competencies. In reality, it is typical for movie productions that they are limited to a short period of time and availability of competencies.

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# A NEW PERSPECTIVE IN TOURISM MANAGEMENT: MANAGING THE SUPPLY CHAINS OF TOURISM ENTERPRISES

Turan PAKSOY[1], M. Atilla ARICIOĞLU[2]


## Abstract

*Supply Chain Management (SCM) refers to the management of materials and information from raw material suppliers through manufacturing and distribution, to the end customers across a complex business network called supply chain. Decisions or acts of taken by one member of the chain can influence the success of all others in the chain. So, managing business in a supply chain is a collective game. SCM has received substantial interest in recent years. In many industries it is applied. In this study, SCM in tourism sector and tourism supply chains, which involve many components such as advertising, transportation, accommodation, catering, food production, recreations (attractions, cultural, social, sportive activities), energy and water supplies, waste disposal are analyzed. Finally, a case study on supply chain management in a tourism enterprise is presented.*


Key words: Supply Chain Management, Tourism Management, Tourism Supply Chains.

## 1. Introduction

The circumstance of competition, which increases more day-to-day, constitutes new markets, new transactions, new products, new threats and new possibilities. This forces firms to do their works best, produce and deliver fast. But, on the other hand, organizational disorders inside of organizations and problems encountered along supply chains block the productivity of firms. The blocking reasons reveal the importance of supply chain, even ensure to be understood that competing in global market goes with competently managed supply chains. Supply Chain Management (SCM) becomes one of the conditions of be kept on the market from reply to changeable customer demands ambiguously and fast by provide integrating itself inside. Today the firms, which apply SCM successfully, constitute superiority over their competitors, reduce costs and think customer satisfaction firstly. In consequence of more need from manufacturing sector, supply chain integrated with production sector at first. Nowadays, SCM is so important for service sector too. In this study, SCM in tourism, which is one of the most important sectors in service industry, is considered.

## 2. Supply Chain Structure

Supply chain is a process, which keeps on from raw materials' ordering and procuring to producing products, transportation and distribution to customers. For instance, a simple supply chain in production sector contains suppliers, manufacturers, distributors, retailers and customers. Essentially this list can extend more (Güner, 2003; Uysal et al., 2004; Kothari et al., 2005).

In a company, supply chain is responsible for guaranteeing from suitable materials, services and technologies, correct sources and correct time, suitable quality purchasing Supply Chain is a means and transformation network which does providing materials, materials' transformation to products and distribution to customers. Despite of supply chain's complexity changes for every industries and firms, supply chains are functions of business vitality both production and service industries. Supply chain contains supply, product design, production planning, materials management, replying orders, inventory management, transportation, storing and customer services (Uysal et al., 2004).

Supply chain starts purchasing and procuring for need of products. After that supply chain directs to inventory management and storing management for to support sales. It comes to end by delivering product to customers. So, a supply chain can be defined as a network of entities that starts with the suppliers' supplier and ends with the customers' custom the production and delivery of goods and services as in Figure 1 (Güner, 2003; Lee and Ng, 1997).

SCM encompasses materials/supply management from the supply of basic raw materials to final product (and possible recycling and re-use). SCM focuses on how firms utilize their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency (Tan et al., 1998).

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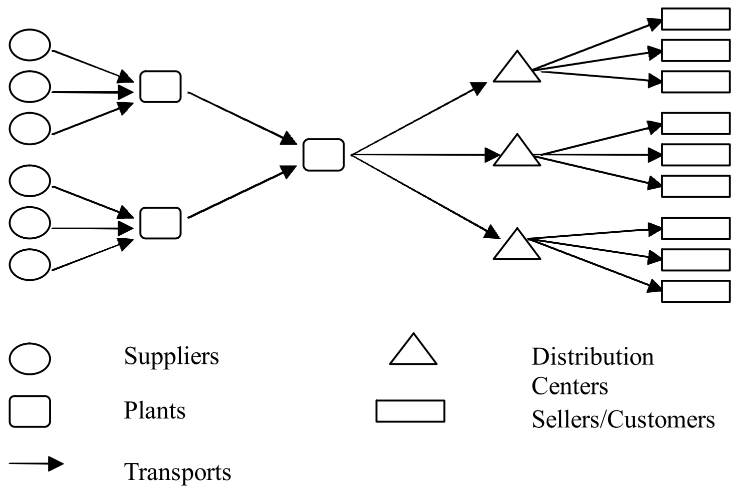


Figure 1. Supply Chain Structure (Güner, 2003)

SCM aims at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular OEM (original equipment manufacturer) so as to release management resources for developing meaningful, long term relationship (Berry et al., 1994).

## 3. Supply Chain Management for Tourism Enterprises

Although, for service industries supply chain existence is not too much different, we encounter the supply chain management studies in production companies more frequently than the service organizations today. However, if high productivity is desired for service industry, first of all supply chain concept must be understood well and then supply chain's performance, which contains customer service, quality, cost etc. must be evaluated (Kothari et al., 2005).

There are various points must allow for generating a customer centered successful supply chain at service industry: (Kothari et al., 2005; Presutti, 2002;)

- Purchasing order must be done in suitable time and way.
- Companies must provide supplies uninterruptedly and they must give information to their customers about the item continuously.
- For reducing the end product's cost, companies bring down their internal outlays to minimum level.
- Decreasing design process time is important because of its decreasing to customer needs' reply time.

Tourism enterprises are so important component of service industry, because of its big quota for the world and Turkish economy. By increasing of tourism's importance, tourism enterprises change from accommodation organizations to today's organizations, which present various services and activities too. Supply increment is bigger than demand increment and customer is not dependent to ordinary ones, means customer obtain choice freedom. Customer wishes its money's equivalent even more than too. This change process of tourism enterprises, existence of competition and customers' increasing expectation level made supply chain management inevitable for them (Brooah, 1999; Kothari et al., 2005).

Hotel is the most common concept of example for the tourism enterprises. A hotel services to customers and simultaneously the hotel is serviced by a lot of product and service suppliers (Fig. 2). Because of hotels' having many suppliers and customers, supply chain becomes a necessity for them. If we explain by a simple expression, hotels' supply chain is information, service and production flow process that is from hotel suppliers to hotel customer. And hotel is a firm, which is between suppliers and customers and is affected from probable misfortunes and displeasures, therefore must manage the supply chain. Supply chain contains materials, information, financial flows and the units, which materialize these flows (Kothari et al., 2005).

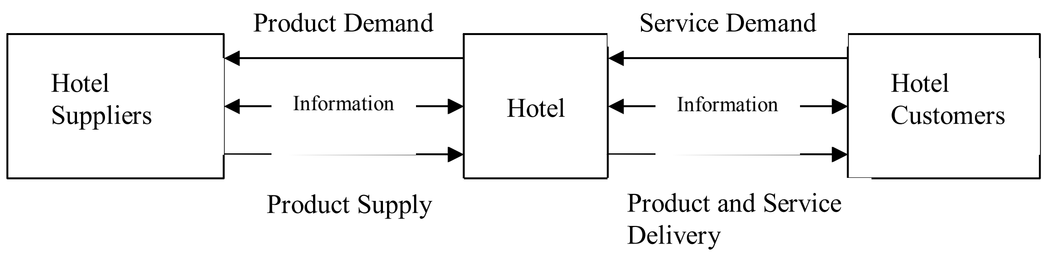


Figure 2. Basic Supply Chain of a Hotel (Reproduced from Kothari et al., 2005)

In this chain, every unit transmits materials or flow objects from proceeding to following. Supply chain continues until material or service's circulation comes to end point. The last customer is the supply chain's last link (Kothari et al., 2005).

Supply Chain Management's main goals are increasing customer satisfaction, making profit maximum and working more productive and cheaper. Following this point of view, the basic duty is applying to hotels by relating to supply chain management's goals (Güner, 2003; Presutti, 2002; Kothari et al., 2005; Brooah, 1999).

Hotels are the units, which present products or services that produced themselves or procured from the outside to customers. Today hotels present below services to customers (Brooah, 1999):

- Accommodation Services
- Food – Drink Services
- Communication Services
- Sporting Activities
- Social Activities
- Trips and Natural Beauties
- Customer Relations (Interest and Acquaint)
- Health and Safety Services

Hotel must directly produce these services or it must provide some of them from suppliers. Because of producing is not possible for all of them like food or drink services, it provides some of them from its suppliers. Under the circumstances, hotels only present those services (Kothari et al., 2005).

Presenting many services perfectly requires well-organized structure for hotels. In the end, products and services will be presented to customers for their needs perfectly. Customers wish fair services and interest, also being informed about replying level to their needs' helps their hotel marking. For positive condition customer gives positive marks to hotel but for negative condition customer blames the hotel (TOI, 2003).

As can see negativeness, which appears while supply chain process, causes to big impacts. For supply chain process works well, the organization must design, build well also after supply chain must manage perfectly too. (TOI, 2003; Kothari et al., 2005)

Tourism, like all other supply chains, operates through business-to-business relationships, and supply chain management can be applied to deliver sustainability performance improvements alongside financial performance, by working to improve the business operations of each supplier in the supply chain. The main differences between tourism supply chains and those of other sectors, are that tourists travel to the product, and the product that they buy has a particularly high service component - in other words, it involves a higher proportion of people in the immediate production of the holiday experience (Tapper and Font, 2005).

The below figure (Fig. 3) shows supply chain diagram and helps us about understanding of tourism supply chain structure;

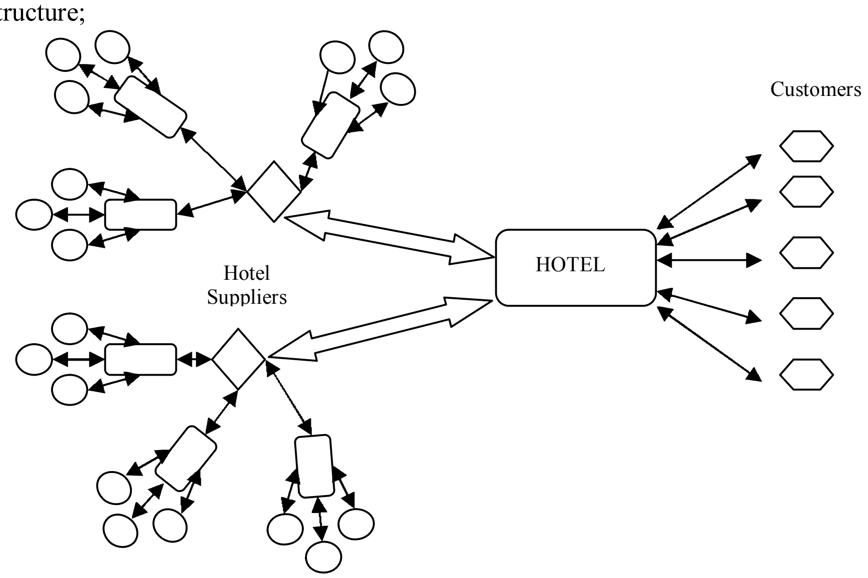


Figure 3. Supply Chain Model At Hotel Firms (Teigen, 1997)

The model in the above figure is only one of the supply chain formation examples for hotels. Essentially every hotel has self-special model. Suppliers' identities, their functions and their suppliers; hotel's organization structure, its staff, its staff number and crowd of customers are components of supply chain model. Experts must take the responsibility of modeling, managing, developing and controlling this supply chain (Brooah, 1999; Lapierre, 2005).

Also SCM is a strategy based on integrated efforts of various functions such as planning, production, distribution, purchasing, marketing and human resources. Like suppliers and last customers, every unit in the firm with their functions takes part in supply chain. Essentially in hotels like marketing, accounting, planning, purchasing functions work independently in supply chain. These functions have self-goals and they work for them. Therefore determining integrated plan is very difficult in the firm. Combining these different functions is supply chain management's duty. Increasing customer demands, local and global competition increase oppressions on supply chain. For to stand in competition, firms rediscover themselves and they have to change their supply chain –determination sources, production planning, purchasing orders, inventory management and customer relations- from high cost stationeries to today's need directed activity (Yamak, 1999).

## 4. Applicability of Supply Chain Management in Tourism Enterprises

Hard competition will continue supply chain management instigating. This competition appears several sources. These are developing of industry technologies, increasing globalization, easiness of getting information, much risk capital, creative business design. These forces put traditional markets into hard condition. When firms couldn't gain more from searching market share they focus on redefine competition circumstance and profit areas. Competition begins to effect firms more violently. These dynamics bring competition to a brand-new level. Firms have to learn supply chain management more active and correct for to stand against intensive competition. Before mentioned, because supply chain management is not a management style, which works miracles, it is a leader management style when it applies correctly (Özdinç, 2005; Güner, 2003).

Successful supply chain relationships between companies and their suppliers are developed and implemented according to a defined series of steps (Tapper and Font, 2005):

1. to establish a sustainable supply chain policy and management system,
2. to support suppliers in reaching Sustainability Goals, including raising awareness on sustainability issues among suppliers and demonstrating why sustainability performance is important,
3. to integrate sustainability criteria into suppliers' contracts and preferentially contract suppliers that meet those criteria.

Tourism supply chains involve many components - not just accommodation, transport and excursions, but also bars and restaurants, handicrafts, food production, waste disposal, and the infrastructure that supports tourism in destinations (see Figure 4). These all form a part of the holiday product that is expected by tourists when they purchase holidays - whether or not the suppliers of those components are directly contracted by a tour operator. Just as no tour operator would provide 1-star transport to take customers to a 5-star holiday hotel, the sustainability of a holiday, like quality, depends on performance at all the links in the tourism supply chain (Tapper and Font, 2005).

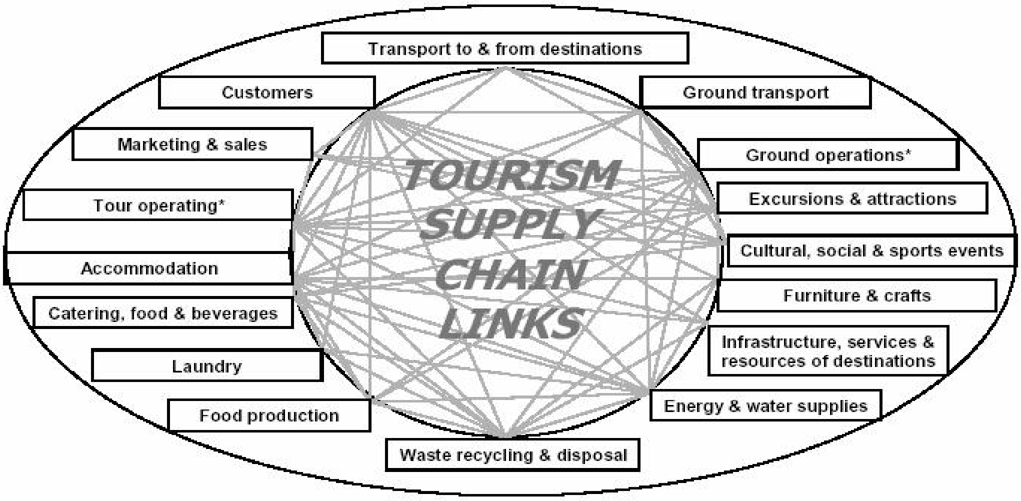


Figure 4. Tourism Supply Chain Links (Tapper and Font, 2005)

Today because of the existence of competition in the tourism industry like other industries, applying SCM discussions must change to "how effective supply chain models could be set?" discussions (Kothari et al., 2005).

## 5. Case Study

Research methodology of the study is based on interview method. The firm analyzed in this study is settled in Antalya, which is the most popular (maybe the capital) city of Turkish tourism sector. A written interview based on a questionnaire (Appendix) modified from Patterson et al. (2003) is revealed at the firm in Antalya. Also, some face to face meetings are done with the top managers of the firm such as manager of purchasing department, manager of marketing department in the plants. As result of the search and observations, the diagnosis and threats are proposed.

The firm located two different places in Antalya. The firm employed more than 1000 people in his company. His customers are generally geographically dispersed as follows: Germany, Russia, Belgium, Turkey, and Holland. The company stated that company's annual budget for operating/managing its supply chain is %30 and 7 employees are dedicated for supply chain management in the firm. The company's supply chain is not extremely complex compared to other industries and firms. Total number of bed capacity of the firm is 3500; total number of rooms is 1500; total number of customers (annual) is 75,000; total number of suppliers is more than 60; number of strategic suppliers is 10; total number of tour operators is about 50; number of strategic tour operators is 8.

Diagnosis

- Although the firm has started to reduce formal organizational structure to more fully integrate operations, company's decision making process is still concentrated at top management levels. The firm does not utilize cross-functional work teams for managing day-to-day operations.
- The company has not clearly stated and comprehensive supply chain management strategy yet. The company's supply chain management strategy is not clearly incorporated into the organization's overall business strategy. So, the company supply chain management planning is not well coordinated with the overall strategic planning process.
- The firm doesn't feel too much the competitive pressure on himself and the competitive environment for the company is not extremely intense compared to other industries. But the sector in which the firm participates is facing much change and uncertainty. So, the demand for the company's services is not stable. Because the company is facing much change and uncertainty, managing and planning the sources of the firm becomes more difficult.
- The firm stated that company's suppliers are generally keen on cooperating. The number of suppliers of the firm has remained stable over the past three years. But there is not a performance measuring system for evaluating the suppliers yet.
- The company doesn't improve long-term relationships with his tour operators. Many developments in supply chain could be provided through long term working relationships and the guarantee of stable partners. But, there *is not* a strong commitment between the company and his tour operators. Tour operators direct and influence the volume of tourists and tourist destinations enormously. A sustainable supply chain depends on first ensuring mutual trust and respect of the supply chain partnerships. The company interviewed reported that tour operators can easily annul the relationships in case of a little social and economic crisis. A secure income stream with stable contracts and foreseeable future is very important for the firm in order to plan, facilitate the necessary investments and manage his supply chain. So, the company is generally not satisfied with the level of cooperation between the firm and his tour operators. Therefore, it is very difficult to improve a sustainable supply chain, when there is not sustainability of chain partners.
- The company has trouble when getting energy and water services. The regional infrastructure is not developed enough. Similar infrastructure problems have been observed in communication. For example, there is no ADSL in the area where the plants of the company are located.

Suggestions

- The company should change his management policy from traditional to more flexible and participating through Total Quality Management philosophy and start to utilize cross-functional work teams, quality circles etc..
- The company should urgently define a clear and comprehensive supply chain management strategy.
- In order to manage with the uncertainty, the firm should start to use an Enterprise Resource Planning system as soon as possible.
- The company should build up a performance system which is not only based on price issue but also qualitative factors such as consistency of quality of components acquired from suppliers in order to evaluate the firm's suppliers.
- The company should try to improve long term relationships with his tour operators. Because developing relationships require time, this might be gradually. First of all, the company should create a clear firm policy on sustainability. Through this, the company should develop a dialogue process that will engage tour operators in sustainability; offer some incentives to sustainable tour operators.
- Infrastructure problems are not private of the company, they are regional problems. So, the company would move together with the other companies and organizations or NGO's to actuate the municipality or regional government.

## 6. Conclusions

Internet technologies began to be important in service industry's supply chain management. The reason is E-Commerce decrease costs and work fast. As studies show that decision-makers adopt commerce on the Internet already. Next days are possible to see that supply chain management's relations in every industry with technology (Kothari vd., 2005).

The way of competition advantage in the future is instead of focusing on product, managing effective supply chain. While industries ripen, differentiations between products decrease. While product base developments are happening, selling and service activities have great different between companies. These services can be presented like changing directed to customer needs, decreasing time between order and demand time, products or services prices. So, if firms want to be leader their industrial market, they must manage supply chain effectively. E-Procurement is not an application for big companies, if e-procurement takes place in a marketplace, it can provide advantages for KOBİ too (Şahin ve Demir, 2002).

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## APPENDIX: The written interview

Company's name ____________________________________________

Your name, phone number and email address ______________________________

Your title ____________________________________________

Your address
____________________________________________

Please indicate the total number of employees in your company (all locations) by checking the appropriate line:

1______100 or fewer
2______101–250
3______251–500
4______501–1000
5______1001 or more

Please indicate the total revenues for your company (all locations) in 2005 by checking the appropriate line:

1______$100 million or less
2______MORE than $100 million, up to $500 million
3______MORE than $500 million, up to $1 billion
4______MORE than $1 billion, up to $2 billion
5______MORE than $2 billion

Please indicate the geographic scope of your company's operations? Write down the countries sending customers most respectively.
1____________ (for example Germany)
2____________
3____________
4____________
5____________

Please indicate the extent to which you agree with the survey statements by circling your responses using the following scale.

Not at all (1) Very little (2) Somewhat (3) A significant amount (4) To a great extend (5)

1. Please indicate the extent to which you agree with the following statements.

(a) Company decision-making is highly concentrated at top management levels.
1 2 3 4 5
(b) My company has a clearly stated and comprehensive supply chain management strategy.
1 2 3 4 5
(c) My firm extensively utilizes cross-functional work teams for managing day-to-day operations.
1 2 3 4 5
(d) My firm has reduced formal organizational structure to more fully integrate operations.
1 2 3 4 5
(e) In my company supply chain management planning is well coordinated with the overall strategic planning process.
1 2 3 4 5
(f) My company's supply chain management strategy is clearly incorporated into the organization's overall business strategy
1 2 3 4 5

2. What is the company's annual budget for operating/managing its supply chain?

________(%)

3. How many *supply chain management employees* are dedicated in the firm?

________

4. Please indicate the level of your firm's performance in the following measures compared to major sector competitors.

Well below average Average Well above average
1 2 3 4 5

(a) Market share 1 2 3 4 5
(b) Return on total assets 1 2 3 4 5
(c) Average annual market share growth (over the past three years) 1 2 3 4 5
(d) Average annual sales growth (over the past three years) 1 2 3 4 5
(e) Average annual growth in return on total assets (over the past three years) 1 2 3 4 5
(f) Average production costs 1 2 3 4 5
(g) Overall customer service levels 1 2 3 4 5
(h) Overall product quality 1 2 3 4 5
(i) Overall competitive position 1 2 3 4 5
(j) Overall cost to serve 1 2 3 4 5

5. Please indicate the extent to which you agree with the following statements.

(a) Compared to other industries, *the competitive environment* for my company's products and services is extremely intense 1 2 3 4 5
(b) My firm's supply chain is extremely complex due to number of customers/sellers, geographical dispersion, delivery timing requirements, etc. 1 2 3 4 5
(c) The demand for my company's goods and/services is stable 1 2 3 4 5
(d) My company is facing much change and uncertainty 1 2 3 4 5
(e) The sector in which my firm participates is facing much change and uncertainty 1 2 3 4 5
(f) My company's customers are generally keen on cooperating 1 2 3 4 5
(g) My company's suppliers are generally keen on cooperating 1 2 3 4 5
(h) My company's tour operators are generally keen on cooperating 1 2 3 4 5
(i) The number of suppliers of my firm has remained stable over the past 3 years 1 2 3 4 5
(j) The percentage of certified suppliers for my company has remained consistent over the past three years 1 2 3 4 5
(k) The supply of components from my firm's suppliers is stable 1 2 3 4 5
(l) The quality of components from my firm's suppliers is consistent 1 2 3 4 5

6. Please indicate the following:

(a) Total number of bed capacity ________________

(b) Total number of rooms ________________

(c) Total number of customers (annual) ________________

(d) Total number of suppliers ________________

(e) Number of *strategic* suppliers ________________

(f) Total number of tour operators ________________

(g) Number of *strategic* tour operators ________________

7. Please indicate the extent to which you agree with the following statements.

*Customers*

(a) There is a strong commitment between my company and its customers 1 2 3 4 5
(b) My company's customers can be trusted to do what is right 1 2 3 4 5
(c) My company is generally satisfied with the level of cooperation between our firm and its customers 1 2 3 4 5
(d) My company is generally satisfied with the exchange of information between our firm and its customers 1 2 3 4 5
(e) My company's implementation of supply chain technologies (ERP, CRM, bar-coding systems, e-commerce etc.) has reflected customers on better service quality 1 2 3 4 5
(f) Requests of supply chain technology by my company's customers has encouraged my company to implement the technology 1 2 3 4 5
(g) My company switches customers more often than before 1 2 3 4 5
(h) My company's relationships with customers tend to last longer than before 1 2 3 4 5

*Suppliers*

(i) There is a strong commitment between my company and its suppliers 1 2 3 4 5
(j) My company's suppliers can be trusted to do what is right 1 2 3 4 5
(k) My company is generally satisfied with the level of cooperation between our firm and its suppliers 1 2 3 4 5
(l) My company is generally satisfied with the exchange of information between our firm and its suppliers 1 2 3 4 5
(m) My company's implementation of supply chain technology has encouraged suppliers to implement the technology 1 2 3 4 5
(n) Implementation of supply chain technology by my company's suppliers has encouraged my company to implement the technology 1 2 3 4 5
(o) My company switches suppliers more often than before 1 2 3 4 5
(p) My company's relationships with suppliers tend to last longer than before 1 2 3 4 5

*Tour Operators*

(q) There is a strong commitment between my company and its tour operators 1 2 3 4 5
(r) My company's tour operators can be trusted to do what is right 1 2 3 4 5
(s) My company is generally satisfied with the level of cooperation between our firm and its tour operators 1 2 3 4 5
(t) My company is generally satisfied with the exchange of information between our firm and its tour operators 1 2 3 4 5
(u) Implementation of supply chain technology by my company's tour operators has encouraged my company to implement the technology 1 2 3 4 5
(v) My company's implementation of supply chain technology has encouraged its tour operators to implement the technology 1 2 3 4 5
(w) My company switches tour operators more often than before 1 2 3 4 5
(x) My company's relationships with tour operators tend to last longer than before 1 2 3 4 5

8. Please indicate the level your firm have problems when getting following services from your suppliers. Please state the problem briefly (in English or Turkish):

(a) Accommodations services 1 2 3 4 5

______________________________________________

______________________________________________

(b) Food-drink services 1 2 3 4 5

______________________________________________

______________________________________________

(c) Communication services 1 2 3 4 5

______________________________________________

______________________________________________

(d) Sporting and social services 1 2 3 4 5

(e) Health and safety services 1 2 3 4 5

(f) Energy and water services 1 2 3 4 5

(g) Waste disposals services 1 2 3 4 5

(h) Advertising and marketing services 1 2 3 4 5

(i) Any other (Please specify:…………………………………..) 1 2 3 4 5

9. Developing a better supply chain management policy and operation strategy in our company would provide the following benefits:

(a) Reduced the cost of placing orders with suppliers 1 2 3 4 5
(b) Reduced the cost of processing customer orders 1 2 3 4 5
(c) Reduced inventory levels 1 2 3 4 5
(d) Improved inventory turnover 1 2 3 4 5
(e) Improved shipment accuracy 1 2 3 4 5
(f) Reduced lead time from receipt of order to delivery 1 2 3 4 5
(g) Improved customer service 1 2 3 4 5
(h) Increased customer satisfaction 1 2 3 4 5
(i) Provides better understanding of our cost to serve 1 2 3 4 5
(j) Improved product to market speed 1 2 3 4 5
(k) Increased time to product 1 2 3 4 5
(l) Improve on-time delivery from suppliers 1 2 3 4 5
(m) Improved information sharing with suppliers and customers 1 2 3 4 5
(n) Improved coordination of logistics activities with suppliers and customers 1 2 3 4 5
(o) Increased trust in suppliers and customers 1 2 3 4 5
(p) Increased commitment to supply chain relationships 1 2 3 4 5

10. Please discuss the problems faced in your companies supply chain (in English or Turkish):

THANKS IN ADVANCE, SINCERLY YOURS.

Note: This questionnaire is modified from K.A. Patterson et al. / Transportation Research Part E 39 (2003) 95–121 ©.

# SERVICE SUPPLY CHAINS: A NEW FRAMEWORK

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## Abstract

*The structure of service supply chains is today mostly unexploited. This paper aims at verifying and explaining this gap with a particular focus to unique nature of services industry and applicability of existing supply chain management literature to service businesses. Implications of this study are relevant both to the practitioners in the services industry and to researchers to conduct further studies in the field.*

Keywords: *Service Supply Chain, Supply Chain Management, Services Industry*

## 1. Introduction

Starting from the early 90's, the field of supply chain management has become extremely important to companies operating in an increasingly competitive global marketplace. However, due to the fact that an extensive amount of scholarly work focused on the issue with regard to manufacturing businesses, our knowledge on the structure of supply chains in service businesses is scarce. This paper aims to emphasize the need for a distinctive supply chain model for services and develop a general framework built on our existing knowledge of supply chains and the nature of service businesses.

## 2. The Supply Chain

Although the "supply chain" and "supply chain management" concepts first appeared in recent decades in literature; the research related to supply chain especially in the fields of managing inter-organizational operations, channel structure, system integration, information sharing and exchange of inventory for information existed before. However, when the company is isolated from its suppliers and other units in the supply chain, effective competition in both national and international markets will be impossible. That is the main reason of development of the supply chain management system (Lummus and Vokurka, 1999). The need to improve operations, increasing levels of outsourcing, increasing costs, competitive pressures, increasing globalization, increasing importance of e-commerce and the complexity of supply chain are some of the reasons of need for supply chain management (Stevenson, 2002).

Many different definitions of a supply chain have been offered in the literature. A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials; transformation of these materials into intermediate and finished products; and distribution of these finished products to customers (Ganeshan and Harrison, 1995). Following, during the Global Supply Chain Forum which was held in 1998, supply chain management was defined as the integration of the key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stake holders (Lambert, Cooper and Pagh, 1998). Another definition of supply chain management by Mentzer et al. (2001) as "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across business within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole". In this context, a number of logistics functions are proposed to be the elements of supply chain management, of which inventory management, materials handling, transportation management, warehouse management, operations planning and control, customer service, order management and logistics information systems management are usually taken as the core functions. In addition, functions such as demand forecasting and planning, packaging, purchasing, and cash flow management are sometimes included in a supply chain approach.

Supply chain was thought as just a chain of businesses with one to one, business-to-business relationships for many years (Lambert, Cooper and Pagh, 1998; Laseter and Oliver, 2003). In time, especially in the recent years, many definitions and aspects were added to the supply chain literature. Basically, the supply chain is the network of organizations. In this network, the upstream and downstream linkages, many processes, activities and operations produce value in the form of products, services or information to the consumer through the supply chain. Although supply chain approach is based on vertical integration, and accordingly focuses on core competence and specialization, these two concepts are not the same. Supply chain consists of many different relationships with suppliers and customers. Cooperation and coordination between each unit of a supply chain are as important as the vertical integration concept (Christopher, 1998). Accordingly, Cooper et al. (1997) indicate that the business

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processes, the management components, and the structure of the chain are the basic three elements of a supply chain management. These three elements are related to the functions within the firm as well as across other firms within the supply chain. Cooperation and coordination between all these elements are vital to supply chain approach.

In practice, one of the firms in the supply chain usually grows more powerful and may claim the director role. This focal company of the supply chain sets some strategic objectives and supply chain policies (Laseter and Oliver, 2003) in order to achieve such aims. Consequently, the supply chain becomes a united body in which the value flow is incorporated and this is basically why supply chains are sometimes referred as value chains. This value creation in supply chain is mainly related to the synchronization between the logistics activities (Stank, Keller and Closs, 2002). Main benefits of supply chain efforts are reducing costs, boosting revenues, increasing customer satisfaction, improving on time delivery and product or service quality.

The nature of supply chain network is not same in all industries. It varies from industry to industry as well as from product to product. Supply chain management concept also differs according to the focal company's characterization such as being in manufacturing business or service business. However, despite a vast amount of scholarly work focusing on the issue of supply chain management for manufacturing businesses, there is little information on the structure of supply chains in service businesses and how they are managed.

## 3. The Service Businesses

Over the past decades, the world has witnessed a tremendous growth in the service industries. With the advance of technology and globalization, the diversity and complexity of services have increased dramatically. In 1995, services accounted for 66% of the GDP in developed countries, followed by 32% in manufacturing. In developing and underdeveloped countries, the share of the services sector in GDP was 52% and 35%, respectively (World Bank, 1999). Today, the services sector accounts for 58 percent of worldwide gross national product (GNP), and this figure is approximately four times the figure that was in 1980.

Rapid expansion of the services sector is a consequence of increasing global trade, advance of technology and the increased focus in specialization. The economic growth and prosperity worldwide has fueled the need for services, as today more companies and individuals are willing to buy services rather than spending time to do them themselves. Consequently, new services are offered each day increasing the product diversity and making the already available ones more complex.

The growth of the services industry ultimately reflected itself in the scholarly work, beginning from the early 80s. Services marketing and management of services businesses emerged as the key focus areas. This interest was largely due to the difference of the service product compared to manufacturing goods. Although many products come in a combination of both goods and services (such as a restaurant meal), a product is classified as a service if the source of a product's core benefit is more tangible than intangible (Berry and Parasuraman, 1991). Other than intangibility; simultaneity, perishability and heterogeneity are usually taken as distinguishing characteristics of services. These distinctive features attached to services undoubtedly require special managerial and marketing approaches to be implemented when running a service business.

However, despite the vast amount of work devoted to services marketing and management, other areas where the existing literature and models should be analyzed for, revised and implemented to service businesses remain untouched. Supply chain management (SCM) is unquestionably is one of these areas. Although supply chain management today constitutes a focus area with numerous sub-areas, ranging from operations management to transportation, and from order management to information technologies, resources on how a supply chain management approach should be implemented to services industries are, at best, scarce. Even, in many popular textbooks on operations management, purchasing and supply chain management, the "services" issue only constitutes a single chapter (Ellram, Tate and Billington, 2004) and in many, services is taken as the service product that is created during the implementation of supply chain management approach, i.e. logistics as a service. This misleading approach is due to several reasons. First, the existing literature in many fields focus on the manufacturing sector and widely accepted models in these areas are built on goods rather than services. Therefore, the scarcity of a well-developed and sophisticated literature on services appears as a major obstacle. Second, general research and teaching focus of most operations management academics is manufacturing-oriented (Nie and Kellogg, 1999). And finally, many service management problems are unstructured, multidimensional and less conductive to normative modeling (Roth and Menor, 2003). However, the existence of such problems does not justify the little amount of work devoted to service supply chains. In addition, SCM practitioners in services industries are in desperate need for information concerning applicable methods and best practices. In this context, a general framework for service supply chain is urgently needed, taking into account the distinguishing characteristics of services.

## 4. The Service Supply Chain

As mentioned before, there is limited scholarly work devoted to service supply chains. In one of the earliest attempts to integrate two concepts –service businesses and supply chains-, Armistead and Clark (1993) explored the use of Porter's value chain as a strategic tool for service industries. The authors employed a resource activity map to identify the service processes with respect to eight variables, which are people, facilities, information systems, materials, equipment, configuration, cost and revenue. Hellman (1995) investigated the alliances in the service industries by using data derived from insurance companies. He emphasized that alliances is critical for service companies as cooperative relationships are more important for them compared to manufacturing companies. Accordingly, it can be argued that supply chain concept is vitally important to service businesses as they are to manufacturing businesses. Youngdahl and Loomba (2000) made a significant contribution to service supply chain literature by extending the concept of the service factory to global supply chains and providing remarkable insights for further research in conceptualization of the role of services in global supply chain management. Sampson (2000) explored the structure of supply chains in service organizations with a focus on consumer-supplier duality issue. Cook, DeBree and Feroleto (2001) applied the concepts of supply chain management to the healthcare industry and concluded that supply chain management is not yet understood by services sector practitioners and because the functions are not systematically integrated in a supply chain approach, the operation of the system is inefficient. In their attempt to develop a framework for expanding the supply chain concept into services industries, Kathawala and Abdou (2003) focused on the trade-off between decreasing the costs and increasing the quality of the services in the supply chain. They proposed that service quality, physically efficient processes and market responsive processes are the main objectives of a service business and defined how traditional supply chain management functions –with a focus on inventory and production- could be adapted to achieve these. Finally, Ellram, Tate and Billington (2004) made the most remarkable contribution to service supply chain literature by proposing a general framework, which is adapted from manufacturing-oriented supply chain management literature. In their model, the key service processes / functions were identified as information flow, capacity and skills management, demand management, supplier relationship management, customer relationship management, service delivery management and cash flow.

The purpose of this paper, which is built on previous research mainly in supply chain management and services management fields, is to develop a comprehensive framework of service supply chain management by highlighting the distinguishing characteristics of services. We believe that, in such an attempt, new constructs are profoundly needed rather than adapting or expanding the traditional version of supply chain management into service industries. This is due to the fact that a service supply chain is structurally different from a supply chain based on manufacturing goods.

## 5. The Structural Differences of the Service Supply Chain

A service supply chain is in its very basics entirely different from a manufacturing-oriented supply chain. This difference arises from the unique characteristics of services, which distinguishes them from goods, as well as the differences in basic requirements when running a service business. These differences are already reflected immensely in service literature and they constitute the reason that underlies operation management scholars' normative belief that service operations should be managed differently (Nie and Kellogg, 1999). Although these distinguishing characteristics of services are highlighted in any service-oriented work, we find it useful to identify how they change the structure of a service supply chain.

The predominant characteristic of services is often cited as intangibility (Lovelock, 1981; Zeithaml, Parasuraman and Berry, 1985). Services cannot be assessed as done are the goods, that is they cannot be seen, touched, smelt or tasted. Intangibility is also the reason why services cannot be owned by consumers. This characteristic gives rise to abolishment of a number of logistics activities that are traditionally accepted to be fundamental to supply chains, such as transportation. Although it may be argued that transportation is the function that provides the "product" to be available to the consumer at the right place and time, and consequently a pre-customized service product is delivered to the consumers via branches, agencies etc., we assert that this is not a transportation activity, which is largely due to another unique characteristic of services; simultaneity.

Simultaneity refers to the fact that customers must be present for the service to be provided, so that production and consumption are simultaneous. In a service environment, the customer usually contributes to the production process and this leads to a major distinction in service supply chains: the production process takes place only when the service provider and the service customer are both present in the service environment. These two entities cannot be separated from each other in production phase. Therefore, although services may be attempted to be customized and standardized beforehand, the final service product is never the same for a particular consumer. In this context, each branch, and even each service employee acts as a single service factory in the delivery of services. This is why the "transportation" concept proves to be inefficient and inexistent in service supply chains.

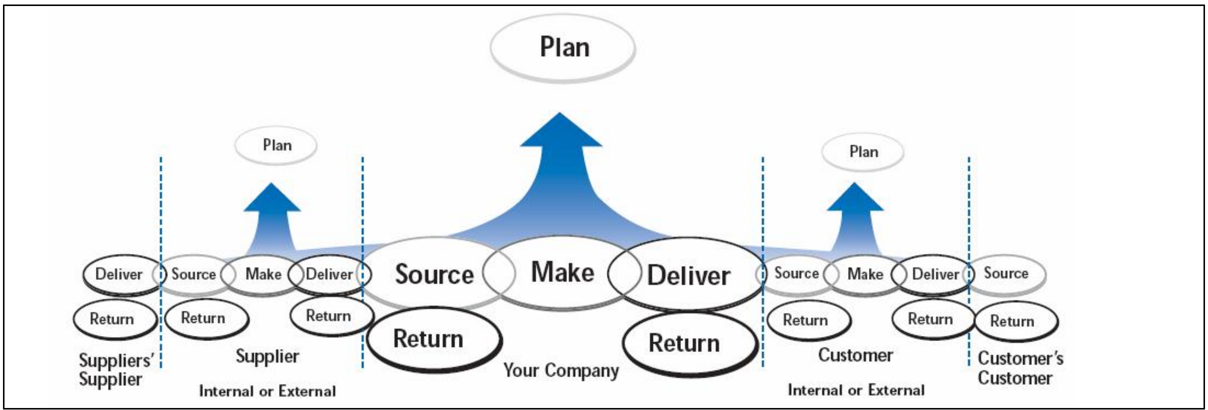
Unstandardization of services reflects heterogeneity dimension, and as stated, no service experience is the same for any single consumer. Even, the same service may be perceived differently by the same consumer in different times, with respect to many factors such as atmosphere, mood of the consumer or the service employee. This feature leads to complexity in planning and analysis of production –i.e. service performance- and the measurement of output when compared to goods (Jones and Hall, 1996).

If a service is not consumed when available, then there is no chance to stock it for future use. Unused capacity, such as not occupied hotel rooms or bus seats, is lost forever. This characteristic is referred as perishability and it makes services impossible to be stored in a warehouse. In this context, warehousing function is totally inapplicable in service supply chains, accompanying a number of extra difficulties in demand management, capacity utilization, production planning and personnel scheduling (Nie and Kellogg, 1999).

Finally, the human aspect in service industries requires notable consideration, both in consumer and employee dimensions. The influence of customers is present in all service operations creating a big deal of complexity. On the other hand, service industries are labor intensive and services are produced by the employees rather than relatively controllable machines. Significant human involvement in the process requires a diverse approach in the study of service supply chains, where the human resources is now a core function rather than a supporting one.

These structural differences emphasize the need for a unique supply chain model for services. However, it is also obvious that the existing supply chain literature constitutes a valuable base in this attempt. In this context, we find it helpful to identify the diversification points of service-oriented supply chains from manufacturing-oriented ones, using the widely recognized SCOR model, developed and endorsed by the Supply-Chain Council as the cross-industry standard diagnostic tool for supply-chain management (Figure 1). The SCOR-model describes the business activities associated with all phases of satisfying a customer's demand[1].

Figure 1. The SCOR Model




Source: www.supply-chain.org

In the SCOR model, the manufacturing company is accepted to be the central unit in the supply chain, where suppliers and customers are identified as other basic units, which operate in a similar way with the manufacturer (i.e. having similar business activities). These five business actives are classified as source, make, deliver, return and plan, which correspond to procurement, production, transportation, returns management and operations planning, respectively. The model also identifies two units at the two ends of the continuum, one being the suppliers' supplier and engaging only in delivery and returns; and the other as the customers' customer (the end-user) who sources and returns the product. Throughout the chain, planning is a central business activity, a role which is dominantly assumed by the focal company. In SCOR model, respective business activities are realized within the particular firm, which we propose to be not applicable to service supply chains.

Unquestionably, some other activities and functions should be identified which provides an efficient management of the supply chain. From a manufacturing perspective and following the Global Supply Chain Forum definitions, Lambert, Cooper and Pagh (1998) classifies them as customer relationship management, supplier relationship management, customer service management, demand management, order fulfillment, manufacturing flow management (which includes sourcing, making and delivering), product development and commercialization, and returns management. However, it is clear that not all these functions are relevant in the services context. In translating this latter model to service supply chains, Ellram, Tate and Billington (2004) identified key functions as capacity and skills management, demand management, customer relationship management, supplier relationship management, service delivery management and cash flow management (Figure 2). In both models, information flow emerges as a suprastructural construct.

## 6. Conclusion and Recommendations for Future Research

The effects of globalization such as borderless markets, global trade, increasing competition makes supply chain management extensively important for all industries. All companies in all sectors are striving to gain the advantage of synergy created by cooperation and coordination with the other companies in the supply chain. There is little doubt that these advantages are also critical for service industries today and this importance will be gaining pace in the following years.

With the advance of technology and globalization, the diversity and complexity of services have increased dramatically and accordingly the service industry has grown rapidly. In this context, both service buyers and service producers face the situation of making more complex and shared decisions. The adaptation of the supply chain approach to different service sectors is therefore a must. Industry based new models and frameworks for service supply chains are needed for the future researches.

This study proposes a general framework for service supply chains. Future research should be directed to determine a general model for service supply chains and examine the validity of the model in different service industries.

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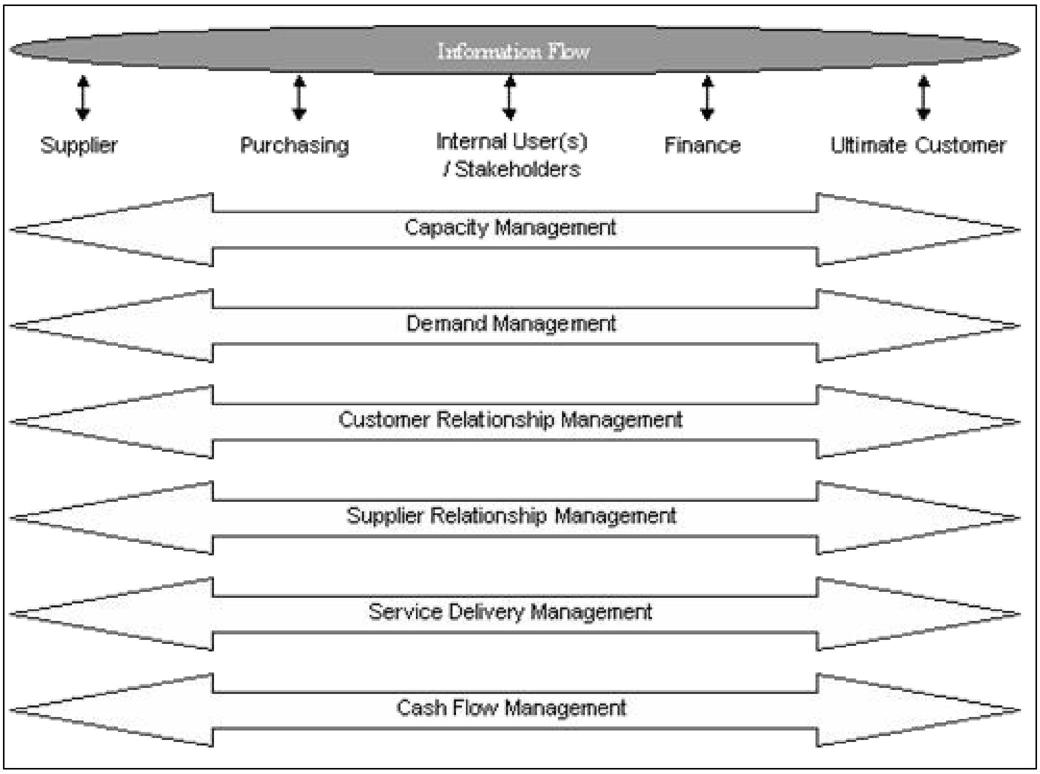
[1] www.supply-chain.org

Figure 2. Ellram, Tate and Billington (2004) Services Supply Chain Model




Source: Ellram, Tate and Billington (2004)

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# SERVICE CHAIN MANAGEMENT – NEW CONSIDERATIONS FOR THE OEM AND 3PL SERVICE PROVIDERS USING A MOTOR CONTROL MONITOR FEATURE AS A WAY TO FOCUS ON BEST PRACTISES

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## Abstract

*Service chain management is being thought of as similar to supply chain management – but with an emphasis on replacing unplanned in-person calls with carefully timed and delivered services based on data retrieved through a data-based Net system (Anderson and Lee, 2000). Today's information technologies (IT) provide companies with tools to manage and integrate customer services information across the value chain while creating competitive advantage (Gold, Dranove, Shanley, Shiber and Hogan, 1998; Dove, 1999). This capability allows both original equipment manufacturers (OEM) and third party logistics services providers (3PL) to automatically have access to data and information on the equipment's condition and performance. With this IT information, they can determine when the equipment will need repairs and allow them to send out field technicians; it also signals the timely and efficient placement and ordering of replacement parts (Bell, 2003; Bookbinder and Dilts, 1989). The researchers set out to examine this capability being offered by a firm in Turkey as they seek to provide huge improvements in overall service costs, equipment uptimes (operational times), technician productivity and overall profitability.*

*Artesis, a subsidiary of one of Turkey's industrial giants of white goods, Arcelik, has undertaken services development activities tied to preventive maintenance of equipment whose main operational features involve rotations, with critical tolerances for balance and revolution rates in attempts to provide optimal services to customers (Keyif, Kapuncu, Durakbasa, 2004). Following the lead by other developed countries that have chosen to involve the intelligent motor control monitor (MCM) detector feature in its preventative maintenance programs – backed up by a web-based network system to provide direct communications between the customer user and the OEM and 3PL – the firm is finding that they should be included in the planning sessions for collaboration on industrial machinery projects – the objective being to find new ways to maximize the returns to the recipient client through service chain management principles (Duyar, 2005; Duyar, 2003). Using primary research results taken from the survey responses of business representatives at Artesis, as well as from examples drawn from customer data and the trade press, the processes involved by the technology are examined in light of its impact on and its place in service chain management functions*

Key Words: Service chain management, OEM/3P,Plant asset management

## 1. Introduction

From the Council of Logistics Management (www. Clm1.org, 01/05/2004): Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be OEM suppliers, intermediaries, third-party service providers, and customers (Caltagirone, Goldsby, Griffis, 2002). In essence, Supply Chain Management integrates supply and demand management within and across these companies through their products and services operations (Christopher, 2000).

Supply chains can be generally regarded as the pathway of events and activities reaching from the supplier's supplier or subcontractor to the customer's main customer (Hewit, 1994). The members of the chain are required to synchronize efforts, initiate cost and schedule savings through continuous improvement. Once the supply chain of a service commitment is defined, management of what becomes a service chain, will result in savings and greater efficiencies (Stevens, 1989).

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The service chain will identify linkage and gaps or holes that cause perturbations in terms of unfavorable impacts on operational costs and schedules and efficiencies (Dabbiene, 1999). Management of the service chain will point out where an organization's time and efforts can be optimized (Roberts, 2003).

An optimized service chain will search for inefficiencies, assist in decision-making support systems, identify areas negatively impacting costs and schedules and will illustrate relationships between the chain's members and the effects of procurement, logistics and distribution decisions (Dougherty, Borrelli and O'Sullivan, 1998; Roberts). As service chains, in principle, exist everywhere as corporations providing services, products, equipment and information flows, it behooves the service chain manager to determine the best fitting flows (Duclos, Vokurka and Lummus, 2003). From a recent poll, the majority of companies surveyed recognize the significance of the service chain, whereby the provisioning of parts and planning of service workforce personnel are vital to a company's successful performance; these same firms have concluded that by optimizing the routing and scheduling of service engineers to work sites, they increase profitability and performance by reducing costs while gaining higher productivity and efficiency rates (http://www.aberdeen.com/summary/report/benchmark/RA_SRO_MVRG_2860.asp).

Typically, the characteristics of the service chain include some unique features. As a group, the chains:

- Reach beyond just an organization's direct suppliers and customers
- Are defined by OEM and 3PL service obligors and their customers
- Require continuous improvement and total quality management (TQM) to reduce and eliminate waste
- Are composed of procurement (strategic out-sourcing, service level computations, alliances, and such), logistics or distribution activities (Knill, 1998).

With this understanding of the characteristics of the service chain and the placement of the MCM into the chain for an equipment maintenance project, we can visualize a services network with all elements leading to the end customer (Goodman and Fichman, 1995). The chain shows the many elements with the activities of the MCM in the process. Many of these components are combined in one service chain/network model. It includes the types of service chain relationships, such as procurement/out-sourcing, logistics and distributions. The service chain may also reflect multi-tier suppliers whose products and services will eventually reach the customer (Magretta, 1998).

The service chain may include large groups of organizations. We are able to achieve maximum focus on the service chain and are able to trace the flow of materials and services, money, information and relationships (Mentzer, Flint and Hult, 2001). We arrive at having identified the main players and to whom each sells its products and services.

While much has been written about MCMs detectors in both technical journals and business-oriented publications, articles and books specifically addressing the issues about service chain management involvement with MCM industrial customers are virtually nonexistent.

As service management evolves as an economic processing activity within the operations of global enterprises, its place and effectiveness in the market place will depend largely and in great measure on the perception of its contributions and how they are evaluated as a player in these strategic partnerships/alliances with customers and, closer to home, with the customers of Artesis.

Studying the service chain and its characteristics in order to synchronize efforts to achieve greater efficiencies and savings by deployment of the MCM and by examining customers that are best served by these applications could best explain how to structure the basis for these perceptions of the service offerings.

Thus a basic rationale for this paper is to explore the use of the MCM as a player within the service chain management as part of developing a world class operation for the manufacturing firm engaged in optimizing preventive maintenance services, through its warranty protection program in fulfillment of its customer services commitment program.

This paper also examines the role of the MCM as an entity engaged by the firm to affect positive relationships with its international suppliers and customers and to maximize the return to the development of the service chain's infrastructure and operating performance.

Moreover, it has become increasingly evident in the technical literature that the development of successful and productive preventative maintenance services programs can be an important factor in the differential advantage for the companies incurring the obligation in exchange for the sale of the equipment / system. From the perspective of the customer, there is evidence that they are largely interested in the scope of the equipment preventative maintenance services package then in a piece of equipment without such technical support backed by the OEM and 3PL (Duyar).

## 2. MCM Fit Into Supply Chain Management

There would appear to be movement for the subject of service chain management to be included in the planning sessions for international industrial projects. Meanwhile the growth and application of technology to improve the optimal levels of services is being facilitated by the deployment of technology and IT systems (Duyar, 2005). This has being observed in several countries and regional sites – originally in the U.S., the EU and now in Turkey

However, a review of both the academic and trade-oriented business literature reveals that very little has been written on the use or participation of this technological ingredient within the supply chain technology in the various countries' equipment and technical services situations. Given increasing pressures to maximize the industrial collaboration returns to the recipient country, service personnel need to be creative and find new ways to aggressively achieve the goals of optimizing equipment and machinery performance in accordance with warranty operation commitments (Mason, Cole, Ulrey and Yan, 2002).

Service chain management it is suggested provides an additional strategic approach to successful performance with greater efficiencies in certain categories (Power, Sohal and Rahman, 2001).

Within the past several years, trends have materialized in factory automation and include involvement with such systems as Plant Asset Management (PAM), Enterprise Resource Planning (ERP) and others (Narasimhan and Das, 2000). Current vision in condition monitoring is to automatically monitor the plant using the so called PAMs which assign work orders for pending equipment problems and will check the inventory for spare parts and order them if they are not in stock (Rutner, Brian, Gibson and Williams, 2003). PAM is expected to communicate with condition monitoring equipment, like MCM, as well as that of the ERP software. Condition monitoring equipment should be inexpensive and capable of being integrated with PAM and be useable without extensive training of personnel (Duyar).

Many PAMs exist, as well as companies who are developing more PAMs under different derivative names. For the time being, MCM seems to be the one existing technology that can be integrated to PAM, however, many companies have developed ERP, PAM and warehouse management systems (WMS) with the resulting need to evaluate MCM in light of these developments (Richardson, 1998). Perhaps because of these events, GE, Rockwell, Emerson and Schenk have decided that they will become total solution providers for factory automation. As a result, we have seen Emerson acquire CSI, GE purchased Bently Nevada, Rockwell has bought Entek and Schenk acquired B&K. Eventually IBM may also be interested in becoming a solution provider; factory automation for the 21st century is alive and well.

## 3. Service Chain Management System and Adaptation to MCM Detector

The MCM in its simplest form is merely a system for controlling and administering to motor control monitoring operations for industrial enterprises and is located in or near the manufacturing plant (Duyar).

A trend in asset and equipment services involving management and the buyer of equipment and services is the use of the MCM, with the feature of intelligent fault locating (IFL) capabilities, as a means to accomplish the equipment warranty service maintenance commitment in the international market place (Teece, 1998). Turkey's Artesis finds that they may be a player in their own efforts to provide greater degrees for quality assurance tied to warranty obligations from equipment suppliers who incur the warranty commitment in exchange for the sale of equipment and technical services. There would appear to be movement for these MCM features to be tied to the service chain management system and be included in the planning for international industrial collaborations – the objective being to find new ways to maximize returns to the recipient customer.

## 4. System Capabilities and Industry Applications

Much international business involves equipment operating systems and warranty obligations being met from a distance (Murphy and Wood, 2004). IT, new technologies and network-based systems have provided ways to optimize service calls and technician calls; equipment uptimes are increasing and instances of downtimes are becoming less (Sharifi and Zhang, 2001). As demonstrated in Figures 1-4 below, the MCM capability has provided significant changes to the performance of the service enterprise.

The advantages of MCM include:

- Increases production and decreases the cost of repair by an early warning of pending breakdowns
- Decreases the cost of energy and production losses by process optimization
- Increases the efficiency and quality of production by remote monitoring machines and related equipment
- Increases the life of machine and related equipment and the plant value by locating the root causes of failure
- Increases the effectiveness of maintenance staff

(http://www.artesis.com)

(Source: Artesis)

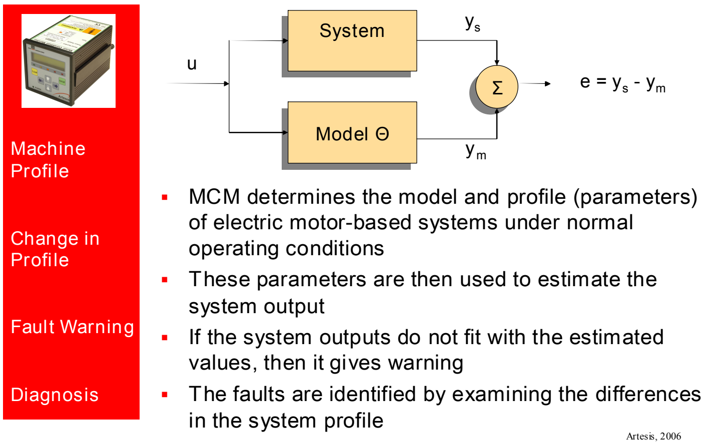


Figure 1. Principles of Model-Based Fault Detection
(Source: Artesis)

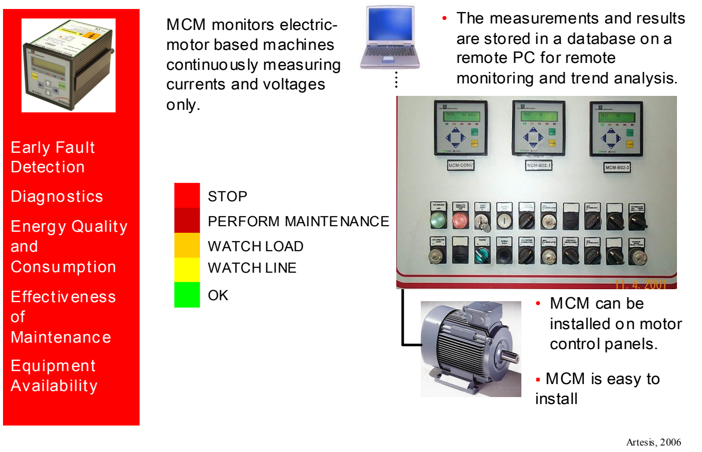


Figure 2. The MCM (Motor Condition Monitor)
(Source: Artesis)

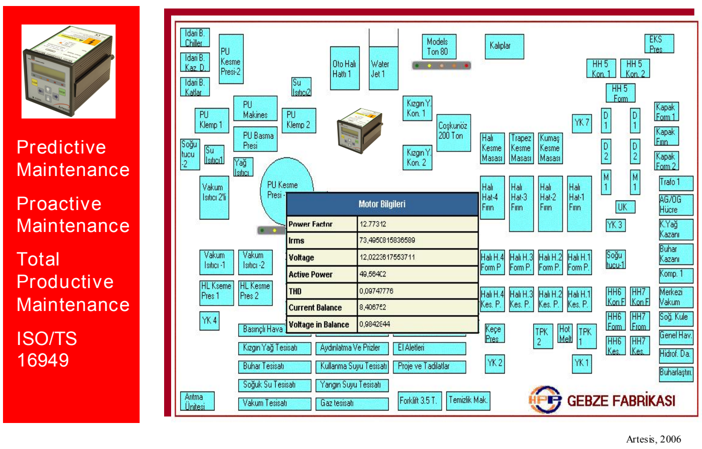


Figure 3. Integration to Maintenance Programs
( Source: Artesis )

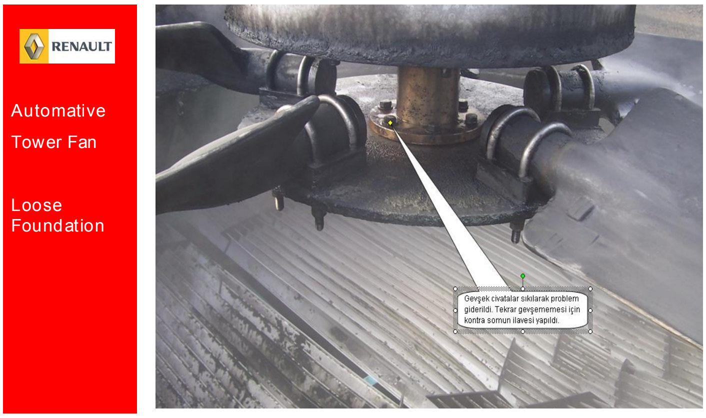


Figure 4. MCM Prevents Unscheduled Downtime
(Source: Artesis)

## 5. The Research and Findings

In addition to commenting on past WMS experiences and involvement of academic institutions, the participants of the survey were asked whether a WMS could be effective in providing certain services as outlined below. What follows is the user's experience and description of how MCM is being used by each user at the following plants in Turkey (Duyar):

- Renault
- Ferro Dokum (Iron Foundry)
- BP

### 5.1 Renault

At Renault, MCM devices are being used to increase the effectiveness for predictive maintenance by the maintenance department team. At the Renault automotive manufacturing plant in Bursa Turkey, the predictive maintenance department utilizes vibration-based equipment, thermal cameras and an electrical analysis system for the condition-monitoring of their critical equipment (fans, compressors, pumps, etc.)

However, both the measurement and analysis of the vibration data is time consuming and does require certain expertise. Though Renault has one of the best teams of predictive maintenance in the industry with the required expertise, MCM was deployed to help them in increasing the effectiveness of the team and to provide them with the capability of expanding the number of equipments that they could effectively monitor, especially in certain hard-to-reach/access areas. MCM is under consideration for providing them with 24 hour continuous monitoring rather than only periodic (once a month) monitoring.

At Renault MCM is being used to monitor equipment, so that if MCM gives an alarm then the predictive maintenance team gets into the picture and is activated to provide diagnosis, using every means available to them, i.e., vibration, thermal camera, electrical analysis equipment as well as the diagnostic feature of MCM.

Using MCM, 5 cases of alarms were observed at Renault.

In one of the cases, the MCM was monitoring a tower fan which gave an alarm indicating imbalance. Since MCM has the capability of providing advanced warnings up to three months earlier, the predictive maintenance team examined the tower fan (the team took the opportunity for check up during a routine stop for maintenance) and observed that one of the bolts fixing the fan blades to the foundation was loose. The team took the needed maintenance action. In this case a visual observation was sufficient for diagnostics.

The second case was a weakening of insulation in one of the phases of a compressor motor which could have led to a short circuit. Again MCM gave an alarm indicating an electrical insulation problem. The predictive maintenance team examined this case also utilizing their thermal camera and verified the diagnostics of MCM.

The third and fourth cases were associated with dirty filters of two different compressors. After MCM gave alarms indicating load changes, the predictive maintenance crew determined that the filters needed to be changed. They also noted that none of the other techniques they were deploying (vibration, thermal camera etc.) were capable of providing in indication of this problem.

### 5.2 Ferro Dokum (A foundry plant)

At Ferro Dokum, MCM is used to add predictive and proactive maintenance capability to the maintenance team. They monitor some of their more critical equipment using MCM. In one case, they used one MCM to monitor more than one motor in the process. Here MCM is used not only to detect developing faults but also to monitor the process as well. Additionally, depending on when each individual motor starts and stops in the process, they are able to monitor the quality of manufacturing as well.

### 5.3 BP Fuel filling station

At one of the fuel pumping stations of BP, MCMs were adopted mainly as an added precaution against the potential fire hazard due to short circuits that may occur in the motors of the pump. MCM units are being used in this facility for monitoring as well as for verification of the maintenance activities performed.

From a macro perspective, the implications for the inclusion of the MCM within the service chain (value stream) may be far-reaching and powerful with a high impact on the nature of equipment operations activities in Turkey. New service chain networks are being developed and are competing against older established value streams in search of competitive advantages and fulfillment of equipment performance obligations through inclusion of the MCM into the service chain.

## 6. Conclusion

The MCM modeling within equipment preventative and service maintenance programs can be a useful and beneficial way to demonstrate how a customer can acquire needed equipment and services while gaining important progress in its own equipment operation and industrial development goals. The successful operation of the service chain is tied to the outsourcing of equipment servicing to third-party logistics providers (3PLs). Original equipment manufacturers (OEMs) have found these services may fulfill their commitments to customers. Firms that need to gain new market access and shares have the option to achieve them through a preventive maintenance services program for equipment. Such service chain programs are growing in frequency and size. Equipment preventative maintenance services programs are increasing in number and importance; yet research shows that many firms have not yet tried to use the MCM with the IFL capability as an innovative ingredient to their equipment operation services programs – particularly as a role player in the service chain. Involvement of the MCM offers a number of advantages, as reflected above. Specifically, it may be a useful process in the industrial equipment servicing and support functions of manufacturing and logistics (Duyar).

In particular, companies with extensive operations involving equipment with certain characteristics are most apt to benefit from the use of the MCM feature at this point in time. While not a panacea to every specific difficulty that exists between the firms approach to its equipment services operation, the results of this approach using the service chain suggests that there are specific advantages to be gained as a factor in achieving a world class equipment preventive maintenance services program – particularly in light of supply chain management. Equipment services management planners and managers who have not examined this supply chain tie-in involvement may be overlooking an opportunity to engage in more effective and rewarding equipment maintenance services programs.

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# EMERGENCY LOGISTICS FOR GLOBAL OPERATIONS

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## Abstract

*Global attention to natural disasters has increased over the last few decades. Consequently the cost, not only in financial terms, but also in terms of human lives, of dealing with these disasters has reached astronomical levels. It is not only a concern for governments and NGO; private organisations do also have responsibilities when it comes to dealing with natural disasters. The literature on emergency logistics has identified three main variables such as preparation; risk mitigation; and collaboration. These variables are incorporated into a conceptual model by indicating the possible relationship between them and their drivers to emergency logistics performance.*

Key words: Emergency Logistics, disaster management, risk mitigation in logistics

## 1. Introduction

*"Watch out for emergencies. They are your big chance!"*
Fritz Reiner (1905)

Conductor Fritz Reiner did not think of emergency logistics when he said this. However, it is very relevant for emergency logistics. It is better to be prepared for the worst, than to hope for the best.

Emergency logistics contains many of the same components and practices found in business logistics; including purchasing, forecasting, transportation, customs clearance, warehousing, insurance and control of loss and damage levels. An important difference is that speed is more vital than cost, as lives are at stake (Moody, 2001). The International Rescue Committee (2006) states that the biggest threats to human lives usually occur in the early stages of a major emergency. This is where many lose their lives and many more suffer unnecessarily due to the lack of help.

Natural disasters, appear to be occurring with increasing frequency over the last few decades (Bechler, 2004; Nates & Moyer, 2005). This leads to an increase in the costs for governments, NGOs (non-governmental organisations) and private companies in dealing with these growing occurrences of natural disasters. The United Nations Environmental Programme (UNEP), (2002: 4) informs us that the cost of natural disasters world wide has reached almost 1 trillion USD over the last 15 years. This cost supported by aid donor countries such as the United States and Australia (Bureau of Transport Economics, 2001). In Australia alone the annual costs of natural disasters is $1.14 billion (Bureau of Transport Economics, 2001: 120). One reason for the increase in disasters, according to the UNEP (2002) is human caused climate change (an assertion supported by for example AMP Henderson, 2003; Deegan, 2005; McLeman & Smit, 2006).

Figure 1 shows reported natural disasters over the last 100 years. Nates and Moyer (2005) point out that one reason for the apparent 'boom' in terms of frequency of disasters is simply that they are now actually reported, whereas in the past, communications were more limited. However, Nates and Moyer (2005) also point out that the number of people affected by disasters has also increased dramatically over the last few decades.

When emergency logistics take place in another country, or an unfamiliar place, the process becomes more complex. In these instances logistics and transportation activities face unknown infrastructures, or in the worst case scenario, devastated and unknown infrastructures (Wood et al., 2002) that significantly increase the complication. Emergency logistical processes face the same restrictions and problems as commercial international logistics. Export related issues such as, documentation, transport, communication and inventory management still need to be processed in ways similar to usual commercial transactions (Wood et al., 2002). Therefore, emergency logistics for global operations in the context of disasters (human made or natural) is becoming an important issue, not only for the various NGOs and governmental rescue agencies, but also for private companies, as globalisation has led to increased operations across international borders.

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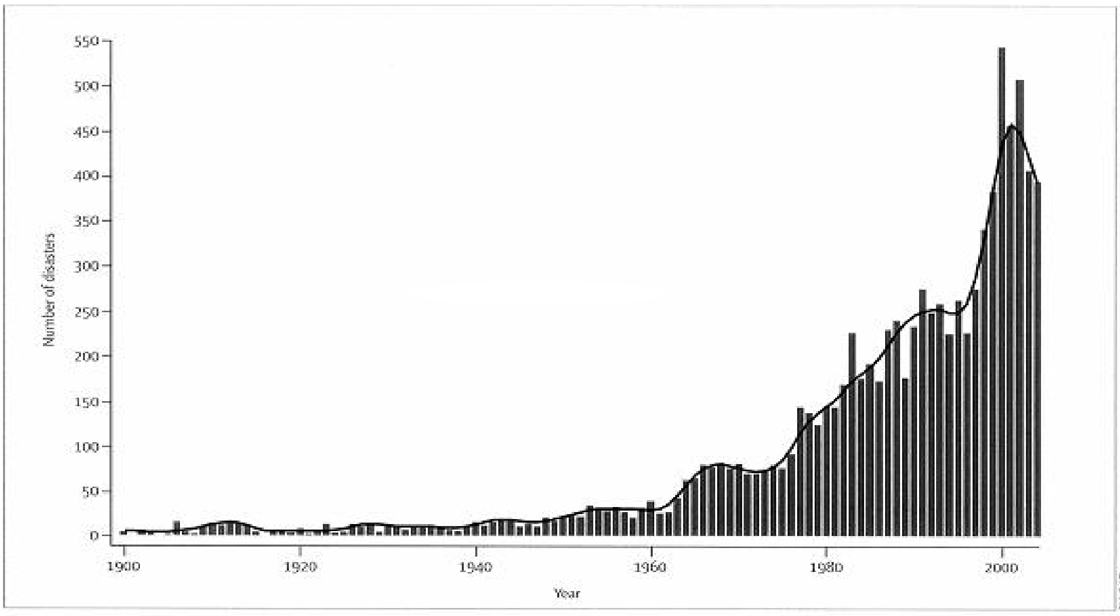


Figure 1: Natural disasters from 1900-2004 (Adopted from Nates & Moyer, 2005: 1145).

This conceptual paper aims to identify some important variables in emergency (global) logistics operations, their related factors and the possible relationship between the variables. The remainder of this paper is structures as follows. First, a review of the literature is presented with specific focus on three variables, i.e. preparedness, risk mitigation and collaboration related to emergency logistics for global operations. Thereafter, a conceptual model is constructed to where in the possible relationships between variables for emergency logistics-performance are indicated. The model also identifies some factors related to the variables incorporated in the model. The paper ends with a conclusion.

## 2. Literature Review

*"Be prepared."*
Baden Powell (1937)

Emergency management is a widely researched topic, and interest in it has increased during recent years (see for example; Bechler, 2004; Burnham, 2006; Drabek & McEntire, 2003; Hale & Moberg, 2005; Hoffmann, 2005; Perry & Mankin, 2005; Pettit & Beresford, 2005). However, despite the focus given after the 2004 Boxing Day Tsunami, less attention has been given to logistics and emergencies (Hale & Moberg, 2005). It is still a topic in need of more research (Hoffmann, 2005; Thomas & Kopczak, 2005).

The focal points of emergency logistics and management research are preparedness and risk mitigation (Edmonson, 2005; Rodriguesz & Marks, 2006). This broadly means evaluating the relief effort after a disaster has occurred, to learn from it. However, it is argued that this puts limitations on emergency research. This does not necessarily give an accurate view of how organisations actually behaved during an emergency as it can be affected by the stress of the event (Bechler, 2004). Another argument is that emergency plans are too often developed after an emergency event, purely to obtain funding, instead of being used as an opportunity to develop comprehensive plans for future emergencies (Schneider, 2002). This "one-size-fits-all" approach is not an appropriate strategy in such an environment (Bechler, 2004). Any organisation (government, NGO or private) dealing with an emergency event will have most probably different preparation, mitigation and response strategies to an emergency situations (Bechler, 2004).

### 2.1 Preparedness

Being prepared involves having an emergency plan that is compatible with the organisation's resources and appropriate to the level of risks. It is not only good practise, but actually necessary to plan for extreme events or disasters (Hale & Moberg, 2005). Emergency preparedness was an important subject during the Cold War, where governments prepared for nuclear attacks and how to continue afterwards (Haddow & Bullock, 2006; Perry & Mankin, 2005). Recently, governments, and to a larger extent, businesses are preparing for possibilities such as terrorism, natural disasters or other human made (also known as technological) emergencies (Gill, 2005; Perry & Mankin, 2005). However, Allaire and Firsirotu (1989: 7) argue that these "predict-and-prepare" strategies are not enough when planning for uncertainty. Strategies that consider unpredictable events that can happen must be applied. For example, in the year 2000, a fire caused the supplier of microchips to two major mobile phone producers to close down its plant, and could therefore not supply the two companies. One of the mobile phone producers responded promptly and arranged microchips from other suppliers using its multiple supplier strategy. On the other hand, the second company, which had no emergency strategy in place for such events lost $400 million in sales (Chopra & Sodhi, 2004: 53).

Emergency management theory considers preparedness as one of the more vital issues (Adams, 2005; Bimal, 2006; Chopra & Sodhi, 2004; Haddow & Bullock, 2003; Hale & Moberg, 2005; Peck, 2005; Sheffi, 2002). A common theme in these studies is the argument that preparedness is achieved by learning from experience. As Nates and Moyer (2005: 1146) point out; *"He who forgets history is destined to repeat it"*. However, to what extent we learn from disaster experience is disputed. For example, Keane (2005) refers to the inept emergency logistics system during Hurricane Katrina, and questions if there will be any lessons learned from such large scale disasters. There is no lack of willpower, but politics seems to be a tough barrier to overcome (Adams, 2005; Keane, 2005; Pettit & Beresford, 2005).

An essential factor for preparedness is being in the right place at the right time, and having disaster response equipment in the right locations (Hale & Moberg, 2005). This includes a 'just-in-case' inventory system. Having warehouses and storage areas strategically placed within the supply chain locations will increase an organisation's preparedness for the next emergency (Hale & Moberg, 2005), and hence, reduce economic losses (for example, the microchip supplier and the two mobile telephone producers). This idea parallels the push model of business logistics management. Push logistics is important during emergency operations; however, when the relief operation is under more control, a pull system would be preferable (Long & Wood, 1995).

Although, the literature praises the importance of businesses role in emergency logistics, it cannot be done without some sort of cooperation with NGO's or governmental agencies. This was only too evident during the relief effort in New Orleans (after Hurricane Katrina) when Wal-Mart trucks with bottled water were turned back by governmental agencies (Leonard, 2005). Interstingly; Wal-Mart's emergency logistics system proved to be much more competent than that of the Federal Emergency Management Agency (Peck, 2005). According to Dimitruck (2005), it is simply that Wal-Mart has managed logistics and supply chain management: Supply chain technology is Wal-Mart's specialty (Bonacich, 2004).

Lessons learned are also a central topic in the emergency literature. Warhurst et al. (2005) provide examples of some of these 'lessons learned' from previous disasters. After the earthquake in Bam, Iran, in December 2003, the Airport Emergency Team (AET) was developed by using logistics expertise from the private sector. The AET's main task is to coordinate supply going through airports in the affected areas. Another similar 'lesson' was the development of Logistics and Transportation Corporate Citizenship Initiative (L&TCCI), which was formed in January 2003 by the CEOs of a group of logistics and transportation companies (who would normally be competitors). They launched a set of principles in January 2004 committing them to 'Corporate Social Responsibility' in the global society (Warhurst et al., 2005). That is, the aim is to provide logistical assistant during disasters, worldwide.

An area in relief operations that is in need of more attention is social behaviour (Drabek & McEntire, 2003). Studies have found that people are rational during disasters, by not panicking or engaging in antisocial behaviour (Drabek & McEntire, 2003; Osorio & Hurych, 2004). There is also evidence to contradict this (Adams, 2005). Human error is found to one of the biggest causes of system failure (Bankoff, 2005; Dudley, 2006; Grabowski et al., 2000; Walker, 2001). Osorio & Hurych (2004) However, people are also the most significant element in preparing and dealing with disasters (Osorio & Hurych, 2004). One suggestion for improving emergency personnel and manager, is to teach stress management techniques (Paton, 2003). It is argued this will help emergency planning and responses, and make the relief process more effective (Paton, 2003). These finding are supported by Alexander (2003), who goes a bit further and suggests the development of standardised international emergency training, which will lead to improved collaboration. Reconstruction and recovery training is an important element of being prepared: while prevention of disasters is impossible, their impact can be limited by quicker and more efficient processes for rebuilding in the aftermath (Trunick, 2005). Hardy and Roberts (2003: 7) report that over 40 percent of businesses affected by a disaster never re-open, and 30 percent close within two years, due to lack of, or poor continuity plans.

## 2.2 Risk Mitigation

Along with preparedness, risk mitigation is one of the mostly discussed components in emergency logistics and management (Adams, 2005; Atkinson, 2006; Barry, 2004; Chopra & Sodhi, 2004; Gill, 2005; Kleindorfer & Saad, 2005; Sheffi, 2002). Schneider (2002) reports that risk mitigation has been identified as the most important activity in emergency management, especially in regard to natural disasters that are to some extent predictable. Even when disasters are unpredictable, relief organisations have developed estimates of what will be needed in various emergency scenarios to mitigate disastrous outcomes (Trunick, 2005). This is unfortunately not enough, especially in global emergencies. Even though an emergency operator (being a government, NGO or business) has a predicted inventory or a list of vital items (e.g. for donation purposes) as part of their risk mitigation strategy, other factors plays a big role. Nevertheless, it is being argued that risk mitigation is the "cornerstone" in emergency management, as its main cause is to lessen the impact made on people and land. Preparedness on the other hand deals more with the functional sides of emergencies (Haddow & Bullock, 2003).

Disagreements exist, however, about the focus on technology and science in emergency risk management is being disputed (Cannon, 2000). The risk mitigation process becomes too mechanical and directs its attention to what is possible rather than what is needed (Cannon, 2000). Therefore, is argued to include vulnerability analysis in risk mitigation strategies is proposed (Atkinson, 2006). Burnham (2006: 83) states that: "Disaster relief is not just about meeting immediate needs but also about building capacity for future responses and mitigating the conditions which created the vulnerabilities for the disaster". One of these conditions is identified as the supply chain (Atkinson, 2006; Bannon & Fisher, 2006; Barry, 2004; Kleindorfer & Saad, 2005). It is argued that the supply chain will be heavily affected, or even break down completely during an emergency (Chopra & Sodhi, 2004; Hale & Moberg, 2005; Kleindorfer & Saad, 2005). For example, following the Boxing Day Tsunami there was no shortage of aid agencies, but one of the problems was poor communication and co-operation between the agencies (Bannon & Fisher, 2006; Hoffmann, 2005; Thomas & Kopczak, 2005). Hoffmann (2005) further argues that the 2004 Boxing Day Tsunami identified the vital importance of international emergency logistics as a global risk mitigation device. With reference to *Medicens sans frontiers*, he uses the concept "supply managers without borders" (2005: 1) to state the importance of logistics and geographical knowledge in emergency operations. This is also pointed out by Long (1997) as an important factor in achieving successful emergency logistics.

Six common risk mitigation tools in emergency management are suggested (Haddow & Bullock, 2003: 39):

- Hazard identification and mapping
- Design and construction applications
- Land-use planning
- Financial incentives
- Insurance
- Structural control

These (rather broad) strategies are used to identify and control disaster risks. Despite the availability of disaster risk mitigation tools like the above; however, willpower (political and managerial), costs, lack of funding and acknowledging liabilities prevent the various risk mitigation tools from being applied (Haddow & Bullock, 2003: 43). Although this is changing (Haddow & Bullock, 2003), the research indicates that an enhanced relationship between private and public interests will lead to improved emergency logistics systems, and it is becoming evident that business logistics can be used as a benchmark for future emergency operations (Gill, 2005; Murray, 2005; Sheffi, 2002; Thomas, 2005; Tomasini & Van Wassenhove, 2004).

### 2.3 Collaboration

Some recent studies also point to collaboration as a vital factor for successful emergency logistics (see for example; Fritz Institute, 2005b; Tomaszewski et al., 2006; Warhurst et al., 2005). The Fritz Institute strongly supports the concept of 'public and private collaboration'. That is, collaboration between the private sector, governments, governmental agencies and NGOs. In a recent survey of the Boxing Day Tsunami's relief operations, the Fritz Institute found that collaboration, where it existed, was successful on an "*ad-hoc basis",* but did not have the desirable effect in "*meeting ongoing needs*" (Fritz Institute, 2005b: 4). However, it was found that an international supply chain collaboration system was lacking during the relief operations (Fritz Institute, 2005a, 2005b).

Collaboration has been strongly recommended in private sector supply chain management for the long-term survival of businesses (Ayers, 2004; Manrodt & Fitzgerald, 2001). Bowersox et al. (2005) note that collaboration makes the supply chain more transparent and efficient, and improves its performance. They further argue (with support from Ayers, 2004; Bryan, 2005; Tomasini & Van Wassenhove, 2004) that while the benefits of collaborating on their own are great, applying technology, it will enhance the process even more. With the view on humanitarian supply chain, the Fritz Institute (2005a) and Tomasini and Van Wassenhove (2004) outline similar views for both collaboration and technology. Emergency supply chain technology is playing a vital role that cannot be ignored when preparing for emergencies. A private-public collaboration, or even a partnership-based model should be created as soon as possible to prevent another chaotic relief operation (Fritz Institute, 2005b; Keane, 2005).

## 3. Conceptual Model

The conceptual model, shown in Figure 2, illustrates the relationships between the variables (preparedness, risk mitigation and collaboration), and the affect they have on emergency logistics performance.

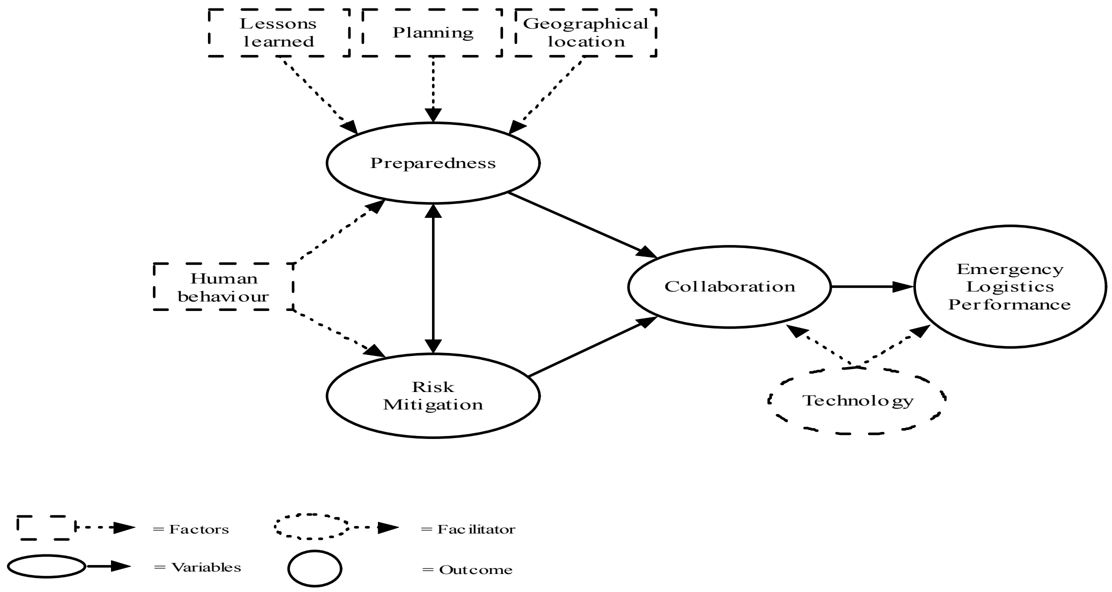


Figure 2: Conceptual model - variables effecting emergency logistical performance in global operations.

Preparedness is how ready an organisation (NGO, private company or government) is for any forecasted or imminent disasters. That is, developments of emergencies plan, strategies and security measures to deal with disaster situations (Alexander, 2002; Haddow & Bullock, 2003; Hale & Moberg, 2005). Risk mitigation is applied to minimise loss or the impact of an emergency (Hood et al., 1992). Collaboration, in this instance, means a network of private and public organisations working together, sharing information and cooperating before, during and after an emergency operation. These three variables, some more than others, have been identified in the research literature as important variables for successful emergency logistical operations.

As discussed, preparedness deals more with the practical side of emergency logistics (Alexander, 2002). Historically, preparedness has been the main focus point for emergency management (Haddow & Bullock, 2006). But, as already noted, it cannot be seen as a solitary element in emergency logistics. None of the identified variables can work in a functional manner without the support of the others. It is the relationship between the three variables that enhances emergency logistics performance.

Factors such as lessons learned, planning and geographical locations have been identified as influencing preparedness. Some lessons have been learned from previous disasters (Warhurst et al., 2005). Some of the devastating disasters that have occurred over the last few years, e.g. Boxing Day tsunami (2004), Hurricane Katrina (2005) and the earthquake in Kashmir (2006), have put more pressure on emergency logistics and management and how it was handled (Burnham, 2006). Burnham (2006) argues that this "new" focus on lessons learned will reduce the focus on planning, which according to Hale and Moberg (2005) and Alexander (2002) is not the right direction to take. Planning for uncertainty is a very important part of good emergency logistics. The last factor affecting preparedness is geographical location. Disasters can happen anywhere, whether it is a natural or human made disaster. Therefore, when disaster occurs, the geographical location needs to be understood and mapped out (Alexander, 2002). Having this information in advance of emergencies, or having the means to promptly obtain it, will therefore improve preparedness. If the emergency is of an international nature, export and international trade issues become important components. As with commercial international logistics, international emergency logistics fall under the same legal restrictions (Long & Wood, 1995). As reported by Bannon and Fisher (2006) one year after the Boxing Day Tsunami, containers and vehicles were still at Indonesian custom authorities. The same happened in Sri Lanka, where equipments that could be of use to rebel militants were denied custom clearance (Bannon & Fisher, 2006; Thomas, 2005). Criticism on the legal framework of international emergency operations have been raised after the Boxing Day Tsunami, and 'legal preparedness' must be considered by any organisations dealing with international emergencies (Bannon & Fisher, 2006).

The second variable, risk mitigation is strongly connected to preparedness (Haddow & Bullock, 2003), and an important factor for both variables are human behaviour. Human behaviour is, as discussed, a factor for failure in emergency operations (Osorio & Hurych, 2004). Risk mitigation, especial in large scale systems such as an emergency operation, becomes hard due to the important role of humans (Grabowski et al., 2000). This was evident during the emergency relief operations after Hurricane Katrina (Nates & Moyer, 2005), where human behaviour (or antisocial behaviour) became a focal point in the media. In addition, human error and lack of mitigation was also heavily criticised by the media.

An interesting argument is that the media is a source of stress behaviour among emergencies personnel and managers (Paton, 2003). This indicates that any organisations dealing with an emergency should work with the media. This can increase funding and stakeholders perceptions of the organisation and the emergency in question

(Bimal, 2006; Long & Wood, 1995; Southall, 2005). This is also often refer to as legitimacy theory (Deegan, 2005). Ross (2004) argues that organisations should sponsor journalist and provide them with information and material regarding the emergency. By collaborating with the media in this way, focus on the negative or what is/went wrong can be shifted towards what is being achieved and what is needed (Ross, 2004).

Technology, in this model, is considered a facilitator for collaboration and the emergency logistical performance. It is important to note that the human interaction is the vital factor for collaboration to exist. However, technology will make collaboration easier (Bowersox et al., 2005; Sanders & Premus, 2005). Technology allows different organisations to, for example, "talk to each other" and share information from an early stage of an emergency situation (Wood et al., 2002). Openly sharing information and communicating between the different participants, time, which is so important in emergencies, can be used more efficiency (Long, 1997). A survey conducted by the Fritz Institution (2005b) also emphasizes the importance of technology in relief operations, and it is stresses that information systems are the single most important factor in emergency logistics (Long, 1997).

The literature has recognised preparation and risk mitigation as two important factors in emergency operations. Collaboration, on the other hand, has not received as much attention. However, collaboration in the literature on technology and supply chain management is greatly researched. By applying collaboration in emergency operations, which, for example, the Airport Emergency Teams is an example of, can enhance emergency efficiency (Keane, 2005). In the private sector, collaboration is being applied to improve both financial and operational aspects of logistics and supply chain (Bowersox et al., 2005). It should therefore be a natural step for emergency management to do the same, especially when so many disasters are lacking financial funding and having ineffective logistics systems (Burnham, 2006).

The model proposes positive correlations between impendent variables such as preparedness, risk mitigation and collaboration. The relationship between independent variables and dependent variable (emergency logistics performance) has also been assumed in the model as positive.

## 4. Conclusions

There is a strong trend toward an increasing need for emergency logistics (Leonard, 2005; Nates & Moyer, 2005). It is no longer only the responsibility of governments and NGOs to act when a disaster hits. Businesses are becoming an important factor in the emergency logistics and disaster management, as shown by Leonard (2005) and Dimitruck (2005), who assessed the emergency logistics activities after hurricane Katrina hit the USA. Leonard looked at Wal-Mart's emergency logistics system, and states that the retailer was better prepared for the disaster than the Federal Emergency Management Agency. Nevertheless, the majority of businesses are not well enough prepared for an emergency and the logistical problems that follow (Hale & Moberg, 2005: 196). An important statement by (Trunick, 2005: 38) illustrate the importance of an emergency logistical system "*…as long as there's a need for aid, logistics will be on call*".

The indication is clear that emergency logistics, whether a relief operation under NGO or a rescue operation for a company are to face more obstacles and complications compared to usual commercial transaction. The conceptual model presented in the paper, in our views, would enhance the understanding of emergency logistics for global operations. The model would also be useful in undertaking future research project(s) in this emerging area that may lead to examine the validity of the model. The project(s) may also lead to identify and incorporate additional variables and/or factors related to emergency logistics operations in order, to not only to further enrich the body of knowledge, but also to provide valuable insight into this area for practitioners and researchers.

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# A MIXED INTEGER LINEAR PROGRAMMING MODEL FOR REVERSE LOGISTICS NETWORK DESIGN PROBLEM

Gülfem Bıyık[1], Bahadır Gülsün[2], and Doğan Özgen[3]

## Abstract

*Environmental concerns, competition, economic factors, etc. motivates both the academicians and practitioners to study on reverse logistics activities. Reverse logistics contains activities such as product returns, recycling, substitution, reuse, disposal, refurbishment, repair and remanufacturing. Product returns constitutes an important portion in total company costs. A company can take competitive advantage with cost reductions in product returns in terms of transportation, inventory and warehousing costs. Determining convenient quantities and location places for centralized return centers is an important decision in reverse logistics networks. In this paper a mixed integer linear programming model is applied for this decision making area.*

*Keywords: Reverse Logistics Networks, Mixed-Integer Linear Programming*

## 1. Introduction

Due to the threatening level of environmental problems, environmental initiatives, which are enforced by governments, customers or companies themselves, have become an obligation. As a part of environmentally conscious initiatives, reverse logistics has taken considerable attention both from academicians and practitioners. Rogers and Tibben-Lembke (1998) defined reverse logistics (RL) as “the process of planning, implementing and controlling the cost effective flow of row materials, in-process inventory, finished goods and related information from the point of origin for the purpose of recapturing value or proper disposal” (Tibben-Lembke et al., 1998). Traditionally, the term of “logistics” is perceived only with the forward side of the concept. On the other hand, many reasons, such as (Brito et al., 2002):

- manufacturing returns,
- commercial returns (B2B and B2C),
- product recalls,
- warranty returns,
- service returns,
- end-of-use returns,
- end-of-life returns,

cause reverse direction product corridors and this additional reverse side of the logistics provides a closed-loop.

Usually, RL can be perceived as exactly the reverse of the forward logistics (FL), however, in lots of decision making areas, RL is not similar to the FL. RL may have different channels, collection points, decision making units, product characteristics, etc. Differences between forward and reverse logistics are in Table 1 (Tibben-Lembke et al., 2002).

Given the differences, it is obvious that, there is a need to examine the RL concept as an independent research area. Considering this need, a large body of study has been built since 1992 (the time that the first recognized the RL field). The researchers examine the RL concept in different point of views and the various sides of the field are investigated. Related literature is investigated in the next section. The aim of this paper is to examine a basic model which is prepared by Fleischmann (2000) for RL network design. An illustrative example considering a hypothetical firm is also prepared.

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Table 1. Differences between forward and reverse logistics (Tibben-Lembke et al., 2002)

| Forward Logistics | Reverse Logistics |
|---|---|
| Forecasting relatively straightforward | Forecasting more difficult |
| One to many transportation | Many to one transportation |
| Product quality uniform | Product quality not uniform |
| Product packaging uniform | Product packaging often damaged |
| Destination/routing clear | Destination/routing unclear |
| Standardized channel | Exception driven |
| Disposition options clear | Disposition not clear |
| Pricing relatively uniform | Pricing dependent on many factors |
| Importance of speed recognized | Speed often not considered a priority |
| Forward distribution costs closely monitored by accounting systems | Reverse costs less directly visible |
| Inventory management consistent | Inventory management not consistent |
| Product lifecycle manageable | Product lifecycle issues more complex |
| Negotiation between parties straightforward | Negotiation complicated by additional considerations |
| Marketing methods well-known | Marketing complicated by several factors |
| Real-time information readily available to truck product | Visibility of process less transparent |

## 2. Literature Review

There are several RL literature survey papers in the literature and all classified RL literature with different point of views. One of the leading literature surveys, which reviewed the quantitative models for reverse logistics networks, prepared by Fleischmann et al. in 1997. In this paper, RL investigated in three classes. In the first class, distribution side of the RL is examined with its two sub dimensions: (1) separate modeling of the reverse flows, (2) integration of the forward and reverse distribution. In the second class, the inventory control in systems with return flows, which examined into two dub dimensions as deterministic and stochastic models, is examined. Finally they investigated the production planning with reuse of parts and materials side of the RL concept. They examined this part into two dimensions such as: (1) Selection of recovery options, (2) Scheduling in a product recovery environment.

In 2002, Brito et al. reviewed case studies in RL. In their valuable study, they reviewed the case studies in five main classes. First class is related with RL network structures which contain four subclasses: (1) networks for reusable items, (2) networks for remanufacturing, (3) public reverse logistics networks, (4) private reverse logistics networks for product recovery. In the second class, they studied on the RL case studies related with the RL relationships which classified as two subclasses: (1) economic incentives to stimulate/enforce the acquisition or withdraw of products for recovery, (2) non-economic incentives to stimulate/enforce the acquisition or withdraw of products for recovery. In the third class, they reviewed the literature related with the inventory management which can be investigated in four subclasses: (1) commercial returns cases, (2) service return cases, (3) end-of-use returns cases, (4) end-of-life returns cases. In the fourth class, they investigated planning and control of recovery activities into five subclasses: (1) disassembly planning, (2) planning and control of collection activities, (3) planning and control of processing, (4) integral planning and control of collection-distribution, (5) integral planning and control of processing-distribution. In the last class, they reviewed the studies related with ICT. In addition to these two valuable studies, several studies can be helpful to the researchers, which are interested in RL concept, prepared by Fleischmann et al. (2000), Carter (1998), Subramaniam (2004), etc.

RL studies can be investigated into three classes: RL network structures, inventory control in RL, production planning in RL. Based on Fleischmann et al. (2000) RL networks can be investigated in three classes. First class is the bulk recycling networks which are related to the material recovery from rather low value products. (Barros et al., 1998; Biehl et al., article in press; Listeş et al., 2005; Lebreton et al., article in press) can be shown as examples of this class. Barros et al. (1998) proposed a two-level location model for the sand problem optimization using heuristic procedures. Biehl et al. (article in press) simulate a carpet RL supply chain and use a designed experiment to analyze the impact of the system design factors impacting the operational performance of the RL system. Listeş (2005) presented a stochastic approach to a case study for product recovery network design. Lebreton et al. (article in press) investigated the profitability of the car and truck tire remanufacturing systems. Second class is the assembly product remanufacturing networks which are related to re-use on a product or parts level of relatively high value assembled products. (Schultman et al., 2005; Franke et al., 2005; Shih, 2001, Krikke et al., 1999) can be shown as examples of this class. Schultman et al. (2005) modeled RL tasks within closed-loop supply chains and they give an example from the automotive industry. Franke et al. (2005) presented a paper about the remanufacturing on mobile-phones. Shih (2001) presented an article for reverse logistics system planning for recycling electrical appliances and computers in Taiwan. Krikke et al. (1999) proposed a RL network redesign methodology for copiers. The last class is related with the re-usable item networks which are concerning containers, pallets, etc. (Kroon et al, 1995) can be shown as an example of this class. In their study, Kroon et al. (1995) gave an RL example for returnable containers.

## 3. Reverse Logistics Networks

Logistics network design has a fundamental impact on the profitability of RL systems. In order to maximize the value recovered from used products, companies need to setup logistics structures that facilitate the arising goods flows in an optimal way. To this end, one needs to decide where to locate the various processes of the reverse supply chain and how to link them in terms of storage and transportation. In particular, companies need to choose how to collect recoverable products from their former users, where to inspect collected products in order to separate recoverable resources from worthless scrap, where to reprocess collected products to render them remarketable, and how to distribute recovered products to future customers (Dekker et al., 2003).

As briefly explained in the previous section various studies have been prepared in the literature related with RL networks. While differ from case to case, several steps are common in the RL networks (Fleischmann et al., 2000):

- Collection refers to all activities rendering used products available and physically moving them to some point where further treatment is taken care of.
- Inspection/Separation denotes all operations determining whether a given product is in fact re-usable and in which way. Thus, inspection and separation results in splitting the flow of used products according to distinct re-use (disposal) option.
- Re-Processing means the actual transportation of a used product into a usable product again. This transformation may take different forms including recycling, repair and remanufacturing.
- Disposal is required for products that cannot be reused for technical or economical reasons. This applies, e.g. to products rejected at the separation level due to excessive repair requirements but also to products without satisfactory market potential, e.g. due to outdating. Disposal may include transportation, landfilling, and incineration steps.
- Re-Distribution refers to re-usable products to a potential market and to physical moving them to future users. This may encompass sales (leasing, service contracts), transportation, and storage activities.

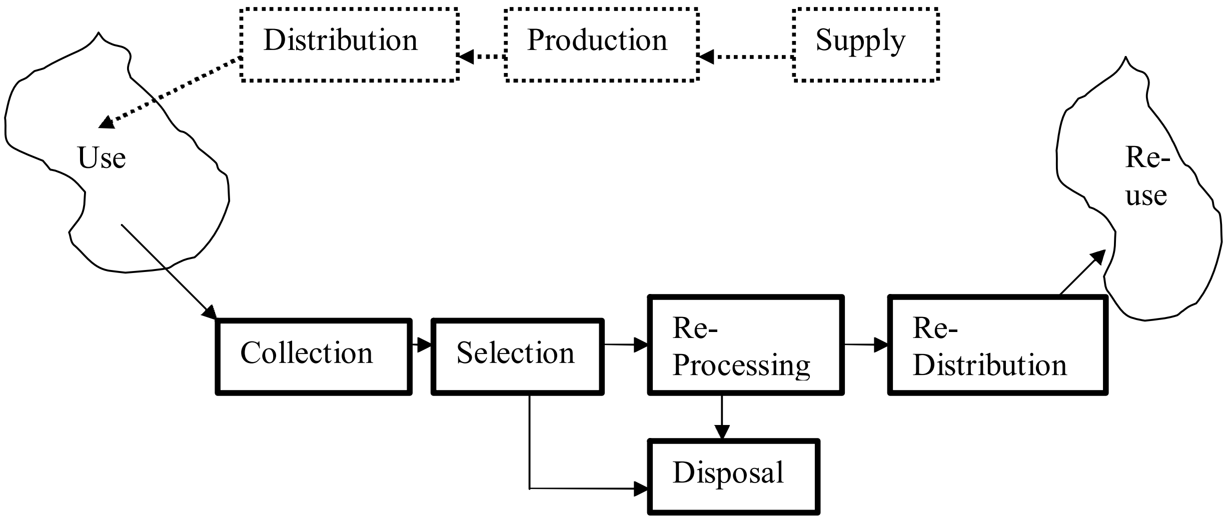


Figure 1. The recovery chain (Fleischmann et al., 2000)

Besides, RL networks have some characteristics which differs these networks from traditional production-distribution networks (Dekker et al., 2004):

- Supply uncertainty: In traditional supply chains, demand is typically perceived as the main unknown. In a RL setting, however, it is the supply side that accounts for significant additional uncertainty. Used products are a much less standardized input resource than conventional component supplies or raw materials. Quantity, quality, and timing of product returns are, in general, not known with certainty and may be difficult to influence. Effectively matching demand and supply, therefore, is a major challenge in RL. Consequently, robustness with respect to variations in flow volumes and composition is an important perquisite of RL networks.
- Degree of centralization of testing and sorting: The need for testing and sorting operations in reverse logistics is a direct consequence of the supply uncertainty. The degree of centralization of this stage has a fundamental impact on the transportation needs in a reverse logistics networks and is subject to the

following trade-off: testing collected products early in the channel may minimize the total transportation distance since inspected products can be sent directly to the corresponding recovery operation. In particular, this approach helps avoid excessive transportation of worthless scrap. On the other hand, investment costs, for example, for advanced test equipment or specially trained labor, may call for centralizing the testing and sorting operations. There appears to be no direct equivalent to this issue in traditional production-distribution networks as product routings are.

- Interrelation between forward and reverse flows: Another important characteristic of RL networks concerns potential synergies between different product flows. While traditional networks typically act as one-way streets, closed-loop chains encompass multiple inbound and outbound flows crossing each other's paths. In this setting, it is intuitive to consider integration as a potential means for attaining economies of scale. Opportunities may concern transportation and facilities. For example, integrating the collection of used products with the distribution function may help reduce empty rides. Similarly, integrating operations of the forward and reverse channel in the same facilities possibly reduces overhead costs. At the same time, these opportunities raise a compatibility issue. In many cases, closed-loop supply chains are not designated in a single step but are realized by adding reverse logistics activities to an existing distribution network. It is not clear, however, whether such a sequential approach yields a good solution or whether one should consider an integral redesign of the entire closed-loop network.

Given these different characteristics and specifications, it is obvious that, RL network design is an important problem to study on. In the next section, a RL network design model will be given.

## 4. A Basic Reverse Logistics Network Design Model

In this section a Mixed Integer Linear programming model is examined. This model, taken from Fleischmann (2000), is a basic model which can be expanded for specific cases. Figure 2 shows the recovery network structure to be modeled. Forward flows (from plants to warehouses, from warehouses to customers) and reverse flows (from customers to disassembly centers, from disassembly centers to disposal or to plants) are investigated in the model.

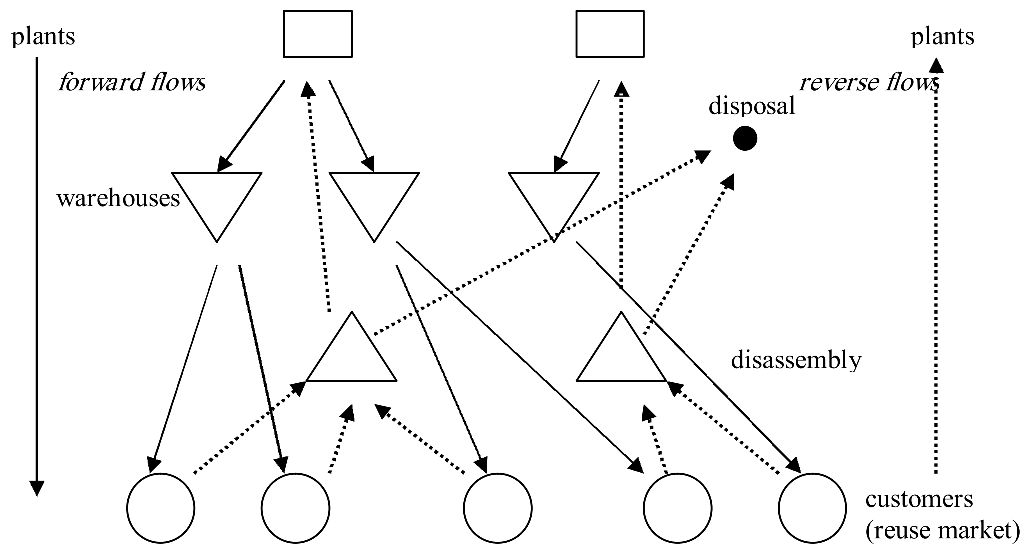


Figure 2. Structure of the recovery network model (Fleischmann, 2000)

Table 2 shows the index set, variables and costs and the parameters of the model.

Table 2. Nomenclature

| | |
|---|---|
| Index sets | |
| I | $\{1,\ldots,N_p\}$ set of potential plant locations |
| $I_0$ | I U{0}, where 0 denotes the disposal option |
| J | $\{1,\ldots, N_w\}$ set of potential warehouse locations |
| K | $\{1,\ldots, N_c\}$ set of fixed customer locations in disposer and reuse markets |
| L | $\{1,\ldots, N_r\}$ set of potential disassembly locations |
| Variables | |
| $X^f_{ijk}$ | forward flow: fraction of demand of customer k to be served from plant i and warehouse j; $i \in I, j \in J, k \in K$ |
| $X^r_{kli}$ | reverse flow: fraction of returns from customer k to be returned via disassembly center l to plan i; $k \in K, l \in L, i \in I_0$ |

| | |
|---|---|
| $U_k$ | unsatisfied fraction of demand of customer k; $k \in K$ |
| Wk | uncollected fraction of returns of customer k; $k \in K$ |
| $Y_i^p$ | indicator opening plant i; $i \in I$ |
| $Y_j^w$ | indicator opening warehouse j; $j \in J$ |
| $Y_l^r$ | indicator opening disassembly center l; $l \in L$ |
| Costs | |
| $c_{ijk}^f$ | unit variable cost of serving demand of customer k from plant i and warehouse j, including transportation, production, and warehouse handling cost; $i \in I, j \in J, k \in K$ |
| $c_{kli}^r$ | unit variable cost of returns from customer k via disassembly center l to plant i; including transportation and handling cost minus production savings at plant i; $k \in K, l \in L, i \in I$ |
| $c_{kl0}^r$ | unit variable cost of disposing returns from customer k via disassembly centre l; including collection, transportation, handling and disposal cost; $k \in K, l \in L$ |
| $c_k^u$ | unit penalty cost for not serving demand of customer k ; $k \in K$ |
| $c_k^w$ | unit penalty cost for not collecting returns of customer k ; $k \in K$ |
| $f_i^p$ | fixed cost for opening plant i; $i \in I$ |
| $f_j^w$ | fixed cost for opening warehouse j; $j \in J$ |
| $f_l^r$ | fixed cost for opening disassembly center l; $l \in L$ |
| Parameters | |
| $d_k$ | demand of customer k in the reuse market; $k \in K$ |
| $r_k$ | returns from customer k in the disposer market; $k \in K$ |
| $\gamma$ | minimum disposer fraction |

Based on the product recovery network structure, the model is constructed as follows:

min

$$\sum_{i \in I} f_i^p Y_i^p + \sum_{j \in J} f_j^w Y_j^w + \sum_{l \in L} f_l^r Y_l^r + \sum_{k \in K} \sum_{l \in L} \sum_{i \in I_O} c_{kli}^r r_k X_{kli}^r + \sum_{k \in K} c_k^u d_k U_k + \sum_{k \in K} c_k^w r_k W_k \qquad (1)$$

Eq. (1) is the objective function which tries to minimize total network costs including fixed and variable costs.

subject to

Eq. (2) and Eq. (3) try to satisfy customer reverse and forward demands.

$$\sum_{i \in I} \sum_{j \in J} X_{ijk}^f = 1 - U_k \qquad \forall k \in K \qquad (2)$$

$$\sum_{l \in L} \left( \sum_{i \in I} X_{kli}^r + X_{kl0}^r \right) = 1 - W_k \qquad \forall k \in K \qquad (3)$$

Eq. (4) is about the minimum disposal level.

$$\gamma \sum_{i \in I_0} X_{kli}^r \le X_{kl0}^r \qquad \forall k \in K, l \in L \qquad (4)$$

Eq. (5) tries to ensure that incoming flows can not exceed outgoing flows to a plant.

$$\sum_{k \in K} \sum_{l \in L} r_k X_{kli}^r \le \sum_{j \in J} \sum_{k \in K} d_k X_{ijk}^f \qquad \forall i \in I \qquad (5)$$

Eqs. (6) ~ (8) are about facility opening conditions.

$$\sum_{j \in J} X_{ijf}^f \le Y_i^p \qquad \forall i \in I, k \in K \qquad (6)$$

$$\sum_{i \in I} X_{ijf}^f \le Y_j^w \qquad \forall j \in J, k \in K \qquad (7)$$

$$\sum_{i \in I_0} X^r_{kli} \leq Y^r_l \qquad \forall k \in K, l \in L \tag{8}$$

Eqs. (9) ~ (10) are about variable domains.

$$Y^p_i, Y^w_j, Y^r_l \in \{0,1\} \qquad \forall i \in I, j \in J, l \in L \tag{9}$$

$$0 \leq X^f_{ijk}, X^r_{kli}, U_k, W_k \leq 1 \qquad \forall i \in I, j \in J, k \in K \tag{10}$$

## 5. An Illustrative Example

An illustrative example is given to foster the better understanding of the model. A hypothetical network is investigated. This network includes three customers, three potential warehouses, two potential disassembly centers and two potential plants. The ways which the customers may satisfy the forward and reverse demands are investigated. Also the decision about the number of plants, disassembly centers and warehouses is trying to be given. Table 3 and Table 4 shows the input data used in the structuring process.

Table 3. Fixed costs (YTL), forward and reverse demands

| $i$ | $f^p_i$ | $j$ | $f^w_j$ | $l$ | $f^r_l$ | $k$ | $d_k$ | $r_k$ | $\gamma$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5000000 | 1 | 5000000 | 1 | 2500000 | 1 | 10000000 | 7000000 | 0.5 |
| 2 | 4000000 | 2 | 4000000 | 2 | 3000000 | 2 | 20000000 | 8000000 | |
| | | 3 | 3000000 | | | 3 | 15000000 | 9000000 | |

*Table 4. Variable costs (YTL)*

| $ijk$ | $c^f_{ijk}$ | $kli$ | $c^r_{kli}$ | $kl0$ | $c^r_{kl0}$ | $k$ | $c^u_k$ | $c^w_k$ |
|---|---|---|---|---|---|---|---|---|
| 111 | 500 | 111 | 100 | 110 | 100 | 1 | 500000 | 100000 |
| 121 | 700 | 112 | 100 | 120 | 150 | 2 | 300000 | 200000 |
| 131 | 300 | 121 | 150 | 210 | 150 | 3 | 200000 | 300000 |
| 211 | 600 | 122 | 200 | 220 | 220 | | | |
| 221 | 500 | 211 | 300 | 310 | 100 | | | |
| 231 | 800 | 212 | 200 | 320 | 150 | | | |
| 112 | 500 | 221 | 200 | | | | | |
| 122 | 400 | 222 | 300 | | | | | |
| 132 | 500 | 311 | 100 | | | | | |
| 212 | 600 | 312 | 200 | | | | | |
| 222 | 700 | 321 | 100 | | | | | |
| 232 | 600 | 322 | 150 | | | | | |
| 213 | 800 | | | | | | | |
| 223 | 300 | | | | | | | |
| 233 | 100 | | | | | | | |
| 113 | 200 | | | | | | | |
| 123 | 300 | | | | | | | |
| 133 | 200 | | | | | | | |

Using the above data, the model is solved via Lingo 9.0. The objective value (cost minimization) is found as 14221500000 YTL. The other results are shown in the Table 5 and Table 6.

Table 5. The results: Satisfaction levels and opening/closing decisions.

| $k$ | $U_k$ | $W_k$ | $i$ | $Y^p_i$ | $j$ | $Y^w_j$ | $l$ | $Y^r_l$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 2 | 0 | 0 | 2 | 1 | 2 | 1 | 2 | 1 |
| 3 | 0 | 0 | | | 3 | 1 | | |

As can be seen from Table 5, unsatisfied fraction of demand of customer $k$ and uncollected fraction of returns of customer $k$ are zero for all customers. Plants 1 and 2, warehouses 2 and 3 and disassembly centers 1 and 2 should be open.

Table 6. The results: The forward and reverse flow fractions

| Ijk | $X^f_{ijk}$ | kli | $X^r_{kli}$ |
|---|---|---|---|
| 111 | 0 | 111 | 1 |
| 121 | 0 | 112 | 0 |
| 131 | 1 | 121 | 0 |
| 211 | 0 | 122 | 0 |
| 221 | 0 | 211 | 0 |
| 231 | 0 | 212 | 0 |
| 112 | 0 | 221 | 0.67 |
| 122 | 1 | 222 | 0 |
| 132 | 0 | 311 | 1 |
| 212 | 0 | 312 | 0 |
| 222 | 0 | 321 | 0 |
| 232 | 0 | 322 | 0 |
| 233 | 1 | 110 | 0 |
| 213 | 0 | 120 | 0 |
| 223 | 0 | 210 | 0 |
| 113 | 0 | 220 | 0.33 |
| 123 | 0 | 310 | 0 |
| 133 | 0 | 320 | 0 |

As can be seen from Table 6, the forward flow to customer one is only from plant one and warehouse three, the forward flow to customer two is only from plant two and warehouse two and the forward flow to customer three is only from plant two and warehouse three. On the other hand, reverse flow from customer one goes two plant one from disassembly center one. The %67 of the reverse flow from customer two goes two plant one from disassembly center two and disposal from disassembly center two. Finally %100 of the reverse flow of the customer two goes two plant one from disassembly center two.

It is obvious that, in a real word application, %0 disposal level is an impossible disposal level. But in our hypothetical network two customers' reverse flows' disposal level is zero. This situation implies the lack of some constraints such as technical constraints which reflect to real world situation and problem specific conditions. In this case problem specific conditions are not considered.

It is known that, real sized reverse logistics networks problems are NP-hard. Considering this situation, for the future studies, the heuristic approaches can be utilized. In this point of view, a few studies are used Genetic Algorithms. Also some other approaches such as Tabu Search, Lagragian Heuristics, and Scatter Search can be utilized and a comparison can be made.

## 6. Conclusions

Increasing environmental problems, the level of product returns, legal obligations, etc. motivates the practitioners and academicians to study on RL concept. As a scientific field, RL has been known and applied in many countries such as USA, Spain, German, etc. for many years. However, for Turkey, this concept is still very young and there is a need to study on. RL network design problem is an important part of RL concept. In this study a brief introduction is made to this field and an implementation of a basic model for RL networks is given. For the future studies, Turkey specific cases should be investigated.

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# LOGISTICS INTEGRATED PLANNING OF DISTRIBUTING TOURS IN A COOPERATIVE ASSEMBLY SYSTEM CONSIDERING DIFFERENT ROUND TOUR TYPES

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## Abstract

*The events that led up to this scientific work that the detailed in the former publications (Oláh et al., 2004) analysis of assignment algorithms of assembly plants to the final product requirements of the end users in a cooperative assembly system we take direct delivery per products (shuttle tours) into account by the determination of the objective function as a simplified cost function. Leaning on the before-described model this work details the solution of distribution tasks by the help of consolidated shuttle tours concern several products and round tours generates a cost reduction for shuttles per products. The authors review the description of the algorithms for route planning and the different round tour types such as collecting tour from assembly plants to an end user, distributing tour from an assembly plant to end users, and both models of mixed tour (distributing tour attendant upon collection and combined round tour) in the first part. The elaborated heuristic algorithms are demonstrated by a concrete example considering different round tour types in the next part of the scientific paper. Finally we discuss in detail the evaluation and comparison of investigational results of methods (shuttle and round tours) adjunct to showed models, and determination of further tasks for optimal operation of the distribution system for instance the modification of the vehicle capacity, and the effects of change of cost elements and data structure.*

*Keywords: Logistics, Network, Shuttle tour, Distributing tour, Round tour*

## 1. Introduction

The network-like operating logistics integrated assembly system means when the production planning is planned integrated by the purchasing and distribution logistics system, accordingly we search aggregate optimum of not merely the production but also the logistics resources and factors. The network-like means that the same product can be assembled by several assembly plants in different points, and the components needful to assembling can be purchased from several different sited suppliers. Additionally the network-like means that the procurement of components and the distribution of final products may be direct and indirect, in other words by the help of distribution warehouse. In case of the network-like operating systems the logistics integrated production planning details how search the optimal result having regard to capacity-limits and conditions, fulfil to the requirements of the end users according to described objective functions.

Mathematical modelling and optimisation of a network-like operating assembly system as an integrated logistics system there is no even early attempt in the international scientific literature. A mere scattering of publications for the logistics integrated production scheduling can be found in the international literature (Smilowitz, & Daganzo, 2004; Jünemann, 1990; Schönenburg et al., 1994; Schönsleben, 1998). Therefrom can be determined that the used objective functions and conditions are in accord with the used by us. At the same time in the system drawn by us the objective functions and the conditions can be demonstrated in an other form, it follows from this, that this defined principle can be used for the optimisation. All these require that we lean on the considerable results made in the Department of Materials Handling and Logistics at the University of Miskolc for solution of this logistics model (Kovács et al., 2005; Cselényi, 2002; Cselényi, & Illés, 2006; Cselényi, & Tóth, 1994; 2001; Oláh et al., 2003).

In the described model (Figure 1.) the amount of the final products ordered by the end users in a given time interval is given. This system consists of the following units: assembly plants ($P_\lambda$), component distribution warehouses ($CDW_j$) and final product distribution warehouses ($PDW_\eta$). Transports of component parts can take place into the above mentioned assembly plants: indirectly, i.e. through component distribution warehouses, or by direct transports from the suppliers ($S_i$) in case of bypassing the distribution warehouse. Transports of final products occur to the end users ($U_\mu$) in like manner, i.e. direct delivery from the assembly plants or indirectly through final product distribution warehouses. The optimal operation of this complex and large cooperative logistics system requires absolutely modern theoretical establishment of planning and control methods (Evans, 1993; Winston, 2003). The task to be completed is the logistics integrated assembly scheduling task, which includes the distribution and storage of final products and the storage of components.

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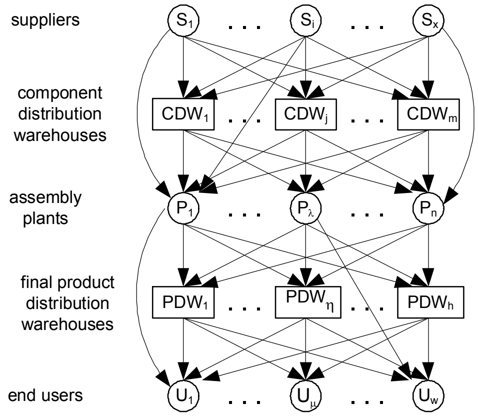


Figure 1. Cooperative assembly system

Different objective functions and conditions should be taken into consideration during the solution of these tasks. In the first case the cost function was chosen as the objective function, the components of which were detailed in (Oláh et al., 2003). The optimisation was completed by a hierarchical jointed feedback heuristic method due to the high number of cost function parameters to be optimised. The modules of a multistage optimisation are illustrated in (Oláh et al., 2003). The principles, solution methods and heuristic algorithm of the assignment are demonstrated in (Oláh et al., 2004). Earlier we have taken shuttle tours (direct delivery) by assignments. This scientific work reviews the description of the algorithms for route planning and the different round tour types. The authors discuss in detail the evaluation and the comparison of investigational results of methods (shuttle and round tour) adjunct to showed models by a concrete example in the main part of the paper.

### 1.1 Total cost function of the model

$$C = C_P + C_T + C_S + C_A + C_{RT} + C_\Psi + C_W + C_D \rightarrow min. \qquad (1)$$

which can be obtained as a sum of the following costs: purchase costs of components ($C_P$), transportation costs of components ($C_T$), storage costs of components ($C_S$), assembly costs ($C_A$), changeover costs of assembly lines ($C_{RT}$), costs of standby of lines ($C_\psi$), warehousing charges of final products ($C_W$), and distribution costs of products ($C_D$).

In the present case as we used to for the determination of the annual amount of the final products of the individual user we simplify the total cost function (1) and then only the assembly and delivery costs should be considered. Because this module considers the schedule of assembly and transportation, the warehousing cost of the components and final products cannot be taken into consideration and the considered costs are also global and simplified. The above-mentioned cost-components have not to be taken into account by optimisation, because these components are not known by this step of assignment, but we will take these into account in after modules and effects of these components will appear from the principle of feedback.

### 1.2 Objective function of the assignment in case of product k

$$C_I^k = C_A^k + C_D^k \rightarrow min. \qquad (2)$$

where $C_D^k$ is the distribution cost, $C_A^k$ is the assembly cost.

The matrix Q gives the annual quantity ordered from product $k$ by the user μ. The searched matrix Y shows that

- *The user μ obtains the product k from the assembly plant λ or not. The* $y_{\mu\lambda}^k$ *value is 0 if not, or 1 if yes (case a) with the following condition:* $\sum_{\lambda=1}^{n} y_{\mu\lambda}^k = 1.$ *(3)*
- *Or how much part of the final product k will be come out to the end user μ from the assembly plant λ (case b). Conditions are:* $0 \leq y_{\mu\lambda}^k \leq 1$ *and* $\sum_{\lambda=1}^{n} y_{\mu\lambda}^k = 1.$ *(4)*

#### 1.2.1 Cost of distribution in case of product k

$$C_D^k = \sum_{\lambda=1}^{n} \sum_{\mu=1}^{w} c_D^k Q_\mu^k y_{\mu\lambda}^k s_{\mu\lambda} \qquad (5)$$

where $c_D^k$ is the specific delivery cost of final product $k$, $s_{\mu\lambda}$ is the length of delivery route.

1.2.2 Assembly cost in case of product k

$$C_A^k = \sum_{\lambda=1}^{n} \sum_{\mu=1}^{w} Q_\mu^k y_{\mu\lambda}^k c_{A\lambda}^k \qquad (6)$$

where $c_{A\lambda}^k$ is the specific cost of assembly in case of the final product *k* in the assembly plant λ.

1.2.3 Simplified cost function of the assignment in case of product k

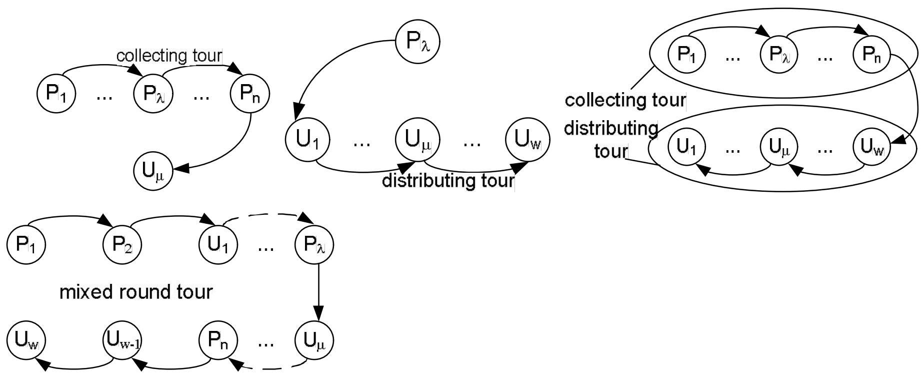
The objective function (2) becomes the following formula by the considered and simplified objective functions (Oláh et al., 2004):

$$C_1^k = \sum_{\lambda=1}^{n} \sum_{\mu=1}^{w} Q_\mu^k y_{\mu\lambda}^k (c_D^k s_{\mu\lambda} + c_{A\lambda}^k) \rightarrow min. \qquad (7)$$

In the first step we analyse that in case of inhomogeneous shuttle tours and round tours how modify the simplified cost function in accordance with shuttle tours (direct delivery). Subsequently we analyse that the round tours when (for what conditions) become necessary and profitable.

## 2. Representation of tour types

- *Collecting tour from assembly plants to an end user (Figure 2/a.).*
- *Distributing tour from an assembly plant to end users (Figure 2/b.).*
- *Mixed tour (distributing tour after collecting tour) (Figure 2/c.).*
- *Mixed tour (combined round tour) (Figure 2/d.).*




a.) b.) c.) d.)

Figure 2. Representation of round tour types

### 2.1 Philosophy of solution

- *Assignment of the assembly plants to the end users with shuttle tours (direct delivery) is given.*
- *Come to determinate the delivery cost by the use of round tours.*
- *It must be analysed, that*
  - *How the delivery costs decrease.*
  - *It is possible to decrease the total cost with modification of the assignment.*

## 3. Distribution of final products

Under Figure 2. unmixed tours are supposed, which means for example there is no interposition of plant between users in case of distributing tours. Variable is the assignment matrix Y. Let $D_\kappa$ be the capacity of vehicle, where κ is the vehicle type. $D_\kappa$ shows, how many loading units fit on the vehicle type κ. Intensity of material flow matrix: $q_{\lambda\mu}^k = Q_\mu^k y_{\lambda\mu}^k$, the assembly plant λ delivers so much from the product k to the end user μ. Number of tours matrix:

$$r_{\lambda\mu}^{\kappa k} = \frac{1}{D_\kappa}\left[ Entier(\frac{q_{\lambda\mu}^k}{e_k}) + 1 \right], \qquad (8)$$

where $e_k$ is the loading unit vector, which shows, how many product k fit in the loading unit. Number of shuttle tours with final product k from the assembly plant λ to the end user μ in case of vehicle type κ, so it is the number of 100 % utilisation „full" tours, which delivery only the product k (homogeneous tour):

$$r'^{\kappa k}_{\lambda\mu} = Entier(r^{\kappa k}_{\lambda\mu}) . \qquad (9)$$

Sum of „partial” products from the assembly plant λ to the end user μ in case of vehicle type κ:

$$r^{\kappa *}_{\lambda\mu} = \sum_{k=1}^{g} (r^{\kappa k}_{\lambda\mu} - Entier(r^{\kappa k}_{\lambda\mu})) . \qquad (10)$$

Hereafter these partial units must be combined in tours. However also two further versions arise in this case:

- *Shuttle tours from (10):* $r'^{\kappa}_{\lambda\mu} = Entier(r^{\kappa *}_{\lambda\mu})$ , *(11)*

which transport several products (homogeneous products).

- *And partial tour:* $r''^{\kappa}_{\lambda\mu} = r^{\kappa *}_{\lambda\mu} - r'^{\kappa}_{\lambda\mu}$ . *(12)*

Number of shuttle tours from the plant λ to the end user μ in case of vehicle type κ during the given period:

$$r^{\kappa 0}_{\lambda\mu} = \sum_{k=1}^{g} r'^{\kappa k}_{\lambda\mu} + r'^{\kappa}_{\lambda\mu} . \qquad (13)$$

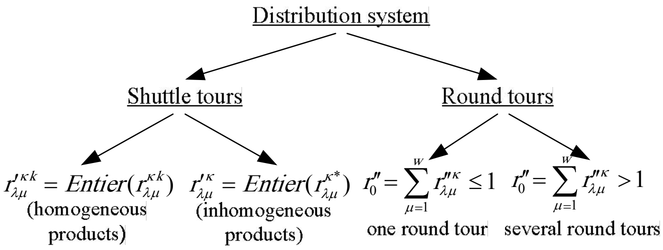



Figure 3. Sorting of distribution system

3.1 Modification of the delivery cost function

Cost of one shuttle tour from the assembly plant λ to the end user μ in case of vehicle type κ:

$$C^{\kappa S}_{D\lambda\mu} = (c_{D0\kappa} + \varphi^{\kappa}_{\lambda\mu} c_{D1\kappa}) s_{\lambda\mu} , \qquad (14)$$

where $c_{D0\kappa}$ is the specific delivery cost of the leer vehicle by the vehicle-type κ, $\varphi^{\kappa}_{\lambda\mu}$ is the utilisation factor of tour, $c_{D1\kappa}$ is the specific delivery cost depends on the vehicle loading, where let the ratio of $c_{D0\kappa} / c_{D1\kappa}$ be 2.

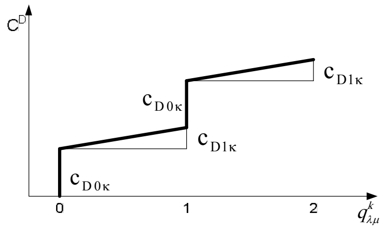



Figure 4. Changing of the specific delivery cost as a function of the deliverable volume

Cost of tours from the assembly plant λ in case of vehicle type κ if the partial units go into one round tour:

$$C^{\kappa}_{D\lambda} = \sum_{\mu=1}^{w} (c_{D0\kappa} + c_{D1\kappa}) r^{\kappa 0}_{\lambda\mu} s_{\lambda\mu} + (c_{D0\kappa} \sum_{\mu\in\Omega_\lambda} s_{\lambda\mu} + c_{D1\kappa} \sum_{\mu\in\Omega_\lambda} \varphi^{\kappa}_{\lambda\mu} s_{\lambda\mu}) , \qquad (15)$$

where the firs part is the cost of sum of shuttle tours from the assembly plant λ to the end users in case of vehicle type κ. The second part is the delivery cost of the round tour from the assembly plant λ to the end users in case of vehicle type κ (Figure 5/a.), where $\mu\in\Omega_\lambda$ is those end users which form part of the round tour from the plant λ.

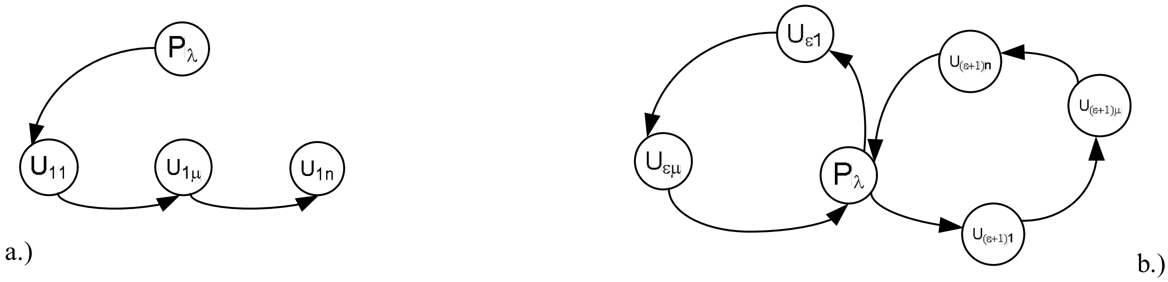



Figure 5. One or several round tours model

Cost of tours from the assembly plant λ in case of several round tours (Figure 5/b.):

$$C_{D\lambda}^{\kappa} = \sum_{\mu=1}^{w} (c_{D0\kappa} + c_{D1\kappa}) r_{\lambda\mu}^{\kappa 0} s_{\lambda\mu} + c_{D0\kappa} \sum_{\varepsilon=1}^{p_\lambda} \sum_{\mu_\varepsilon \in \Omega_{\lambda_\varepsilon}} s_{\lambda\mu_\varepsilon} + c_{D1\kappa} \sum_{\varepsilon=1}^{p_\lambda} \sum_{\mu_\varepsilon \in \Omega_{\lambda_\varepsilon}} \varphi_{\lambda\mu_\varepsilon}^{\kappa} s_{\lambda\mu_\varepsilon} \qquad (16)$$

where $p_\lambda$ is the number of round tours in case of the plant λ, $\mu_\varepsilon \in \Omega_{\lambda_\varepsilon}$ means the end users in the round tour ε.

### 3.2 Planning of distributing round tours

Minimal delivery cost proportional to the utilisation of tour can be used as an objective function by the planning of distributing tours. Solution of the problem can be separated into cases of account for one tour or several tours.

- The problem can be solved by the help of one tour if $r_0'' = \sum_{\mu=1}^{w} r_{\lambda\mu}''^{\kappa} \leq 1$. (17)
- It can be solved by the help of several tours if $r_0'' = \sum_{\mu=1}^{w} r_{\lambda\mu}''^{\kappa} > 1$. (18)

#### 3.2.1 Planning of one distributing round tour system

The objective function can be stated as follows: $C_{D\lambda}^{\kappa} = c_{D0\kappa} \sum_{j=0}^{n} \sum_{i=0}^{n} s_{ij} x_{ij} + c_{D1\kappa} \sum_{j=0}^{n} \sum_{i=0}^{n} \varphi_{ij}^{\kappa} s_{ij} x_{ij} \rightarrow \min.$, (19)

where *n* is the number of end users which form part of the round tour, $x_{ij}$ shows that the relation i-j is part of the round tour or not (it can take values 0 or 1). This problem is a Vehicle Routing Problem (VRP), where $C_{D\lambda}^{\kappa}$ means the delivery cost of the tour in case of vehicle type κ. Conditions are, that $\sum_{i=0}^{n} x_{ij} = 1$, and $\sum_{j=0}^{n} x_{ij} = 1$. (20)

The routing problem is a complex combinatorial optimisation problem. It can be described as follows: given a fleet of vehicles with uniform capacity, and several costumer demands, find the set of routes with overall minimum route cost which service all the demands. The conditions (20) represent, that all the itineraries start and end at the assembly plant λ and they must be designed in such a way that each costumer is served only once and just by one vehicle. VRP is NP-hard, and therefore difficult to solve (Tavares, 2005). The authors use a heuristics method based on the Column Summation of distance matrix, which always gives a nearby optimum solution. This algorithm can be found in (Cselényi & Illés, 2006).

#### 3.2.2 Planning of several distributing tours system

The application of several distributing tours will be actual if the sum of the partial units combinable in tour from the assembly plant *λ* is larger than one, so this problem can be solved by just several tours. This is an unmixed (without shuttle) distributing tour. Hereafter we take up the planning of the unmixed, several distributing.

Optimal number of tours can be determinated from the vector $r_{\lambda\mu}''^{\kappa}$, which is $p_\lambda = \mathrm{Entier} \frac{1}{\varphi_0} \sum_{\mu=1}^{w} r_{\lambda\mu}''^{\kappa} + 1$, where $\varphi_0$ is the requireable utilisation factor of tour (take it as an optimal). It is easy demonstrable, that the unlimited increase of the value of $\varphi_0$ increases the total length of itineraries. By the planning of the unmixed, several round tours the objective function is the following: $C_{D\lambda}^{\kappa} = c_{D0\kappa} \sum_{\varepsilon=1}^{p_\lambda} \sum_{j=0}^{n} \sum_{i=0}^{n} z_{i\varepsilon} s_{ij} x_{ij} + c_{D1\kappa} \sum_{\varepsilon=1}^{p_\lambda} \sum_{j=0}^{n} \sum_{i=0}^{n} z_{i\varepsilon} \varphi_{ij}^{\kappa} s_{ij} x_{ij} \rightarrow \min.$ (21)

where ε is the symbol of round tour, $z_{i\varepsilon}$ shows, that the stage i forms part of the tour ε or not (it can also take values 0 or 1), and $s_{ij}$ is the distance matrix. Additional condition: $\varphi_0 \leq \sum_{i=1}^{n} r_{\lambda i}''^{\kappa} z_{i\varepsilon} \leq 1$ (ε=1… $p_\lambda$)

(22)

The heuristics algorithm in (Cselényi, & Nagy, 2006) can be used for the optimisation of matrices $x_{ij}$ and $z_{i\varepsilon}$ according to the formulas (21) and (22).

## 4. Effect of different tour types upon delivery costs

Basic data are the followings: $n=3$, $w=6$, $g=8$. Values of the ordering matrix $Q = [q_{k\mu}]$ can be between 1000 and 6000, the average of these values is about 2000. The capacity matrix A can be taken in like manner:

$$Q_\mu^k = 2\begin{bmatrix} 0.5 & 2.5 & 0 & 0 & 1.5 & 1 \\ 0 & 1 & 2 & 3 & 2 & 0 \\ 3 & 0 & 1 & 0.5 & 0 & 0 \\ 1.5 & 0 & 0 & 1 & 2.5 & 0 \\ 2 & 1.5 & 1 & 0 & 3 & 0 \\ 0 & 0 & 2 & 0 & 0 & 3 \\ 0 & 0.5 & 0 & 0 & 1 & 2 \\ 1 & 0 & 3 & 0 & 0.5 & 0 \end{bmatrix}\left[1000\text{pieces}\right],\ A_\lambda^k = 4\begin{bmatrix} 1.5 & 1 & 0.5 \\ 0 & 2 & 2 \\ 0.5 & 0.5 & 1.5 \\ 1 & 1.5 & 0 \\ 1.5 & 0 & 2.5 \\ 0.5 & 1 & 1 \\ 0 & 1 & 1 \\ 1.5 & 0 & 1 \end{bmatrix}\left[1000\text{pieces}\right]\ S = 100\begin{bmatrix} 0.2 & 0.8 & 1.5 \\ 2.5 & 0.6 & 1.2 \\ 1.8 & 2 & 1 \\ 0.6 & 0.5 & 1.5 \\ 2 & 1 & 2.5 \\ 2.2 & 1.2 & 0.2 \end{bmatrix}\left[\text{km}\right]\ C^A = c_0\begin{bmatrix} 0.7 & 0.525 & 0.875 \\ 1 & 0.75 & 1.25 \\ 1.2 & 0.9 & 1.5 \\ 0.8 & 0.6 & 1 \\ 1.3 & 0.975 & 1.625 \\ 0.9 & 0.675 & 1.125 \\ 1.4 & 1.05 & 1.75 \\ 1.1 & 0.825 & 1.375 \end{bmatrix}\left[\frac{\text{EUR}}{\text{piece}}\right]$$

The values of the route matrix $S = [s_{\mu\lambda}]$ (between assembly plants and end users) can change between 20 and 250 km, the average value of elements is about 100 km. Values of the specific assembly cost are taken in harmony with the former example.

We defined a data-structure, which is suitable sensitivity analysis and comparison of the different optimisation methods too. By the planning of round tours of the before-mentioned example – is stated in the former publications (Oláh et al., 2004) too – we take the assignment matrix Y respecting the case b (4) is effected by the Hungarian Method to the starting data, so supposing that the assembly plants are assigned to the end users:

$$Y = \begin{bmatrix} 1^{0^{0}} & 0^{0^{0}} & 0.33^{0.33^{0.33}} & 1^{0^{0}} & 1^{0^{0}} & 0^{0^{0}} & 0^{0^{0}} & 1^{0^{0}} \\ 0^{0.8^{0.2}} & 0^{0^{1}} & 0^{0^{0}} & 0^{0^{0}} & 0^{0^{1}} & 0^{0^{0}} & 0^{1^{0}} & 0^{0^{0}} \\ 0^{0^{0}} & 0^{0^{1}} & 0^{0^{1}} & 0^{0^{0}} & 0^{0^{1}} & 0.5^{0.5^{0}} & 0^{0^{0}} & 0.33^{0^{0.67}} \\ 0^{0^{0}} & 0^{1^{0}} & 0^{0^{1}} & 0.5^{0.5^{0}} & 0^{0^{0}} & 0^{0^{0}} & 0^{0^{0}} & 0^{0^{0}} \\ 1^{0^{0}} & 0^{0.5^{0.5}} & 0^{0^{0}} & 0^{1^{0}} & 0.33^{0^{0.67}} & 0^{0^{0}} & 0^{1^{0}} & 1^{0^{0}} \\ 0.5^{0^{0.5}} & 0^{0^{0}} & 0^{0^{0}} & 0^{0^{0}} & 0^{0^{0}} & 0^{0.33^{0.67}} & 0^{0^{1}} & 0^{0^{0}} \end{bmatrix}$$

The three-dimensional matrix Y is converted in the interest of the briefer representation, that $Y = [\,y_{\mu\lambda}^{k}\,]$, so the matrix $y_{\mu k}$ can be seen in the plane and the values $\lambda$ are represented with smaller numbers. It can be seen from the assignment matrix Y which final products will the assembly plants deliver to the end users by the optimisation respecting the homogeneous shuttle tours.

Table 1. Results of the assignment respecting homogeneous shuttles

| Users | Code of final products | | |
|---|---|---|---|
| | plant 1 | plant 2 | plant 3 |
| 1. | 1,3,4,5,8 | 3 | 3 |
| 2. | - | 1,7 | 1,2,5 |
| 3. | 6,8 | 6 | 2,3,5,8 |
| 4. | 4 | 2,4 | 3 |
| 5. | 1,5,8 | 2,4,7 | 2,5 |
| 6. | 1 | 6 | 1,6,7 |

To the exact determination of the utilisation of tour considering the delivery together of different final products, the loading unit vector $e_k$ must be specified that shows how many final product k fit in the given loading unit: $e_k$ = [120 50 250 100 60 150 360 20] [piece/LU].

This vector is supposed to be constant, but other loading unit types will be taken into account in after assignments. By means of definition of the loading unit vector from the Table 1. considering the assignment matrix Y it can be determined how many loading units will the plants deliver to the end users from each final products.

Table 2. Number of homogeneous loading units

| Users | Number of homogeneous loading units [piece] | | |
|---|---|---|---|
| | plant 1 | plant 2 | plant 3 |
| 1. | 9,8,30,67,100 | 8 | 8 |
| 2. | | 34,3 | 9,40,50 |
| 3. | 14,100 | 14 | 80,8,34,200 |
| 4. | 10 | 120,10 | 4 |

| | | | |
|---|---|---|---|
| 5. | 25,34,50 | 40,50,6 | 40,67 |
| 6. | 9 | 14 | 9,27,12 |

Elements of the Table 2. can be calculated by the help of the following formula: $h_{\lambda\mu}^{k} = Entier(q_{\lambda\mu}^{k} / e_{k}) + 1$. Nevertheless it can be taken that how many loading units must the plants deliver to the end users total: $h_{\lambda\mu} = \sum_{k=1}^{g} h_{\lambda\mu}^{k}$.

Table 3. Total number of loading units, number of shuttle tours and partial units

| Users | Total number of loading units [piece] | | | Number of shuttles/partial units [piece] | | |
|---|---|---|---|---|---|---|
| | plant 1 | plant 2 | plant 3 | plant 1 | plant 2 | plant 3 |
| 1. | 214 | 8 | 8 | 4/22 | 0/8 | 0/8 |
| 2. | - | 37 | 99 | - | 0/37 | 2/3 |
| 3. | 114 | 14 | 322 | 2/18 | 0/14 | 6/34 |
| 4. | 10 | 130 | 4 | 0/10 | 2/34 | 0/4 |
| 5. | 109 | 96 | 107 | 2/13 | 2/0 | 2/11 |
| 6. | 9 | 14 | 48 | 0/9 | 0/14 | 1/0 |
| Sum-total | 456 | 299 | 588 | 8/72 | 4/107 | 11/60 |

It must be given to the exact determination of the delivery costs how many loading units fit on the vehicle type κ from the above-mentioned loading unit type. Supposing that the vehicle type is given, it is not purposed to analyse the effectiveness of different vehicle types in the course of this scientific work: $D_{\kappa} = 48$ [LU/vehicle].

After taking the capacity of vehicle it must be determined how many tours need the assembly plants to delivery the loading units to the end users. In Table 3/b. the full tours (inhomogeneous shuttles) are represented ahead of sign / and the number of partial loading units behind, those must be combined in round tours.

In the first step we calculate the value of the delivery costs by the help of new cost function (14) in case of the former optimal assignment: $C_{D\lambda\mu}^{\kappa k} = (2c_{D0\kappa} + c_{D1\kappa}) r_{\lambda\mu}^{\prime\kappa k} s_{\lambda\mu} + (2c_{D0\kappa} + \varphi_{\lambda\mu}^{\kappa k} c_{D1\kappa}) s_{\lambda\mu}$ (23)

where $c_{D0\kappa}$ is the specific delivery cost of the leer vehicle by the vehicle-type κ, $\varphi_{\lambda\mu}^{\kappa k}$ is the utilisation factor of tour ($\varphi_{\lambda\mu}^{\kappa k} = r_{\lambda\mu}^{\kappa k} - r_{\lambda\mu}^{\prime\kappa k}$), $c_{D1\kappa}$ is the specific delivery cost depends on the vehicle loading, where let the ratio of $c_{D0\kappa} / c_{D1\kappa}$ be 2 by the given vehicle type. Let $c_{D0\kappa}$ be 12 EUR/km and let $c_{D1\kappa}$ be 6 EUR/km.

Table 4. Delivery and assembly cost of homogeneous shuttles per users and plants

| Users | delivery cost of homogeneous shuttles [$c_0$] | | | | assembly cost of homogeneous shuttles [$c_0$] | | | |
|---|---|---|---|---|---|---|---|---|
| | plant 1 | plant 2 | plant 3 | total | plant 1 | plant 2 | plant 3 | total |
| 1. | 4375 | 2000 | 3750 | 10125 | 12900 | 1800 | 3000 | 17700 |
| 2. | - | 3157,5 | 13005 | 16162,5 | - | 3150 | 8250 | 11400 |
| 3. | 19845 | 5150 | 25625 | 50620 | 4000 | 1350 | 16750 | 22100 |
| 4. | 1515 | 5612,5 | 3675 | 10802,5 | 800 | 5100 | 1500 | 7400 |
| 5. | 21925 | 10800 | 21343,8 | 54068,8 | 5800 | 6600 | 9000 | 21400 |
| 6. | 5527,5 | 3090 | 1560 | 10177,5 | 700 | 1350 | 12375 | 14425 |
| Sum | 53187,5 | 29810 | 68958,8 | 151956,3 | 24200 | 19350 | 50875 | 94425 |

Table 5. Assignment costs per products with use of homogeneous shuttle tours

| Products | homogeneous shuttle tours [$c_0$] | | |
|---|---|---|---|
| | delivery | assembly | total |
| 1. | 16667,5 | 7350 | 24017,5 |
| 2. | 23780 | 16000 | 39780 |
| 3. | 12425 | 11700 | 24125 |
| 4. | 8757,5 | 6800 | 15557,5 |
| 5. | 30206,25 | 22425 | 52631,25 |
| 6. | 13422,5 | 9000 | 22422,5 |
| 7. | 4447,5 | 10150 | 14597,5 |
| 8. | 42250 | 11000 | 53250 |
| Sum-total | 151956,25 | 94425 | 246381,3 |

4.1 Planning of inhomogeneous shuttle tours and distributing tours

In the second step we analyse what cost reduction can be achieved if enable different products to be delivered together, so inhomogeneous shuttle tours are composed of homogeneous partial units stated in the first step.

$$C^{\kappa}_{D\lambda\mu} = (2c_{D0\kappa} + c_{D1\kappa})(r'^{\kappa}_{\lambda\mu} + \varphi'^{\kappa}_{\lambda\mu})s_{\lambda\mu} + (2c_{D0\kappa} + \varphi''^{\kappa}_{\lambda\mu} c_{D1\kappa})s_{\lambda\mu} , \quad (24)$$

where $r'^{\kappa}_{\lambda\mu} = \sum_{k=1}^{n} r'^{\kappa k}_{\lambda\mu}$ , $\varphi^{\kappa}_{\lambda\mu} = \sum_{k=1}^{n} \varphi^{\kappa k}_{\lambda\mu}$ , $\varphi'^{\kappa}_{\lambda\mu} = Entier\varphi^{\kappa}_{\lambda\mu}$ , $\varphi''^{\kappa}_{\lambda\mu} = \varphi^{\kappa}_{\lambda\mu} - \varphi'^{\kappa}_{\lambda\mu}$. (25)

In the third step we analyse what additional cost reduction can be achieved with combination in tours per assembly plants of the inhomogeneous partial units stated in the second step.

$$C^{\kappa}_{D\lambda} = \sum_{\mu=1}^{w} (2c_{D0\kappa} + c_{D1\kappa}) r^{\kappa 0}_{\lambda\mu} s_{\lambda\mu} + c_{D0\kappa} \sum_{\varepsilon=1}^{p_\lambda} \sum_{\mu_\varepsilon \in \Omega_{\lambda_\varepsilon}} s_{\lambda\mu_\varepsilon} + c_{D1\kappa} \sum_{\varepsilon=1}^{p_\lambda} \sum_{\mu_\varepsilon \in \Omega_{\lambda_\varepsilon}} \varphi^{\kappa}_{\lambda\mu_\varepsilon} s_{\lambda\mu_\varepsilon} \quad (26)$$

$$S^{U} = 100 \begin{bmatrix} x & 3.5 & 1.8 & 0.2 & 1.5 & 4 \\ & x & 1.2 & 2 & 0.8 & 1.8 \\ & & x & 2.5 & 1 & 0.5 \\ & & & x & 3.8 & 3.5 \\ & & & & x & 0.4 \\ & & & & & x \end{bmatrix} [\text{km}]$$

The values of the distance matrix $S^U = [s_{\mu\mu}]$ (between end users) can change between 20 and 500 km, nevertheless the average value of elements is about 200 kilometres. That end users be located near one another probably manufacture different group of final products.

Table 6. Delivery costs of inhomogeneous shuttle and distributing tours per assembly plants

| Users | delivery cost of inhomogeneous shuttles [$c_0$] | | | | delivery cost of distributing tours [$c_0$] | | | |
|---|---|---|---|---|---|---|---|---|
| | plant 1 | plant 2 | plant 3 | total | plant 1 | plant 2 | plant 3 | total |
| 1. | 2935 | 2000 | 3750 | 8685 | 2726,25 | 1281,5 | 2037,5 | 6045,25 |
| 2. | - | 1717,5 | 10125 | 11842,5 | - | 1717,5 | 8631 | 10348,5 |
| 3. | 15525 | 5150 | 20825 | 41500 | 12822,8 | 3092,2 | 19193 | 351085 |
| 4. | 1515 | 4412,5 | 3675 | 9602,5 | 978,75 | 3801 | 2037,5 | 6817,25 |
| 5. | 17125 | 6000 | 21343,8 | 44468,8 | 14247,5 | 6000 | 17981 | 38228,5 |
| 6. | 5527,5 | 3090 | 600 | 9217,5 | 2472,2 | 1855,3 | 600 | 4927,5 |
| Sum | 42627,5 | 22370 | 60318,8 | 125316,3 | 33247,5 | 17747,5 | 50480 | 101475 |

By the plant 1 there are 2 distributing tours: 1P-1U-4U-1P & 1P-3U-6U-5U-1P = 1305$c_0$ + 6742,5$c_0$ = 8047,5$c_0$.

3 tours start from the plant 2: 2P-2U-2P, 2P-4U-1U-2P & 2P-6U-3U-2P=1717,5$c_0$ + 2082,5$c_0$ + 4947,5$c_0$=8747,5$c_0$.

In case of plant 3 there are 2 distributing tours also: 3P-1U-4U-3P & 3P-3U-5U-2U-3P = 4075$c_0$ + 5605$c_0$ = 9680$c_0$.

It is difficult to assign the delivery cost coming to each end user in case of the distributing tours therefore this costs are determined commensurately with the delivery lengths in Table 6. The round tour delivery cost of all distributing tours is (8047,5 $c_0$ + 8747,5 $c_0$ + 9680 $c_0$) = 26475 $c_0$. The users that were out of the distributing tours cannot decrease their delivery costs in comparison with inhomogeneous shuttles (cyclamen cells).

Testing results are summarised in Table 4, 5 & 6. If the methods are compared to each other it can be traced that the total delivery cost of distributing tours is over 33 % (101475 $c_0$ / 151956,25 $c_0$ = 0,6678) better than the worst method (homogeneous shuttle tours) and over 19 per cent (101475 $c_0$ / 125316,25 $c_0$ = 0,8098) better than the cost of inhomogeneous shuttle tours. It can be seen that the total delivery cost of inhomogeneous shuttle tours is also over 17,5 per cent (125316,25 $c_0$ / 151956,25 $c_0$ = 0,8247) better than the cost of homogeneous shuttle tours. The results show that the distributing tours guarantee the optimum much better than the shuttles. It can be experienced at plant level, that the highest delivery cost reduction can be observed by the first and second plant: 37,49 per cent (33247,5 $c_0$ / 53187,5 $c_0$ = 0,5251) and 40,46 per cent (17747,5 $c_0$ / 29810 $c_0$ = 0,5954), while the least improvement can be traced by the third plant: 26,8 per cent (50480 $c_0$ / 68958,75 $c_0$ = 0,7320).

## 4.2 Planning of collecting tours

Delivery distance between assembly plants have to be given in order to combine collecting tours. The values of the distance matrix $S^P = [s_{\lambda\lambda}]$ can change between 50 and 400 km, nevertheless the average value of elements is about 200 kilometres.

$$S^P = 100 \begin{bmatrix} x & 2,2 & 1,5 \\ & x & 3 \\ & & x \end{bmatrix} [km]$$

Table 7. Delivery costs of collecting tours per assembly plants

| Users | delivery cost of collecting tours [$c_0$] | | | |
|---|---|---|---|---|
| | plant 1 | plant 2 | plant 3 | total |
| 1. | 3908,7 | 1363,15 | 1363,15 | 6635 |
| 2. | - | 2246,1 | 9146,4 | 11392,5 |
| 3. | 14253,3 | 3339,25 | 20825 | 38417,5 |
| 4. | 1454,375 | 4776,875 | 1373,75 | 7605 |
| 5. | 15564,6 | 6000 | 18505,4 | 40070 |
| 6. | 2883,42 | 2985,33 | 600 | 6468,75 |
| Sum | 38064,395 | 20710,655 | 51813,7 | 110588,75 |

By the first end user there is one collecting tour: 1U-2P-3P-1P-1U = 4235 $c_0$.

In case of the second user there is one collecting tour also: 2U-3P-2P-2U = 4192,5 $c_0$.

Two collecting tours start from the third end user: 3U-2P-1P-3U and 3U-3P-3U = 6792,5 $c_0$ + 2825 $c_0$ = 9617,5 $c_0$.

There is 1 collecting tour by the user 4: 4U-1P-3P-2P-4U = 4605 $c_0$.

There is one collecting tour in case of the $5^{th}$ end user also: 5U-3P-1P-5U = 7070 $c_0$.

Finally there is a collecting tour by the end user 6: 6U-1P-2P-6U = 5868,75 $c_0$.

The round tour delivery cost of all collecting tours is 35588,75 $c_0$, that is 34,42 per cent worse than the round tour delivery cost of distributing tours (26475 $c_0$). It can be seen that the total delivery cost of distributing tours is only 8,24 per cent (101475 $c_0$ / 110588,75 $c_0$) better than the cost of collecting tours, while (195900 $c_0$ / 205013,75 $c_0$) 4,45 percent decrease can be accomplished in case of the total cost.

### 4.3 Planning of mixed tours

Two variants of the mixed tours can be used, the distributing tour after collecting tour and the combined tour.

#### 4.3.1 Distribution after collection

There is one distributing tour in case of the assembly plant 1: 1P-3U-6U-5U-1P = 6742,5 $c_0$.

There are 3 tours by the plant 2: 2P-2U-2P, 2P-4U-1U-2P & 2P-6U-3U-2P=1717,5$c_0$+2082,5$c_0$+4947,5$c_0$=8747,5$c_0$.

Two mixed tours start from the third plant: 3P-1P-1U-4U-3P and 3P-3U-5U-2U-3P = 3505 $c_0$ + 5605 $c_0$ = 9110 $c_0$.

The round tour delivery cost of distributing tour after collection is 24600 $c_0$ that is over 7 per cent better than the round tour delivery cost of distributing tours (26475 $c_0$). In case of total delivery cost the application of distributing tour after collecting tour is only 1,85 per cent (99600 $c_0$ / 101475 $c_0$) better than the distributing tours, while this ration in respect to the total cost is just 0,96 % (194025 $c_0$ / 095900 $c_0$).

#### 4.3.2 Combined round tour

For example: 3P-3U-5U-2P-2U-2P-6U-3U-3P-1P-1U-4U-2P-4U-1U-1P-3U-5U-6U-3P.

The round tour delivery cost of combined tour is 18867,5 $c_0$, that is 28,73 per cent better than the round tour delivery cost of distributing tours (26475 $c_0$), and 23,3 % better than distribution after collection (24600 $c_0$).

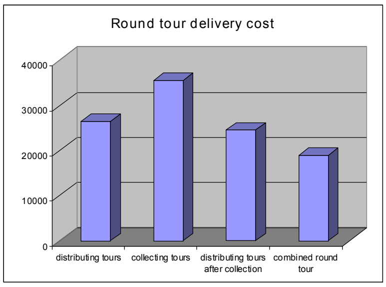



Figure 6: Round tour delivery cost in case of four round tour types

As regards the total delivery cost the application of combined round tour is only 7,5 per cent (93867,5 $c_0$ / 101475 $c_0$) better than the distributing tours and it is 5,76 per cent (93867,5 $c_0$ / 99600 $c_0$) better than the distributing tour after collection, while this rations in respect to the total costs are reduced to 3,88 % and 2,95 %.

Table 8: Delivery costs of inhomogeneous mixed tours per assembly plants

| Users | delivery cost of distribution after collection [$c_0$] | | | | delivery cost of combined round tours [$c_0$] | | | |
|---|---|---|---|---|---|---|---|---|
| | plant 1 | plant 2 | plant 3 | total | plant 1 | plant 2 | plant 3 | total |
| 1. | 3341,4 | 953,8 | 859,3 | 5154,5 | 3041,4 | 593,8 | 559,3 | 4194,5 |
| 2. | - | 1717,5 | 8850,3 | 10567,8 | - | 1133,8 | 8063,8 | 9197,6 |
| 3. | 13176,1 | 2473,75 | 20170,2 | 35820,05 | 12709 | 1873,75 | 20280,6 | 34863,35 |
| 4. | 871,3 | 4128,7 | 833 | 5833 | 571,3 | 3768,7 | 533 | 4873 |
| 5. | 14238,3 | 6000 | 16784,5 | 37022,8 | 13756,5 | 6000 | 16874,3 | 36630,8 |
| 6. | 2128,1 | 2473,75 | 600 | 5201,85 | 1634,5 | 1873,75 | 600 | 4108,25 |
| Sum | 33755,2 | 17747,5 | 48097,3 | 99600 | 31712,7 | 15243,8 | 46911 | 93867,5 |

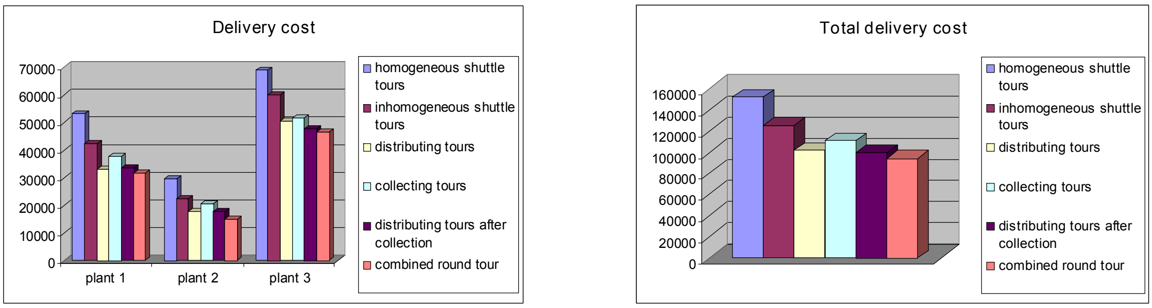



Figure 7. Delivery cost per plants and total delivery cost in case of different tour types

Testing results show (Figure 8.) that the total cost of combined tour is the minimal, distributing tours are over 20 per cent (195900 $c_0$ / 246381,25 $c_0$ = 0,7951) better than the cost of homogeneous shuttle tours, and about 11 per cent (195900 $c_0$ / 219741,25 $c_0$ = 0,8915) better than the cost of inhomogeneous shuttle tours. It can be seen that the total cost of inhomogeneous shuttle tours is also over 10,5 per cent (219741,25 $c_0$ / 246381,25 $c_0$ = 0,8919) better than the worst method (homogeneous shuttle tours). This results show that the combined round tour guarantees the optimum less good than before, because the assembly costs were the same in all cases. The same can be experienced at plant level than before, that the highest delivery cost reduction can be observed by the first and second plant: 29,64 per cent (57447,5 $c_0$ / 77387,5 $c_0$ = 0,7036) and 24,54 % (37097,5 $c_0$ / 49160 $c_0$ = 0,7546), while the least improvement can be traced by the plant 3: 15,42 per cent (101355 $c_0$ / 119833,75 $c_0$ = 0,8458).

Table 9. Total cost of different tour types

| Total cost [$c_0$] | plant 1 | plant 2 | plant 3 | Sum-total |
|---|---|---|---|---|
| homogeneous shuttle tours | 77387,5 | 49160 | 119833,75 | 246381,25 |
| inhomogeneous shuttle tours | 66827,5 | 41720 | 111193,75 | 219741,25 |
| distributing tours | 57447,5 | 37097,5 | 101355 | 195900 |
| collecting tours | 62264,4 | 40060,66 | 102689 | 205013,8 |
| distributing tours after collection | 57955,2 | 37097,5 | 98972,3 | 194025 |
| combined round tour | 55912,7 | 34593,8 | 97786 | 188292,5 |

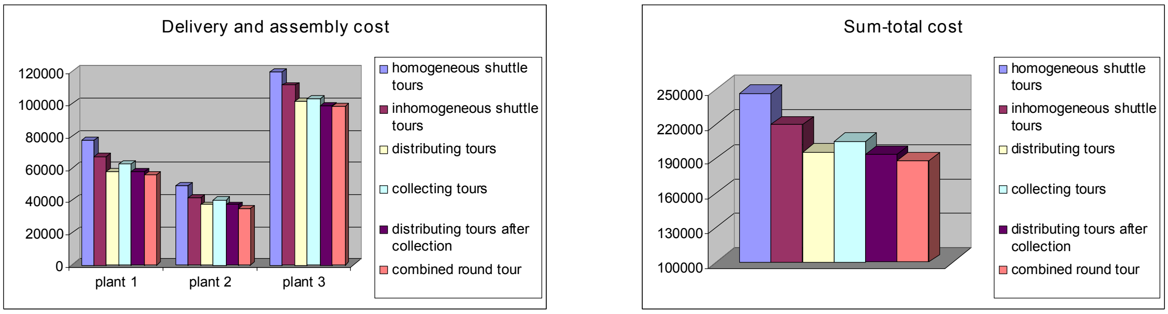



Figure 8. Total cost per plants and sum-total cost in case of different tour types

## 5. Summary

It can be under further investigation, that what cost reduction can be achieved with modification of the given assignment matrix Y, as well as what changes can be generated the case a (if matrix Y can take values 0 or 1) and taking one (or more) distribution warehouse(s) into account. Respectively it is worth analysing that in case of other vehicle types or loading units how can the assignment and the values of cost function be changed. Finally we have to discuss in detail the effects of change of cost elements and data structure in the future.

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# FUZZY LOGIC-BASED DECISION MAKING MODEL ON SELECTION AND EVALUATION OF LOGISTICS SERVICE PROVIDERS WITHIN A FIRM

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## Abstract

*Third party logistics (3PL) decisions involve the use of external companies to perform logistic functions that have traditionally been performed within the organization. Choosing the right logistics provider can create competitive advantages due to the visible service impact on customers. However, just selecting the right logistic firm is not adequate; tracking the performance of these firms regularly also contributes to the sustainability of this competitive advantage. In this study, a fuzzy-based multi-criteria decision making (MCDM) model is proposed for selection and performance evaluation of logistics firms supplied in an agricultural product industry. The selection and evaluation process is developed based on TOPSIS concept in which a closeness coefficient is defined to determine the performance rates of logistic firms by calculating the distances to fuzzy- positive ideal solution (FPIS) and fuzzy-negative ideal solution (FNIS).*

Keywords: Logistics, Fuzzy Logic, Selection, Evaluation, TOPSIS

## 1. Introduction

Within supply chain management, the task of logistics is to move and position inventory to achieve desired time, place and possession benefits with the possible minimum cost. The customer satisfaction should be fulfilled through being responsive, having high capability while controlling operational variance and minimizing inventory commitment (Bowersox, Closs & Cooper, 2002). Logistics Management provides the strategies for the coordination among product flow from supplier to the end user and the information flow that has a high priority. Besides, an efficient logistics management requires the optimization of the activities regarding the movement of the goods due to the intense competitive conditions. In this respect, in order to sustain their competitiveness, the firms have to focus on their core competencies and outsource their logistics activities. Through outsourcing, the customers will be provided with the expertise and experience that otherwise would be difficult or costly to have within the firm (Razzaque, Sheng, 1998). Logistics outsourcing or third party logistics (3PL) are the specialized service providers that provide many advantages like the power acquired by the economies of scale, process expertise, access to capital, reduced financial risks, access to expensive technology for the firms (Aktaş and Ulengin, 2005). In this manner outsourcing decisions became a very critical fact for the firms.

The selection of a 3PL that matches with the needs of the firm is not an easy task. Many researchers have worked on the selection process and suggested some methods. For example in the study of Andersson and Norman (2002) eight points are suggested to select the right 3PL provider. Defining or specifying the service, understanding the volume bought, simplifying and standardizing, market survey, request for information, request for proposal, negotiations and contracting are the eight point plan of the authors. Besides, Jharkharia and Shankar (2005) in their study made a literature review on the selection criteria that can be seen in Table 1. Apart from the criteria illustrated in Table 1 different selection criteria have also been used by other researchers. Management stability (Işıklar, Alptekin & Büyüközkan, 2006), conflict resolution (Chen, Lin & Huang, 2005), innovation (willingness to engage in new logistics concepts) and operative logistical transactions like labels, documents (Schmitz and Platts, 2002), ability of carrier to customize its services to meet specific and unique needs (Aktaş and Ulengin, 2005) are some other criteria that are mentioned in literature. The ultimate aim of selection 3PL provider is to obtain the maximum value by meeting the firm's needs with minimum cost as a matter of fact criteria should be applicable to all providers.

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Table 1. Criteria for the selection of a provider

| Selection Criterion | References |
|---|---|
| Compatibility with the users | Andersson and Norrman (2002), Lynch (2000), Thompson (1996), Boyson et al. (1999), Mohanty and Deshmukh (1993) |
| Cost of services | Lynch (2000), Langley et al. (2002), Boyson et al. (1999), Stock et al. (1998), Tam and Tummala (2001) |
| Quality of service | Razzaque and Sheng (1998), Thompson (1996), Langley et al. (2002), Stock et al. (1998) |
| Reputation of the company | Lynch (2000), Thompson (1996), Boyson et al. (1999) |
| Long term relationships | Lynch (2000), Boyson et al. (1999), Maltz (1995), Stank and Daugherty (1997) |
| Performance measurement | Bhatnagar et al. (1999), Lynch (2000), Langley et al. (2002) |
| Willingness to use logistics man power | Razzaque and Sheng (1998), Ackerman (1996) |
| Flexibility in billing and payment | Bradley (1994) |
| Quality of management | Andersson and Norrman (2002), Lynch (2000), Boyson et al. (1999) |
| Information sharing and mutual trust | Lynch (2000), Stock (1998), Bagchi and Virum (1998) |
| Operational performance | Langley et al. (2002), Tam and Tummala (2001) |
| Information technology capability | Andersson and Norrman (2002), Lynch (2000), Langley et al. (2002), Boyson et al. (1999), Langley et al. (2002), Rabinovich et al. (1999), Closs et al. (1997), Babbar and Prasad (1998) |
| Size and quality of fixed assets | Boyson et al. (1999), Hum (2000) |
| Experience in similar products | Razzaque and Sheng (1998), Ackerman (1996), Richardson (1993) |
| Delivery performance (speed & reliability) | Stock et al. (1998), Gattorna and Walters (1996) |
| Employee satisfaction level | Lynch (2000), Boyson et al. (1999), Langley et al. (2002) |
| Financial performance | Andersson and Norrman (2002), Boyson et al. (1999), Gattorna and Walters (1996) |
| Market share | Thompson (1996) |
| Geographical spread and range of services provided | Boyson et al. (1999), Maltz (1995), Bradley (1994) |
| Risk Management (insurance coverage) | Boyson et al. (1999), Aktaş and Ulengin (2005) |
| Surge capacity of the provider | Anonymous (1999) |
| Clause for arbitration and escape | Richardson (1993) |
| Flexibility in operations and delivery | Stank and Daugherty (1997) |

Source: Adapted from Jharkharia and Shankar (2005)

The selection of the most appropriate 3PL provider through the criteria mentioned above is another issue that must be focused on. Many studies on selection applications are available in the literature. Case based reasoning technique (Choy and Lee, 2002), rule based reasoning and a hybrid intelligent decision support model by integrating both case based reasoning rule based reasoning is proposed by Işıklar, Alptekin and Büyüközkan (2006). Fuzzy multicriterion decision making models are also applicable to selection problems many efficient methods have been used to solve these problems. Average weighted comprehensive method (Brans and Mareschal, 1990), fuzzy optimum seeking method (Belton and Hodgkin, 1999; Belacel, 2000), fuzzy neural networks comprehensive decision making method (5), fuzzy iteration method (3)AHP, ELECTRE, PROMETHEE, ORESTE and TOPSIS are the some of the evaluation methods that can be used (Kahraman, Ateş, Çevik, Gülbay & Erdoğan, 2004).

In this study, a fuzzy-based multi-criteria decision making (MCDM) model is used for selection and performance evaluation of logistics firms supplied in an agricultural product industry. In the following sections literature review on TOPSIS and Fuzzy-AHP, brief information about the methodology that is used in selecting and evaluating the 3PLs is discussed.

### 1.1. TOPSIS- Technique for Order Preference by Similarity to Ideal Solution

TOPSIS was first developed by Hwang and Yoon based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution when solving a multi-criteria decision making problem (Hwang & Yoon, 1981) in which the positive ideal solution is composed of all the best values of criteria whereas the negative ideal solution is composed of the worst values (Chen & Tzeng, 2004).

Under many conditions, crisp data are inadequate to model the real situations. Furthermore, if human judgments include preferences, then these judgments are vague, and in many situations it is difficult to define them with an exact numerical value. The more realistic approach can be to use linguistic evaluations instead of numerical values (Chen, Lin & Huang, 2006). These approaches are preferred for many years since 1970s when the fuzzy sets and fuzzy logic have been introduced for ratings and weights of the criteria in the problem which are assessed by means of linguistic variables (Bellman & Zadeh, 1970; Chen, 2000; Delgado etal., 1992; Herrara et al, 1996; Herrara & Herrara-Viedma, 2000). The fuzzy extension of TOPSIS model developed by Chen (2000) provides a methodology with linguistic assessments and their fuzzy evaluations so that the vagueness is involved in the decision.

In recent years, TOPSIS model with fuzzy data is applied for various real-life situations for evaluating the criteria and/or selecting the best decision among the alternatives, especially when the qualitative variables exist (Jahanshahloo, Lotfi & Izadikhah, 2006). A new method to the multiple criteria parameter calibration problem is proposed for a conceptual model integrating genetic algorithm and TOPSIS model (Cheng et al., 2006) and (Chen, 2000) proposes an extension of TOPSIS model for fuzzy environment using fuzzy numbers. An application of TOPSIS model is introduced to solve multi objective programming problems integrated with α-pareto optimality which is the extension of Pareto optimality on the α-level sets of fuzzy numbers (Abo-Sinna & Abou-El-Enien, 2006). Similar multi objective programming models with TOPSIS is proposed for risk assessment and other decision making processes (Abo-Sinna & Amer, 2005; Wang & Elhag, 2006).

In this study, TOPSIS model is developed for evaluation and selection process of logistics service providers for the purpose of maintaining the quality of service and high performance of logistics service providers. TOPSIS model is well-fitted for such selection and evaluation processes which are also implemented for supplier selection and evaluation (Chen, Lin & Huang, 2006) and selection among the logistics information technologies (Kahraman et al., 2004).

In this paper, selection and evaluation process is developed for logistics service providers by using TOPSIS methodology based on fuzzy sets integrated with Fuzzy –AHP in the step which determines the weight of each criterion.

### 1.2.Fuzzy AHP

One of the steps of TOPSIS model is to determine the weights of each criterion by using methods like analytical hierarchy process, linear programming, fuzzy logic etc. In this study, Fuzzy-AHP method is considered to obtain the weights of each criterion then the evaluation of alternatives is carried out with traditional TOPSIS steps.

The fuzzy-AHP technique can be viewed as an advanced analytical method improved from Saaty's analytic hierarchy process (Saaty, 1994), which is a well-known decision-making analytical tool used for modeling unstructured problems in various areas, e.g., social, economic, and management sciences (Wabalickis, 1988; Bard and Sousk, 1990; Triantaphyllou and Mann, 1995). Despite the convenience of AHP in handling both quantitative and qualitative criteria of multi-criteria decision making problems based on decision maker's judgments, fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgments of decision makers in conventional AHP approaches (Bouyssou et al., 2000). Therefore, more and more researchers (Laarhoven and Pedrycz, 1983; Buckley, 1985a,b; Boender et al., 1989; Chang, 1996; Ribeiro, 1996; Lootsma, 1997; Yu, 2002) have engaged in the fuzzy extension of Saaty's theory, referred to as fuzzy-AHP, which has been shown to provide relatively more accurate descriptions of the decision making process in comparison with conventional AHP techniques (Sheu, 2004, 45). As a result, though the purpose of AHP is to capture the expert's knowledge, the conventional AHP still cannot reject the human thinking style. Therefore, fuzzy AHP, a fuzzy extension of AHP, is developed to solve the hierarchical fuzzy problems using Chang's model which is also implemented in (Kahraman, Cebeci, and Ruan, 2004, 173).

## 2. Methodology

In this paper, a systematic and practical methodology is developed and presented for selection and assessment of logistics service providers among many alternatives based on fuzzy models using linguistic variables.

The sample study of the methodology has been carried out in a firm which exports agricultural foods to many countries like Germany, Japan, Canada etc. During the interviews made with the firm's authorized people it's determined that there is not an existing structured selection and evaluation process for the 3PL providers they work with. First of all a literature review done on the criteria for selection and evaluation of 3PL providers that are summarized in Table 1 is presented to the firm and they are required to eliminate the criteria that are not regarded in their existing selection process. The final list of criteria obtained are as follows: *Cost, flexibility in billing and payment, quality of service, operational performance, delivery performance, long term relationship, information sharing & mutual trust and reputation.*

In order to provide the consistency and completeness of the hierarchy of criteria set, authors and decision makers of the firm worked together and constructed the hierarchy seen in Figure 1.

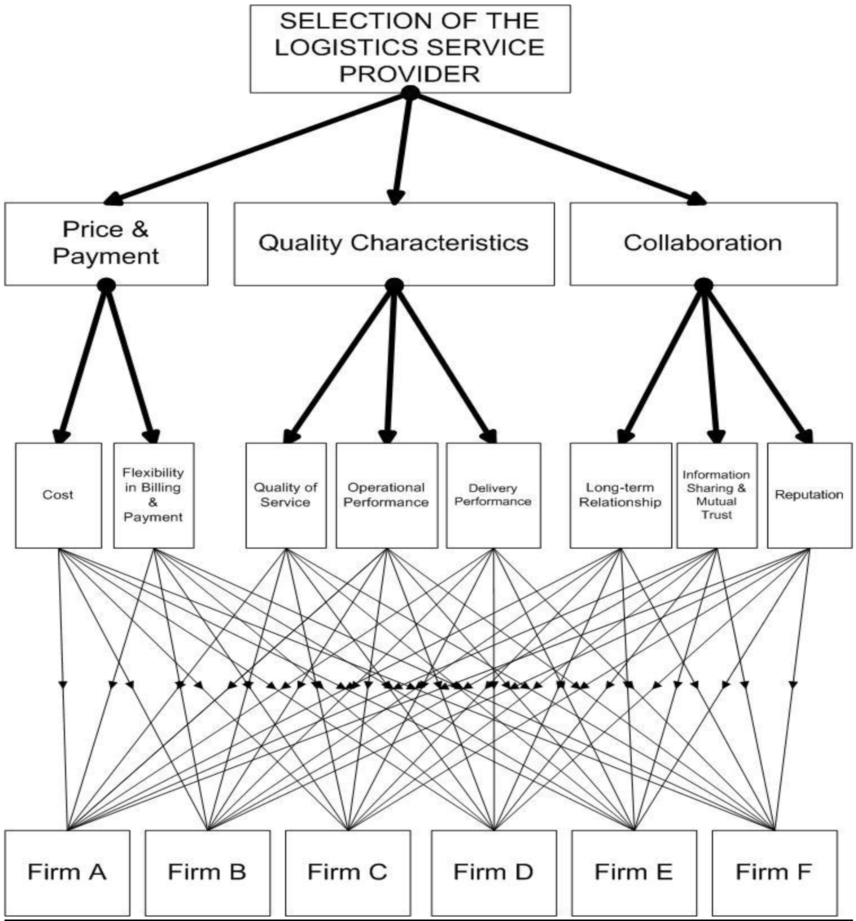


Figure 1. Hierarchy Structure of Criteria Set and Alternatives

Moreover, the list of 3PL providers that the company has been working with is gathered and a question form is prepared asking the pair wise comparison and evaluation of each criterion for each 3PL providers based on fuzzy AHP and TOPSIS, respectively.

The first phase of the methodology consists of weighting the hierarchical criteria set via fuzzy-AHP method so that the weights are calculated in a pair wise comparison manner which is the advantage of AHP method. In the second phase, the alternative logistics service providers are evaluated by considering each criterion in the bottom level of the criteria set. The evaluation process is carried out according to TOPSIS methodology which depends on linguistic variables and fuzzy logic. TOPSIS methodology concerns the distances of each alternative evaluation from negative ideal solution and positive ideal solution. Thus, the results of the solution show the closeness of each alternative that represents the importance among others. There exist two reasons to use TOPSIS model in the evaluation phase instead of any AHP method; when there are so many alternatives to be compared, AHP method may generate inconsistency problem which is approved by so many studies in literature. The second reason is the complexity of comparison process; because alternatives should be evaluated more often than criteria set, the higher the number of alternatives, the higher the complexity. Instead of that, it would be more practical to use TOPSIS which includes linguistic evaluations based on fuzzy logic.

The mathematical formulations for phase 1 and phase 2 are:

Phase 1: Criteria Importance Weighting: Fuzzy-AHP Methodology

To apply the process depending on the hierarchy, according to the method of Chang's (1992) extent analysis, each criterion is taken and extent analysis for each criterion, $g_i$; is performed, on respectively. Therefore, *m extent* analysis values for each criterion can be obtained by using following notation (Kahraman, et al, 2004, p.176):

$$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3, M_{g_i}^4, M_{g_i}^5, \ldots\ldots\ldots\ldots, M_{g_i}^m$$

where $g_i$ is the goal set (*i = 1, 2, 3, 4, 5, ........n)* and all the $M_{g_i}^j$ *(j = 1, 2, 3, 4, 5, ........, m)* are Triangular Fuzzy Numbers *(TFNs)*. The steps of Chang's analysis can be given as in the following:

*Step 1:* The fuzzy synthetic extent value *($S_i$)* with respect to the $i^{th}$ criterion is defined as following equation 1.

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j]^{-1} \qquad (1)$$

To obtain equation 2;

$$\sum_{j=i}^{m} M_{g_i}^{j} \quad (2)$$

perform the "fuzzy addition operation" of $m$ extent analysis values for a particular matrix given in equation 3below, at the end step of calculation, new *(l,m,u)* set is obtained and used for the next:

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (3)$$

Where $l$ is the lower limit value, $m$ is the most promising value and $u$ is the upper limit value.
and to obtain following equation 4;

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} \quad (4)$$

perform the "fuzzy addition operation" of $M_{g_i}^{j}$ *(j = 1, 2, 3, 4, 5, ........, m)* values give as equation 5:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \quad (5)$$

and then compute the inverse of the vector in the equation 6 such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (6)$$

*Step 2:* The degree of possibility of

$M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ *is* defined as equation 7

$$V(M_2 \geq M_1) = \sup_{y \geq x} [\min(\mu_{M_1}(x), \mu_{M_2}(y))] \quad (7)$$

and $x$ and $y$ are the values on the axis of membership function of each criterion. This expression can be equivalently written as given in equation 8 below:

$$V(M_2 \geq M_1) = \begin{cases} 1, & if\ m_2 \geq m_1, \\ 0, & if\ l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise, \end{cases} \quad (8)$$

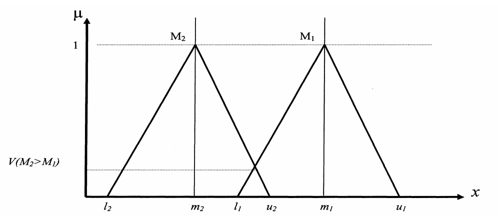


Figure 2. The Intersection between $M_1$ and $M_2$
Source: Zhu, et al, 1999, p.452

where $d$ is the highest intersection point $\mu_{M_1}$ and $\mu_{M_2}$ (see Figure 2) (Zhu, et al, 1999,p. 451).

To compare *M1* and *M2*; we need both the values of $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$:

*Step 3.* The degree possibility for a convex fuzzy number to be greater than $k$ convex fuzzy numbers $M_i$ *(i = 1, 2, 3, 4, 5, ......, k)* can be defined by equation 9:

$V(M \geq M_1, M_2, M_3, M_4, M_5, M_6, ................., M_k) = V[(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_3)$ and $(M \geq M_4)$ and ..... and $(M \geq M_k)] = \min V(M \geq M_i), i = 1, 2, 3, 4, 5, ......, k.$ *(9)*

Assume the expression in equation 10 is:

$$d'(A_i) = \min V(S_i \geq S_k) \quad (10)$$

For $k = 1, 2, 3, 4, 5, ......, n; k \neq i.$ Then the weight vector is given by equation 11:

$$W' = (d'(A_1), d'(A_2), d'(A_3), d'(A_4), d'(A_5), ........., d'(A_n))^T \quad (11)$$

Where $A_i$ *(i = 1, 2, 3, 4, 5, 6, …., n)* are $n$ elements.

*Step 4.* Via normalization, the normalized weight vectors are given in equation 12 below:

$$W = (d(A_1), d(A_2), d(A_3), d(A_4), d(A_5), d(A_6), ........., d(A_n))^T \quad (12)$$

Where $W$ is nonfuzzy numbers.

To evaluate the questions, people only select the related linguistic variable, then for calculations they are converted to the following scale including triangular fuzzy numbers developed by (Chang, 1996) and generalized for such analysis as given in Table 2 below:

Table 2. TFN Values

| Statement | TFN |
|---|---|
| Absolute | (7/2, 4, 9/2) |
| Very strong | (5/2, 3, 7/2) |
| Fairly strong | (3/2, 2, 5/2) |
| Weak | (2/3, 1, 3/2) |
| Equal | (1, 1, 1) |

Source: Tolga, et al, 2005, p.22

By using these linguistic statements and given in Table 2, criteria set is evaluated with the equations given in phase 1 (equation 1 through 12) weight of each criterion is obtained and so that the weights can be used in TOPSIS methodology, they are converted to trapezoidal fuzzy number such as (a,a,a,a).

Phase 2: TOPSIS and Linguistic Variables for Ratings

By considering this main concept of TOPSIS model is implemented according to the following steps :

1) Normalize the evaluation matrix: $x_{ij}$ is the evaluation matrix $R$ of alternative $i$ under the evaluation criterion $j$. After normalization, the elements of matrix $R$ convert into $r_{ij}$. Normalization is carried out one of the methods which convert them into the numerical value, i.e. between 0-1, according to the characteristics of the problem (Chen, Lin & Huang, 2006).
2) Construct the weighted normalization matrix according to the values determined for each criterion. These weights ($w_{\tilde{j}}$) can be obtained by any method such as eigenvector, AHP, fuzzy numbers, linear programming models, etc., then these weight vector is multiplied by normalized matrix $R$ to obtain the weighted normalized matrix $v_{ij}$.
3) Determine the negative and positive ideal solutions.
4) Calculate the separation measure. This measure is selected among the measures for calculating the distances. This can be an Euclidean distance (Chen &Tzeng, 2004) or vertex distance (Chen, Lin & Huang, 2006).
5) Calculate the negative closeness to the ideal solution. The relative closeness of the $i^{th}$ alternative with respect to the ideal solution is calculated by negative distance over total distance.
6) Rank the priority: a set of alternatives sorted according to descending order of relative closeness.

Fuzzy triangular and trapezoidal numbers are used to evaluate each logistics service provider alternative. The linguistic variable for evaluation lies between “very poor” and “very good”, the membership function set is given in Figure 3, and as an example, the linguistic variable ‘‘Very Good (VG)’’ can be represented as (8,9,9,10), the membership function of which is given in equation 13:

(13)
$$\mu_{VeryGood}(x) = \begin{cases} 0, & x < 8 \\ \dfrac{x-8}{9-8}, & 8 \le x \le 9 \\ 1, & 9 \le x \le 10 \end{cases}$$

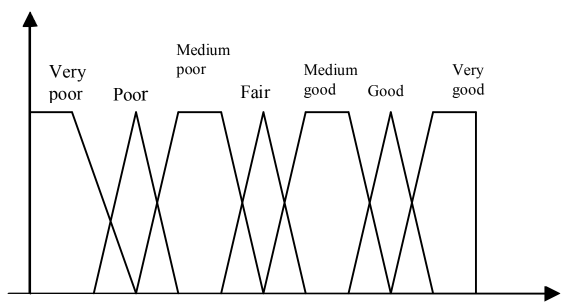


Figure 3. Linguistic variables for ratings
Source: Chen, Lin, Huang, 2006

In fact, Logistics service provider selection is a group multiple-criteria decision-making problem, which may be described by means of the following sets (Chen, Lin & Huang, 2006):

(1) a set of $K$ decision-makers called $E = \{D_1; D_2; \ldots ;D_K\}$
(2) a set of $m$ possible service providers called $A = \{A_1; A_2; \ldots ; A_m\}$
(3) a set of $n$ criteria, $C = \{C_1; C_2; \ldots ; C_n\}$ with which logistics service provider performances are measured;
(4) a set of performance ratings of $A_i$ $(i = 1; 2; \ldots ; m)$ with respect to criteria $C_j$ $(j=1; 2; \ldots ; n)$, called $X= \{x_{ij} ; i = 1; 2; \ldots ;m; j = 1; 2; \ldots ; n\}$

Assume that a decision group has $K$ decision makers, and the fuzzy rating of each decision-maker $D_k$ $(k= 1; 2; \ldots K)$ can be represented as a positive trapezoidal fuzzy number $\tilde{R}_k$ $(k= 1; 2; \ldots ; K)$ with membership function $\mu_{\tilde{R}_k}(x)$. A good aggregation method should be considered the range of fuzzy rating of each decision-maker. It means that the range of aggregated fuzzy rating must include the ranges of all decision-makers' fuzzy ratings. Let the fuzzy ratings of all decision makers be trapezoidal fuzzy numbers $\tilde{R}_k = (a_k; b_k; c_k; d_k,)$, $k = 1; 2; \ldots ; K$. Then the aggregated fuzzy rating can be defined as $\tilde{R} = (a; b; c; d)$, $k = 1; 2; \ldots ; K$. Equation 14 to 17 shows the detailed computations:

Where

$$a = \min_k \{a_k\} \quad (14), \qquad b = \frac{1}{K}\sum_{k=1}^{K} b_k \quad (15), \quad c = \frac{1}{K}\sum_{k=1}^{K} c_k \quad (16), \quad d = \max_k \{d_k\} \quad (17).$$

After the ratings are aggregated into one matrix then normalized weighted matrix is constructed by calculating equation 18: $V_{ij}=w_{ij} \times r_{ij}$. (18)

As mentioned before, weight of each criterion is calculated using Fuzzy-AHP method which produces crisp weights through fuzzy numbers. Thus, in order to aggregate weights with ratings, weights are assumed trapezoidal fuzzy numbers which have equal values (a=b=c=d). Then rating matrix is multiplied by weight matrix and finally weighted normalized matrix is obtained.

According to the weighted normalized fuzzy-decision matrix, normalized positive trapezoidal fuzzy numbers can also approximate the elements $\tilde{v}_{ij}$, $\forall i, j$. Then, the fuzzy positive-ideal solution (FPIS, $A^*$) and fuzzy negative-ideal solution (FNIS, $A^-$) can be defined as

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*), \qquad A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-),$$

Where the values can be calculated by equation 19 and 20:

$$\tilde{v}_j^* = \max_i \{v_{ij4}\} \ (19) \ \text{and} \ \tilde{v}_j^- = \min_i \{v_{ij1}\}, \ (20) \quad i = 1; 2; \ldots ; m, \ j = 1; 2; \ldots ; n.$$

The distance of each alternative (3PL providers) from $A^*$ and $A^-$ can be currently calculated with equation 21-22:

$$d_i^* = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^*) \ (21), \quad i = 1,2,\ldots, m \qquad d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-), \ (22) \quad i = 1,2,\ldots,m$$

Where $d_v$ (.,.) is the vertex distance measurement between two trapezoidal fuzzy numbers that is calculated by equation 23:

$$d_v(\tilde{m}, \tilde{n}) = \sqrt{\frac{\left[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2 + (m_4 - n_4)^2\right]}{4}} \qquad (23)$$

A closeness coefficient is defined to determine the ranking order of all possible s once $d_i^*$ and $d_i^-$ of each 3PL providers $A_i$ $(i=1; 2; \ldots ;m)$ has been calculated. The closeness coefficient represents the distances to the fuzzy positive-ideal solution $(A^*)$ and the fuzzy negative-ideal solution $(A^-)$ simultaneously by taking the relative closeness to the fuzzy positive-ideal solution. The closeness coefficient ($CC_i$) of each alternative (3PL providers) is calculated in equation 24:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \qquad (24), \quad i = 1,2,\ldots, m.$$

It is clear that $CC_i = 1$ if $A_i = A^*$ and $CC_i = 0$ if $A_i = A^-$. In other words, 3PL providers $A_i$ is closer to the FPIS ($A^*$) and farther from FNIS ($A^-$) as $CC_i$ approaches to 1. According to the descending order of $CC_i$, the ranking order of all 3PL providers is determined and the best one among a set of feasible 3PL providers are selected. For evaluation process, approval status for each alternative is defined in Table 3 which can also be used for further evaluation when a decision is required for any 3PL provider.

Table 3. Approval status

| Closeness coefficient (CCi) | Evaluation status |
|---|---|
| $CC_i \in [0;0,2)$ | Do not recommend |
| $CC_i \in [0,2;0,4)$ | Recommend with high risk |
| $CC_i \in [0,4;0,6)$ | Recommend with low risk |
| $CC_i \in [0,6;0,8)$ | Approved |
| $CC_i \in [0,8;1,0)$ | Approved and preferred |

Source: Chen, Lin & Huang, 2006, 8

## 3. Computational Results

According to the criteria set, hierarchy structure the pair wise comparisons within Fuzzy-AHP local and global importance weights are obtained as given in the Table 4:

Table 4. Fuzzy – AHP Results for Each Criterion

| | Criterion Name | Importance level | |
|---|---|---|---|
| Main criterion 1 | Price & payment | 0,632413 | |
| Main criterion 2 | Quality characteristics | 0,22564 | |
| Main criterion 3 | Collaboration | 0,141946 | |
| Price & payment | Sub criteria name | Local importance level | Global importance level |
| Sub criterion 11 | Cost | 0,566667 | 0,358368 |
| Sub criterion 12 | Flexibility in billing & payment | 0,433333 | 0,274046 |
| Quality characteristics | | | |
| Sub criterion 21 | Quality of service | 0,138759 | 0,03131 |
| Sub criterion 22 | Operational performance | 0 | 0 |
| Sub criterion 23 | Delivery performance | 0,861241 | 0,19433 |
| Collaboration | | | |
| Sub criterion 31 | Long-term relationship | 0,221711 | 0,031471 |
| Sub criterion 32 | Information sharing & mutual trust | 0,778289 | 0,110475 |
| Sub criterion 33 | Reputation | 0 | 0 |

It is seen from Table 4 that the most important main criterion is "price and payment" with the weight 0.6324 whereas the second and third criterion is "quality characteristics" (0.2256) and "collaboration" (0.14195), respectively. When the bottom level of the hierarchy is examined in terms of global importance, the first three sub criteria can be sequenced as "cost (0.3584)", "flexibility in billing & payment (0.2740)", and "delivery performance (0,1943)". An interesting result is obtained that "reputation" and "operational performance" has no importance or any effect on selection and/or evaluation of 3PL provider, although these criteria are selected from the candidate list for evaluation. Therefore, these two criteria can not affect the further steps. In the TOPSIS methodology, after the criterion weights are obtained, these weights are distributed to the evaluation matrix consisting of alternative ratings in terms of each criterion. For this purpose simple matrix multiplication is applied as given in the equation 18 to obtain $[V_{ij}]$ matrix. The next step in this methodology is to define the FPIS and FNIS from $V_{ij}$ so that the distances from these solutions can be calculated. Table 5 represents the FPIS and FNIS values for each criterion with trapezoidal fuzzy numbers (a,b,c,d), elements of which is placed in each cell:

Table 5. FPIS & FNIS Values for Each Criterion

| Criterion | FPIS | | | | FNIS | | | |
|---|---|---|---|---|---|---|---|---|
| Long-term relationship | 0,03147 | 0,03147 | 0,03147 | 0,03147 | 0,00000 | 0,00000 | 0,00000 | 0,00000 |
| Reputation | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 |
| Information sharing & mutual trust | 0,11048 | 0,11048 | 0,11048 | 0,11048 | 0,02210 | 0,02210 | 0,02210 | 0,02210 |
| Cost | 0,32253 | 0,32253 | 0,32253 | 0,32253 | 0,14335 | 0,14335 | 0,14335 | 0,14335 |
| Operational performance | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 |
| Delivery performance | 0,19433 | 0,19433 | 0,19433 | 0,19433 | 0,09717 | 0,09717 | 0,09717 | 0,09717 |
| Quality of service | 0,03131 | 0,03131 | 0,03131 | 0,03131 | 0,01565 | 0,01565 | 0,01565 | 0,01565 |
| Flexibility in billing & payment | 0,24664 | 0,24664 | 0,24664 | 0,24664 | 0,10962 | 0,10962 | 0,10962 | 0,10962 |

For each value of [ $V_{ij}$], both distances from FNIS and FPIS is calculated by using vertex distance (equation 23). The distance values are given in Table 6 and Table 7 for FPIS and FNIS, respectively. When this stem has been finished the trapezoidal fuzzy numbers are defuzzificated to single values. For the next step, all distance values through each raw is summed to reach the overall distance of alternative representing evaluations in terms of all criteria for both FPIS and FNIS. Then $CC_i$ ratio is calculated to see the evaluation result of each alternative 3PL provider (see equation 24) and the results are given in Table 8.

Table 6. Distances between Logistics Firms and FPIS With Respect To Each Criterion

| Positive Distance | Long-term relationship | Reputation | Information sharing & mutual trust | Cost | Operational performance | Delivery performance | Quality of service | Flexibility in billing & payment |
|---|---|---|---|---|---|---|---|---|
| d($L_A$,A*) | 0,006676 | 0 | 0,020337 | 0,119157 | 0 | 0,03255 | 0,005244 | 0,09112 |
| d($L_B$,A*) | 0,005271 | 0 | 0,031838 | 0,088187 | 0 | 0,03255 | 0,005244 | 0,067437 |
| d($L_C$,A*) | 0,006676 | 0 | 0,031838 | 0,119157 | 0 | 0,03255 | 0,005244 | 0,067437 |
| d($L_D$,A*) | 0,003519 | 0 | 0,018504 | 0,088187 | 0 | 0,03255 | 0,005244 | 0,067437 |
| d($L_E$,A*) | 0,003519 | 0 | 0,018504 | 0,088187 | 0 | 0,03255 | 0,005244 | 0,067437 |
| d($L_F$,A*) | 0,003519 | 0 | 0,050088 | 0,088187 | 0 | 0,03255 | 0,005244 | 0,067437 |
| d($L_G$,A*) | 0,02221 | 0 | 0,05767 | 0,119157 | 0 | 0,071402 | 0,01041 | 0,09112 |

Table 7. Distances between Logistics Firms and FNIS with Respect To Each Criterion

| Negative distance | long-term relationship | Reputation | Information sharing & mutual trust | Cost | Operational performance | Delivery performance | Quality of service | Flexibility in billing & payment |
|---|---|---|---|---|---|---|---|---|
| d($L_A$,A-) | 0,025275 | 0 | 0,07277 | 0,088187 | 0 | 0,076027 | 0,012249 | 0,067437 |
| d($L_B$,A-) | 0,02776 | 0 | 0,066566 | 0,119157 | 0 | 0,076027 | 0,012249 | 0,09112 |
| d($L_C$,A-) | 0,025275 | 0 | 0,066566 | 0,088187 | 0 | 0,076027 | 0,012249 | 0,09112 |
| d($L_D$,A-) | 0,029227 | 0 | 0,075581 | 0,119157 | 0 | 0,076027 | 0,012249 | 0,09112 |
| d($L_E$,A-) | 0,029227 | 0 | 0,075581 | 0,119157 | 0 | 0,076027 | 0,012249 | 0,09112 |
| d($L_F$,A-) | 0,029227 | 0 | 0,059035 | 0,119157 | 0 | 0,076027 | 0,012249 | 0,09112 |
| d($L_G$,A-) | 0,015674 | 0 | 0,043142 | 0,088187 | 0 | 0,036356 | 0,007705 | 0,067437 |

Table 8. Computations of $d_i$*, $d_i^-$ and $CC_i$

| Alternative | Total d* | Total $d^-$ | $d^* + d^-$ | $CC_i$ |
|---|---|---|---|---|
| $L_A$ | 0,275084 | 0,341946 | 0,61703 | 0,55418 |
| $L_B$ | 0,230528 | 0,392878 | 0,623407 | 0,630212 |
| $L_C$ | 0,262903 | 0,359424 | 0,622327 | 0,577549 |
| $L_D$ | 0,215442 | 0,403361 | 0,618803 | 0,651841 |
| $L_E$ | 0,215442 | 0,403361 | 0,618803 | 0,651841 |
| $L_F$ | 0,247025 | 0,386815 | 0,63384 | 0,610272 |
| $L_G$ | 0,371969 | 0,258501 | 0,63047 | 0,410014 |

According to the approval status scale given in Table 3 and the $CC_i$ results in Table 8, none of the alternatives are in "approved and preferred status". However, none of them also are not in neither "Do not recommend" nor "Recommend with high risk". The highest performance belongs to the alternative $L_D$ and $L_E$ with same ratio 0.6518, and $L_F$ and $L_G$ come after them and also in the "approved" status. The firm should consider this evaluation results when selecting a 3PL provider and should also use this decision process to evaluate them periodically to track the change in status.

## 4. Conclusion

In this paper, a systematic and practical methodology is developed and presented for selection and evaluation of 3PL providers among many alternatives based on fuzzy models using linguistic variables integrating Fuzzy AHP and TOPSIS model. The first phase of the methodology consists of weighting the hierarchical criteria set via fuzzy-AHP method so that the weights are calculated in a pair wise comparison manner which is the advantage of AHP method. In the second phase, the alternative3PL providers are evaluated by and ranked via TOPSIS model. The sample study of the methodology has been carried out in a firm which exports agricultural foods to many countries. In addition to the selection process, an evaluation status scale is given for further evaluations of alternative service provider. An interesting result is obtained that "reputation" and "operational performance" has no importance or any effect on selection and/or evaluation of 3PL provider. If classical AHP were applied on the same hierarchy structure, these "zero importance values" would not be same but would be too close to zero. This is one of important difference between classical AHP and fuzzy AHP.

Computations show that, the firm should revise its alternative list to find out new alternatives which can have the upper approval status. As a result, a systematic and practical process for selection and evaluation has been developed and approved by the executers. The methodology can be applied for the other sectors which have a problem for deciding how to select the 3PL providers.

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# OR APPROACH FOR THE STRATEGIC PLANNING OF NGOS' SOCIAL WELFARE CHAIN

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## Abstract

*Operations research should be conducted to determine the most appropriate techniques to solve the problems in the unique nature of each organization by taking into consideration of constraints like time and cost, and also to form objective decision making mechanism that can be applied to any kind of situations. Due to this reason, this paper is targeting at building an optimal transportation distribution model consolidating and standardizing the non-integrated style of logistics functions in a cost minimising approach that every NGO can benefit.*

Keywords: Social welfare chain, NGOs, distribution

## 1. Introduction

The importance of NGOs has risen dramatically over the past years in response to the increase of the social responsibility consciousness in developed countries, and the more pronounced gulf between the rich and the poor and unsatisfactory responses of government to the natural disasters or postwar demands in less developed countries. NGOs have been reported to be more cost effective in implementing developmental programs than the government or firm.(Reuchlin, 2003) This development means curing poverty by making social reforms and improving human prosperity. Corporations can greatly assist humanitarian agencies by sharing their knowledge, systems and resources (Gustavson). Until now, the developments are all concentrated on the improvement of after-war period or emergency conditions. In addition, due to the fact that many NGO administrators do not have career backgrounds in logistics management, they have difficulties in organizing and overseeing logistics requirements.

In 1991 the Council of Logistics Management defined logistics as 'the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from point of origin to point of consumption for the purpose of conforming to customer requirements' (Cottom, 2004). It can be seen that this explanation is a typical view of logistics of commercial supply chains applied by private enterprises. Later on, another important domain for supply chain management has aroused interest: adapting logistics for non-profit associations like relief organizations. Since, relief organizations had to manage the supply chain, which included procurement, transport, storage and handling from point(s) of origin to final destination(s) or distribution(s), of commodities safely, efficiently and effectively (Cottom, 2004), new definition called humanitarian relief chain is constituted. Non-government organizations (NGOs) are among the worldwide established form of humanitarian relief organizations. These organizations have different characteristics and objectives than those aimed at making profits. Nevertheless, NGOs are concerned about using management and information systems at least as good as private companies. Also, financial resources are fundamental necessities for NGOs to survive. The vast majority of NGOs are in need of continuous funding of external donors and utilization of resources effectively and efficiently. Because, the process in NGOs are generally structured by projects around shared networks with their collaborators, there is not a single value chain but different value chains directly related to every project developed by the NGO. Consequently, if the role of logistics, supply chain management and integrated systems support are better valued by NGOs, a significant financial return on investment could be saved.

The substantial portion of humanitarian relief supply chain research focuses on managing or optimizing the supply of goods and services derived from unpredictable events or global emergencies like volcano eruptions, earthquakes, floods or wars. The ultimate objective of most of the studies is to manage the material flow in the relief chain in delivering the correct amount or number of people, goods, and monetary resources to locations in a timely manner. However, humanitarian demand is not only a seasonal need emerged by the specific requirements of an emergency. To put it another way, project and programs are not only time-bound. Humanitarian environment is becoming more complex requiring better management of a new concept: social welfare chain. Relatively, a significant role of NGOs in terms of continual assistance to enhance the social welfare should be studied. Moreover, it is obvious that there will be a strong need for optimization of resources and activities, logistics, and management know-how. Related to these issues, operations research should be conducted to determine the most appropriate techniques to solve the problems in the unique nature of the each organization by taking into consideration of

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constraints like time and cost, and also to form objective decision making mechanism that can be applied to any kind of situations. Due to this reason, this paper is targeting at building an optimal transportation distribution model consolidating and standardizing the non-integrated style of logistics functions in a cost minimizing approach that every NGO can benefit.

## 2. Characteristics of NGOs

The term non-governmental organization (NGO) could refer to different types of organizations depending on the context in which it is used. In genereal, an NGO can be defined as a beneficial complementary organization filling gaps in society not provided by the public or sectors for profit. NGOs' purposes range from coping with the bad post-effects of disasters, improving the welfare of the disadvantaged to improving the state of the natural environment and encouraging the observance of human rights. In the light of these purposes, NGO's activities can include research, relief, welfare, information distribution, training, local organization, community service, legal advocacy, lobbying for legislative change, and civil disobedience.

NGOs play critical roles both in relief operations responding to disasters and in continuous social welfare activities for the people struggling to stay alive in the hands of poverty and lacking food, shelter and medicine. We are interested in the NGOs that focus on social welfare and deliver aid services for responding these needs directly to beneficiaries.

Although NGOs have many similarities with the private companies, their missions, strategies and goals differ from those organizations looking simply for profits. Based on the study of Gil-Estallo et al. (2006), extended differences between the private enterprises and NGOs are stated in Table 1.

Table 1. The main differences between private enterprises and NGOs

| Essential factors | Private enterprises | NGOs |
|---|---|---|
| Purpose | Economic profit | Free social and humanitarian attention and increase of social welfare |
| Collaboration with | Other companies (e.g., joint-ventures, mergers) | Public sector, cooperating companies, people who offer their effort and time |
| Information System | Information is generally well-defined, using advanced technology. | Information is often unreliable, incomplete or non-existent, inadequate use of technology |
| Processes | Structured oriented to the value chain | Structured by projects and continuous welfare programs |
| Output Variability | High variation in products and services | Social and humanitarian help by delivering limited products and services |
| Performance Measurement Criteria | Being economically efficient and effective | Being socially efficient and effective |

The above stated table attempts to display the main factors that classify the private enterprises and NGOs. NGOs aim to create value in the society and as a result of this, social welfare increases. Since, NGOs differentiated from the private enterprises in managing the procurement, transport, storage and handling respect to increasing the level of social welfare, a new necessity for a *new definition* has revealed.

## 3. Social Welfare Chain

Demand for humanitarian aid does not always occur instantly like it does in emergency situations after natural or man-made disasters. Therefore, the actions needed are not only time-bound. Humanitarian environment is becoming more complex with more requirements waiting to be supplied and this increases the need of better management of a new concept: social welfare chain.

We define 'Social Welfare Chain' as the chain that aims to reach the low income people to satisfy their needs derived from poverty. The operations of social welfare chain are not temporary like disaster relief chains. They are continuous with the periodical delivery of the food, medicine and clothing to the low income and vulnerable people.

In this point of view, the aids to people starving in Africa or the ones that are made to the low income and vulnerable people on particular times, need to be considered in the scope of our social welfare chain because of their continuous pattern.

Characteristics of commercial supply chains and humanitarian relief chains were compared in the study of Beamon (2004). The previous comparison is widened by adding Social Welfare Chain concept. We have compared three chains according to their strategic goals, objectives, demand characteristics, distribution network configuration, inventory control, the importance of time as a constraint and the operation type in order to explain the difference of Social Welfare Chain from the others.

Table 2. Comparison of the three types of chains

| | Commercial Supply Chain | Social Welfare Chain | Humanitarian Relief Chain |
|---|---|---|---|
| Strategic Goals | To produce high quality products at low cost to maximize profitability and achieve high customer satisfaction. | To increase the level of welfare in the society | Minimize loss of life and alleviate suffering in disasters. |
| Objectives | Maximizing profit or minimizing costs. | Minimizing costs , minimizing the detrimental effects of living in poverty | Minimizing the time required to respond, maximizing the ability to meet the needs of the disaster |
| Demand characteristics | Relatively stable, predictable demand patterns. Demands occur from fixed locations in set quantities. | Demand derives from the needs of people with low-income, predictable in terms of time, location, type and size. | Demand is generated from random events, unpredictable in terms of time,location,type and size. Demand requirements are estimated after they are needed. |
| Distribution Network Configuration | Well-defined with predetermined number of locations for distribution | Well-defined subject to change | Non defined because of the nature of the unknowns(locations, type and size of the events, politics and culture) |
| Inventory Control | Relatively less challenging | Challenging | Extremely challenging |
| Time Constraint | Could be restrictive | Not so restrictive | Very restrictive |
| Operation Type | Continuous operations | Continuous operations | Ad-hoc operations |

Social Welfare chain's strategic goal is to increase the level of welfare in the society. Objectives can be defined as minimizing costs and the detrimental effects of living in poverty. Demand derives from the needs of low-income people and it is predictable in terms of time, location, type and size. Distribution network configuration is well-defined but could be subject to change. Inventory control is challenging due to the variations in locations, cost of inventory and the place of inventory. Time is not as restrictive as it is in relief chains but is still important because of having people as the focal point. Operations in the social welfare chain have a continuous pattern with periodical distributions to low-income people.

## 4. The Challenges of NGOs in Social Welfare Chain

Although many concepts in commercial supply chains can be applied to humanitarian logistics, especially to NGOs, this can't protect NGOs from facing challenges in social welfare organizations.( Fritz Institute, 2005):

Lack of recognition of the importance of logistics: In relief and social welfare activities, logistics is generally thought to be as a lower priority function. Therefore, logistics and other support activities e.g., communication, human resources don't have adequate funding and are not taken into consideration until encountering obstacles about them.

Shortage of professional staff: People, who can manage the complex supply chain of relief and social welfare activities, are getting more and more important. Many NGO leaders began their careers with a background in the social sciences, development studies or law. NGO leaders tend to be valued activists and few have corporate point of view or corporate experience on logistics management.

Limited collaboration and coordination: Although many NGOs face the same challenges, they rarely cooperate. They have the same objectives but in contrast to this there is little collaboration or resource sharing. Since the costs are highly important for the NGOs, they can surely benefit from mutual operations like sharing regional warehouses both for their social welfare organizations and relief projects.

Inadequate usage of information technology: In private sector, supply chain technology has enabled the transformation of logistics function to a strategic function. Although integrating logistics and technology is widely used for obtaining higher effectiveness and efficiency, in NGOs supply chain processes are largely manual. Tracking and tracing of shipments are done manually using spreadsheets. Data has to be written out onto multiple forms and keyed into multiple spreadsheets. There is no central database of historical data on prices paid, transit times or quantities received/purchased. As understood, manual, non-standardized, error-prone processes still dominate in NGOs.

## 5. Social Welfare Chain and OR

To design effective distribution systems has been important since the industrial revolution, especially with the monumental task of designing railway nets. But only after the availability of the computers, using the vast computing power it has become possible to reach truly optimal and applicable solutions for the practical purposes.

For the last three decades, corporations reorganized to bring fragmented managerial functions under more centralized managerial control, thus making the dominant theme of logistics as integration, first grouping the materials management, than fully integrated logistics. Exactly this integration made possible the modeling applications of the OR professionals soundly proposing the alternative choices and trade-offs to the logistics executives and managers. Globalization and outsourcing, coupled with high oil prices which has magnified the problems, surfaced the logistics which contain the most realisable opportunities for managerial improvement. Indeed the popularity of OR, might not have been possible without the receptivity created by this need. And the very same need, we believe, will push the improvements of OR research and applications ever higher degrees, and make them more widely used and accessible to a broader range of applications through desktop computers and ingenious software tools. We have observed new and unexpected uses of these tools, which are way beyond the originally envisioned uses.

Unfortunately NGO's, lacking the dominant pressures of cost minimization and/or profit maximization, lagged behind. Building a sustainable business was and is never easy, but, NGO's face particular challenges. Usually for the NGO's , the problem is to acquire a questioning angle; which requires the manager of the organization to be aware that something is not working well or could work better. Often people in an organization do not recognize the symptoms of problems because they have lived with them so long that the situations seem normal or they no longer realize what is possible. But, just to know that OR exists and capable of offering unprecedented solutions, can be the critical knowledge.

"The computer revolution is a rising tide that lifts all boats"(Geoffrion &Powers.1995), which made OR's easy to acquire and apply. NGO's might have a real lot of help from "academic center originated OR" to achieve their purposes. It is obvious that hi-tech oriented events flourish at academic centers and the best way to understand new directions in a field is through social networks with the universities. Hence the easiest source of OR knowledge, is universities, which makes NGO's to cooperate and coordinate with the Universities a must.

Ultimate value of OR is making real differences in organizations, which is particularly important for the NGO's. In recent years, tools, by using operations research concepts, were developed to allow NGOs solve challenging problems and work more productively with improved quality and reduced cost. Efficiency, effectiveness, and equity concepts are the three measures to be taken into account in solving such problems of a non-profit environment (Swaminathan, Ashe, Duke, Maslin, Wilde, 2004).

For example, The Medpin (medicine for people in need) program of the Public Health Institute, used a decision-support system for the drug distribution project (DDP). The Organization was responsible for distributing drugs in an easy, timely and fair manner considering various clinic, pharmaceutical, and allocation constraints. The system was created to accomplish these goals. Then on, many pharmaceutical firms used the DDP's decision-support system to improve their operations (Swaminathan, Ashe, Duke, Maslin, Wilde, 2004).

Another NGO, the Visiting Nurses Assosication used such tools to improve the balance of work among nurses. This decision support system was developed through an effective university-industry joint effort. University of Alabama's Productivity Center and Visiting Nurses Assosication collobarated in solving the problem of scheduling which available nurse to see which patient, when, and what travel routes to use (Begur, Miller, Weaver, 1997).

## 6. Problem Definition

As the main player of the social welfare chain, the NGOs we consider in this study are responsible of providing basic needs such as food, coal, clothing and health care to low-income and other vulnerable populations. With limited resources and a significant number of target groups, NGOs are obliged to fulfill this mission in a most efficient and cost effective way. In the context of social welfare, the operations of such NGOs continuously require advanced logistics planning for their procurement, transportation, storage and distribution operations. Compared to private enterprises, NGOs most often do not have extra resources to invest in expensive logistics and supply chain software and hence operating with ad hoc plans. Therefore, our purpose is to increase the efficiency of NGOs' operations by developing a new distribution network configuration and an optimal logistics plan.

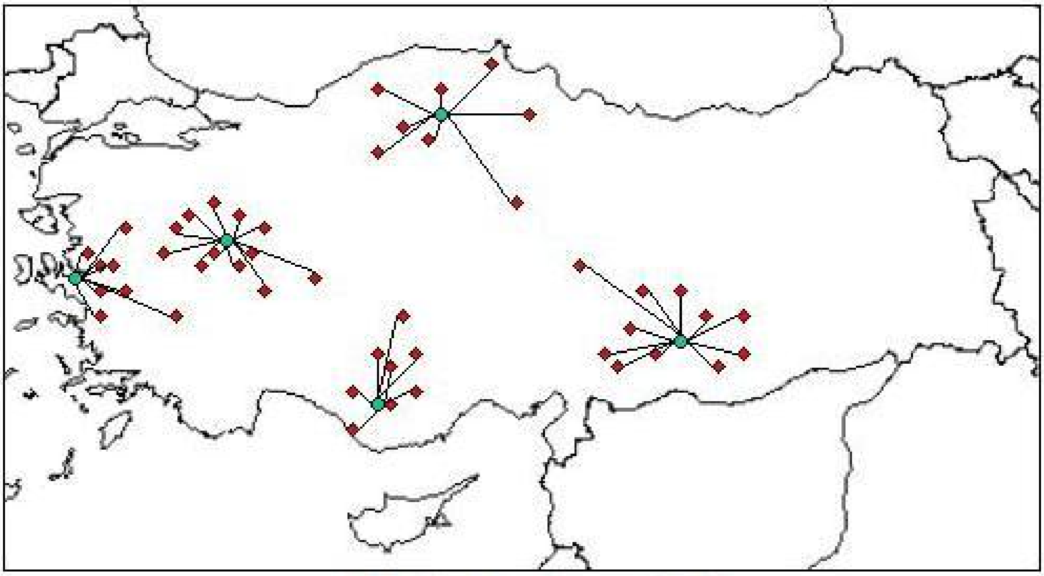

Figure 1. Current operation map of the NGO

A non-profit, nongovernmental organization in Turkey is helping over five thousand low-income people by distributing coal. Currently, the NGO has 22 distribution centers in different city and towns of Turkey with the headquarters located in Izmir. Considering the available resources and capacities of each distribution center, a target group is selected based on certain social criteria developed by the NGO. With a decentralized manner, all distribution centers have been acting independently in procurement, storage and distribution. Each center forecasts the local demand in advance and determines its own procurement strategy. They either use their own storage facilities and trucks or they hire those from local agencies. Therefore, they are able to satisfy the needs of only nearby populations as depicted in Figure 1.

The decision making process and current practices of the NGO are based on experience and manually recorded. As the necessity and importance of their operations are increasing, the administration has been forced to benefit from OR tools in order to shift to a more centralized and more streamlined practice. With a centralized approach, supplier selection process, procurement process and storage facilities are planned to be consolidated. As a strategic decision, the administration would like to answer the following questions: How many new regional warehouses to open? Where to locate them? How to best assign suppliers and distribution centers to the new warehouses? The objective is to minimize social welfare chain costs and to make recommendations that would help NGO to determine the optimal number of new storage facilities and their location, to identify potential leveraging opportunities through pooling common storage locations, and to identify which office should serve each market for people close to multiple locations.

## Network Configuration

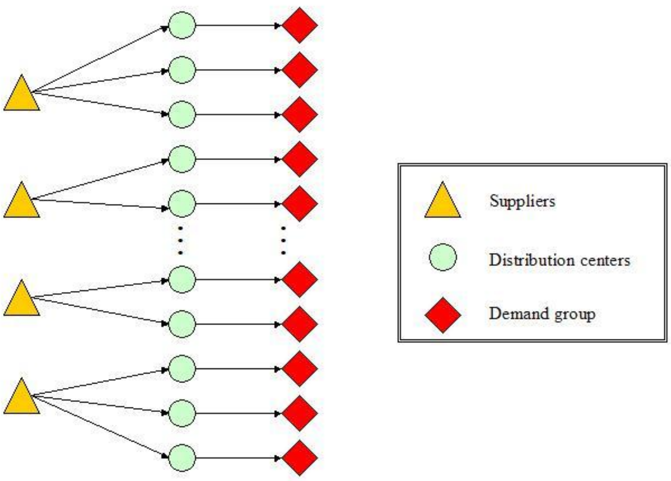


Figure 2. The current social welfare network configuration

The existing distribution network configuration of the NGO is illustrated in Figure 2. The beneficiaries in each town/city are grouped into a single node and assigned to a distribution center. As it is shown, the distribution centers are not given supplier selection capability; the supplier-distribution center assignment is fixed regardless of purchase cost and proximity. Obviously, evaluating all possible supplier-distribution center assignments and hence selecting the best one could cause significant reductions in procurement costs. Therefore, exclusion of other potential supplier-distribution center connections is considered as a major drawback in the current configuration. In order to overcome this drawback and also to consolidate the existing distribution centers, the potential regional warehouse locations are included in our proposed network configuration as shown in Figure 3. Thus, the new configuration would allow the NGO to use its distribution centers more efficiently and reduce procurement costs with a better supplier selection.

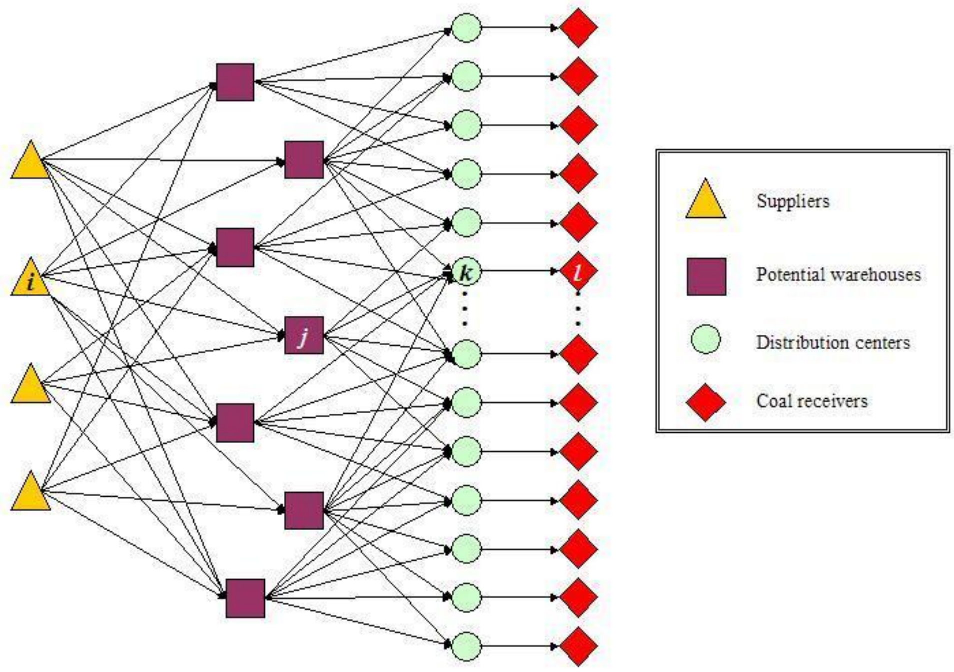


Figure 3. The suggested social welfare network configuration

Selection of the potential locations for the new regional warehouses is critical; choosing too few potential locations would prevent reaching true optimum and choosing too many would make the problem unsolvable. Therefore, we limit the number of potential locations by selecting ten locations based on population size, highway and rail connectivity, and of course expert opinion. In terms of suppliers connected to these regional warehouses, we consider three domestic coal miners (Soma, Aliaga, Zonguldak) and a foreign supplier who is shipping to a port Northern Turkey. Note that due to calorie differences and some other factors, the unit cost of coal at different suppliers are different. With the new configuration, regional warehouses are supposed to select the most cost effective supplier considering not only procurement but also transportation costs.

We develop a mixed integer programming model for a single product, single-period transportation/distribution model based on the social welfare network configuration in Figure 3. We build the mathematical model so as to minimize the total cost which includes procurement, inbound, storage, outbound, distribution and redistribution costs. Transporting coal to regional warehouses is considered as inbound freight and transporting coal to distribution centers considered as outbound freight. Distribution cost is incurred at the distribution centers for delivering the coal to every single demand point. Due to the high cost of truck delivery for small volumes, a significant cost figure occurs when the coal truck is not able to make the delivery in its first round and returns the coal back to the distribution center. The cost of unsuccessful delivery is defined as *redistribution cost* and its computation is based on a ratio of undelivered coal.

In the model, we include demand satisfaction constraints, minimum and maximum usage limitations and open/close decision for the regional warehouses. Hence, we define the following decision variables and input parameters.

Decision variables

$$z_{ijk} = \begin{cases} 1, & \text{regional warehouse } j \text{ is linked to supplier } i \text{ and distribution center } k; \\ 0, & \text{otherwise.} \end{cases}$$

$$w_j = \begin{cases} 1, & \text{if warehouse } j \text{ is chosen to be opened;} \\ 0, & \text{otherwise.} \end{cases}$$

$x_{ij}$ = amount of coal (in tons) supplied from supplier $i$ to warehouse $j$
$y_{jk}$ = amount of coal (in tons) shipped from warehouse $j$ to distribution center $k$

where,
I = 1,…,*i*,…4 ; index set for suppliers
J = 1,…,*j*,…10 ; index set for potential regional warehouses
K = 1,…,*k*,…22 ; index set for existing distribution centers
L = 1,…,*l*,…22 ; index set for demand groups.

Input parameters

$d_{kl}$ = demand arising in region $l$ to be satisfied by distribution center $k$
$f_{ij}$ = inbound freight cost to transport a ton of coal from supplier $i$ to warehouse $j$
$o_{jk}$ = outbound freight cost to transport a ton of coal from warehouse $j$ to DC $k$
$p_i$ = cost for supplying material from supplier $i$ to warehouse $j$
$S_j$ = capital (fixed) cost of opening warehouse $j$
$R_k$ = percentage of undelivarable coal that needs to be redistributed
$r_k$ = redistribution cost for a ton of coal
$g_k$ = normal distribution cost to transport a ton of coal from DC $k$ to demand region $l$
$M_j$ = upperbound on the volume usage of warehouse $j$
$m_j$ = lowerbound on the volume usage of warehouse $j$
$K$ = total number of warehouses to be opened

MIP Model

$$\text{Minimize} \sum_i \sum_j p_i \mathbf{x}_{ij} + \sum_i \sum_j \sum_k f_{ij} \mathbf{x}_{ij} \mathbf{z}_{ijk} + \sum_j \sum_k o_{jk} \mathbf{y}_{jk} \mathbf{w}_j + \sum_j S_j \mathbf{w}_j + \sum_k \sum_j c_k R_k \mathbf{y}_{jk} \mathbf{w}_j + \sum_k \sum_j g_k y_{jk} \mathbf{w}_j$$

subject to

$$\sum_j \mathbf{y}_{jk} = d_{kl} \quad \forall k, l \tag{1}$$

$$\sum_i \mathbf{x}_{ij} - \sum_k \mathbf{y}_{jk} = 0 \quad \forall j \tag{2}$$

$$\sum_i \mathbf{x}_{ij} \mathbf{w}_j \geq m_j \quad \forall j \tag{3}$$

$$\sum_i \mathbf{x}_{ij} \mathbf{w}_j \leq M_j \quad \forall j \tag{4}$$

$$\mathbf{z}_{ijk} - \mathbf{w}_j \leq 0 \quad \forall i, j, k \tag{5}$$

$$\sum_j \mathbf{w}_j \leq K \quad \forall j \tag{6}$$

$$\mathbf{z}_{ijk} \in \{0, 1\} \quad \forall i, j, k \tag{7}$$

$$\mathbf{w}_j \in \{0, 1\} \quad \forall j \tag{8}$$

$$x_{ij}, y_{jk} \geq 0 \qquad (9)$$

The above mixed integer program is a moderate size problem with 1150 (890 binary and 260 continuous) decision variables and 942 constraints and it can be easily solved by any commercial integer programming solver.

## 7. Conclusion

With our approach, the problem has been effectively described and the administration took part and actively contributed to the development process. Although the problem is essentially a typical OR problem, this study differs from the usual disaster framework of the NGOs. Contrary to disaster relief efforts, the social welfare efforts are regular and more prone to strategic planning. The mathematical model we developed can be directly used for products other than coal or easily extended to multi-product case. The results are expected to make considerable difference in the overall efficiency of the NGO. Further research includes data collection, optimization, numerical analysis and re-optimization based on the contributions of the administration and expansion of the NGO's operations.

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# EFFECTS OF GLOBALISATION ON MARITIME INDUSTRY; MERGERS, ACQUISITIONS

İbrahim Aksel[1], Cihan Akça[2]

## Abstract

*International trade has become an increasingly important part of the global economy and more than 80 percent of world trade travels by ship. With the rapid growth of globalization in world maritime trade, maritime managements have undertaken heavier tasks and more important roles to achieve better service quality and agility in the supply chain.*

*This paper will examine the globalization of the maritime transportation industry which accounts for vessels, flag registration, class inspections, insurance and the work of seafarers, are purchased globally. Although globalized production and distribution chains were made possible precisely by the provision of cheap international transport recently in this sector, high capital outlays and rapid technological change, resulting from the globalization of maritime trade, create pressures for greater private sector involvement. Therefore, in recent years, some pressures created by an increasingly competitive environment with globalization becoming both a constraint and a strategy for shipping operators. This stimulation has brought about combine forces in order to reduce costs and increase efficiencies by merger, joint venture, alliances or outright acquisitions in maritime industry.*

*Keywords: Globalization, Maritime industry, Merger, Acquisition*

## 1. Introduction

This paper seeks to investigate global strategy in the maritime sector, with a specific focus on mergers and acquisitions. The aim is also to consider perspectives from this analysis, or in other words to give something of a *prospect of the future*, as a consequence of evolving global strategy in the sector.

No extensive review of the empirical literature on this specific research topic is available. This paper intends to go someway to imply globalization effects on maritime industry especially mergers and acquisitions.

Mergers and acquisitions can and do take many different shapes and forms. A fundamental concern about mergers and acquisitions are how mergers and acquisitions affect the vitality of competition in the affected markets, which depends both upon the terms of the mergers, acquisitions and the carriers involved.

Moreover one of the most significant developments in the container shipping industry over the last decade has been the formation of strategic alliances and equity partnerships. The groupings that have evolved have been quite complex, and in some cases companies have merged through acquisition and then joined larger alliances, or have entered an alliance, only later to merge. These developments mirror what has been taking place in other sections of the economy, where alliances and equity mergers have restructured many industries, such as the airlines (Oum, Yu, & Zhang, 2001)

In the container shipping industry European lines are still very much in charge. Four of the top five carriers are European–owned. In the past times, there have been a number of multi-national mergers. For example, Maersk acquired arch rival Sea-Land in the late 1990s and then acquiring P&O Nedlloyd last year. Maersk-Sealand now ranked first. Strategic merger or acquisition can transform the face of the industry. That is what Hapag-Lloyd, ranked just outside the top 10 before its takeover of CP Ships. After the acquisition of CP Ships in 2005 placed Hapag-Lloyd among the top five biggest shipping companies in the world and greatly expanded its fleet and network.

No- one in the industry expects Maersk Mc-Kinney Moller or his family, MSC's Gianluigi Aponte, CMA CGM's Jacques Saade or Evergreen's Chang Yung-fa to be in the slightest bit interested in mergers that would weaken their grip on business they have nurtured over the past 30 years. The question is whether their sons and daughters will feel as passionately about the business as their fathers. As the next generation begins to take over, they will be faced with an industry still, to some extent, in its formative years (L'Loyd's List, April 18 2006)

Globalization, deregulation, logistics integration and containerization have reshaped the port and shipping industry. Port and maritime companies are challenged to redefine their functional role in the value chain for the sake of creating customer value and of ensuring the survival and growth of the company. The market environment in which container ports and shipping lines are operating is substantially changing. One of the main driving forces to change emerges from the globalization process and the large-scale adoption of the container since the late 1960s.

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International supply chains have become complex and logistics models evolve continuously as a result of influences and factors such as the globalization and expansion into new markets, mass customization in response to product and market segmentation, lean manufacturing practices and associated shifts in costs (Notteboom, 2004).

Therefore the majority of industry experts agree that the trend toward consolidation will continue and may even accelerate. Industrial mergers and acquisitions have become an important reality all over the world. This situation has included even space industries by increases political integration (Lulio, 2000).

On the other hand since liner shipping became an important industry in the 1870s; it has been characterized by various agreements between firms. Conferences agreements have been quite successful and in many cases have lasted for years. There were over 150 conferences operating in the world as of 2001. In the last ten to twenty years, conferences have begun to be supplanted by alliances, which are less complete (they do not, for example, set prices) but encompass more broadly defined trade routes (Sjostrom, 2004). Strategic alliances, mergers and acquisitions have generated twin effects: notable increases in ship size and falls in freight rates (Midoro, Musso, & Parola, 2005).

## 2. Globalization

World seaborne trade has grown almost continuously since World War II, increasing more than two-fold since 1970. During the 1990 transport and communication appear slowly to be on their way into the mainstream again, but now transformed into a much broader concept of logistics, which has become an increasingly important element in the organization and restructuring of the globalizing economy. From being an external factor, transport has become an integrated part of the production and distribution system (Kumar & Hoffmann, 2006).

Global trends were at play creating a new international shipping environment of an enlarged geographical participation but also of enhanced cost differences between major players. Little emphasis has been placed on the role the industry is playing in providing low-cost, efficient international transport extending today to the provision of logistics solutions. The recent wave of mergers and acquisitions in container shipping exemplifies the extent of internationalization and the role attributed to scale and quality of service as a means for market survival, at least as far as liner shipping is concerned. The number of mergers in the 90s underlines the limits of operational co-operation when confronted with a global market place while the fact that some of the most prominent mergers and acquisitions have taken place in an, unexpectedly for many, East-West direction (Thanopoulou, 2000).

Transport is one of the four cornerstones of globalization. Together with telecommunications, trade liberalization and international standardization, the increased efficiency of port and shipping services has made it ever easier to buy and sell merchandise goods, raw materials and components almost anywhere in the world. In fact, a simple commercial transaction may easily involve people and property from a dozen different countries: A Greek owned vessel, built in Korea, may be chartered to a Danish operator, who employs Philippine seafarers via a Cypriot crewing agent, is registered in Panama, insured in the UK, and transports German made cargo in the name of a Swiss freight forwarder from a Dutch port to Argentina, through terminals that are concessioned to port operators from Hong Kong and Australia (Kumar & Hoffmann, 2006).

In the globalized production, trade and distribution channels of today, managing the entire - and increasingly complex - process of movement of materials and goods has become more important than producing transport. Globalized production and distribution chains were made possible precisely by the provision of cheap international transport (Thanopoulou, 2000).

Meanwhile trade will take place if price differences between two countries are higher than the total transaction costs. Allowing and facilitating trade has obvious positive impacts on economic growth. If Chile can produce bananas only under glass, and Ecuador grow grapes only on an inaccessible highland, then both countries' populations can eat more bananas and grapes (i.e., achieve measurable economic growth) if they specialize and trade - as long as the shipping services are less expensive than the savings in production costs (Kumar & Hoffmann, 2006).

At the moment, most of the top-20 carriers are grouped into three global alliances:

– The New World Alliance: APL, MOL, Hyundai;
– Grand Alliance: P&O Nedlloyd, NYK, Hapag Lloyd, OOCL and MISC;
– CKYHS Alliance: Cosco, K-Line, Yang Ming Line and Hanjin-Senator.

Besides these operators we find some ‘lonely players’. The main ones are:

– Maersk-Sealand;
– MSC;
– Evergreen;
– CMA-CGM;
– China Shipping.

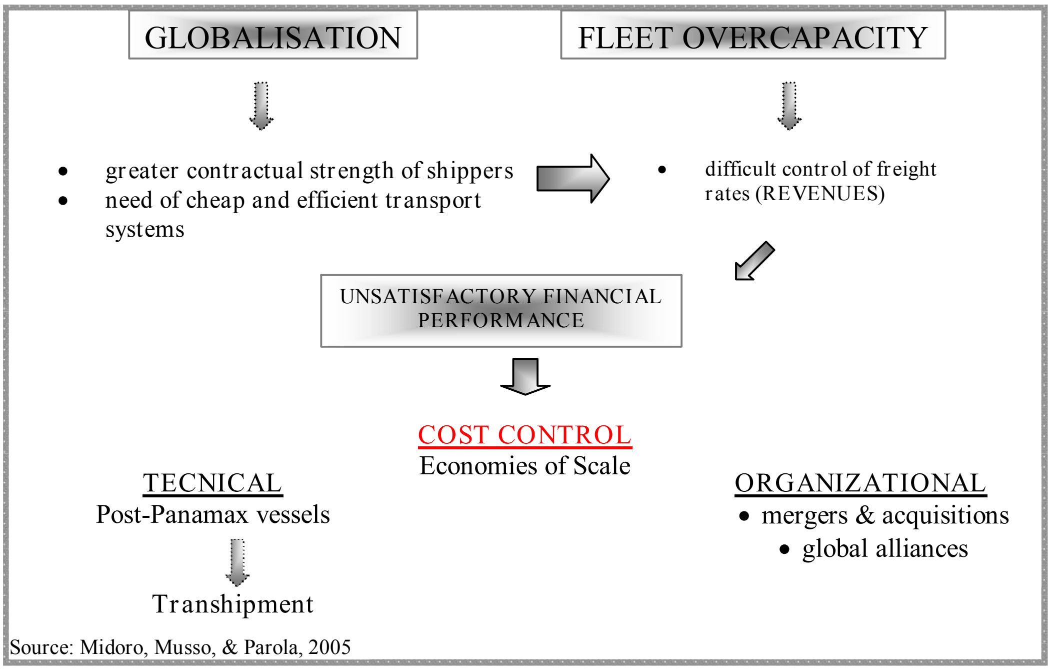



Figure 1. Present market forces in the liner sector

Globalization has extended and deepened the effects of containerization. Production systems are increasingly global, as firms depend upon the door-to-door services and just-in-time deliveries that containers have made possible. Logistics is the means by which trade is being organized, and ports, which used to be gateways (or bottlenecks) through which trade flowed, are now but one many links in chains that are global in scope. The shipping lines have emerged as the most important players in these logistics chains, widening their maritime services and extending their control over landward movements. A number of external developments are creating conditions of great uncertainty and change, which are making obsolete traditional port planning approaches. The port industry has always been competitive. Every port has a history of rivalry with competitors near and far. The shipping lines have themselves responded to globalization in ways that impact directly on ports. Over the last five years the container shipping industry has been restructuring itself in a revolutionary fashion. Several firms have come together through equity mergers, such as NOLAPL, P&O-Nedlloyd, and SeaLand-Maersk (Slack, 2001).

The growth of world trade, a direct outcome of the internationalization of the economy, has made it essential for container shipping companies to extend their market coverage globally. At the same time, the costs of providing such global services have been increasing because of the need to deploy ever larger and more costly vessels. The emergence of new carriers has also heightened competition. Faced with these circumstances, the shipping lines have moved to restructure. Alliance membership and/or participation in other types of joint service have given carriers opportunities to rationalize their existing operations by pooling assets (vessels), and expand their activity with their liberated ships. There is one other way lines could have achieved this expansion: by greatly enlarging their fleets and allocating more ships to serve more markets. (Slack, Comtois, & McCalla, 2002)

As a process expected to increase global economic integration, port reform is now a significant part of the neo-liberal agenda. In this sector, high capital outlays and rapid technological change, resulting from the globalization of maritime trade, create pressures for investor. While all countries are affected by globalization, the consequences for developing countries are particularly controversial. Globalization is most clearly a spatial process whereby separate locations are integrated into a single international market as world port container traffic doubled between 1990-98 and has continued to grow exponentially ever since. The majority of global maritime trade is now controlled by an oligopoly of shipping lines and container operators who have consolidated their position through a series of mergers (Hill, 2006).

## 3. Mergers and Acquisitions in Maritime Industry

The label ‘strategic alliance’ has been used to denote a variety of interfirm relationships. We refer to strategic alliances as co-operative agreements in which two or more separate organizations team up in order to share reciprocal inputs while maintaining their own corporate identities. Mergers and acquisitions occur when independent companies combine their operations into one new entity. Such combinations can refer to the merging of two more or less equal companies as well as to acquisitions where one company obtains majority ownership in another company. Over the past decades, a strong upheaval in the use of alternative forms of organization gave way to increased attention in the academic literature to the performance effects of, in particular, strategic alliances and mergers and acquisitions. Technological know how is often tacit and can therefore not be easily transmitted from one firm to another. In order to avoid high transaction costs, firms may be inclined to engage in an acquisition in order to solve problems related to the transmission of tacit knowledge (Man & Duysters, 2005)

Industrial mergers have become an important reality in Maritime industry. Horizontal integration in liner shipping comes in three forms: trade agreements such as liner conferences, operating agreements (that is vessel sharing agreements, slot chartering agreements, consortia and strategic alliances) and mergers and acquisitions. The economic rationality for mergers and acquisitions is rooted in the objective to size, growth, economies of scale, market share and market power. Other motives for mergers and acquisitions in liner shipping relate to gaining instant access to markets and distribution networks, obtaining access to new technologies or diversifying. Acquisitions typically feature some pitfalls, certainly in the highly international maritime industry: cultural differences, overestimated synergies and expense of acquisition. In a shipping industry already dominated by large vessels, mergers/acquisitions and strategic alliances the potential cost savings at sea still left are getting smaller and the pressure to find cost savings elsewhere is growing (Notteboom, 2004).

Mergers and acquisitions remain a popular strategy for companies seeking to improve profitability and growth prospects. There are some causes and consequences for the poor success rate of mergers and acquisitions. Such as, human resource management problems that occur as a consequence of mergers and acquisition, potential for high labor turnover, lower workforce morale, higher workplace stress, under utilization of employee's skills (Waring, 2006) and a direct impact on the stock price of liner shipping companies after mergers and acquisitions (Panayides, & Gong, 2002).

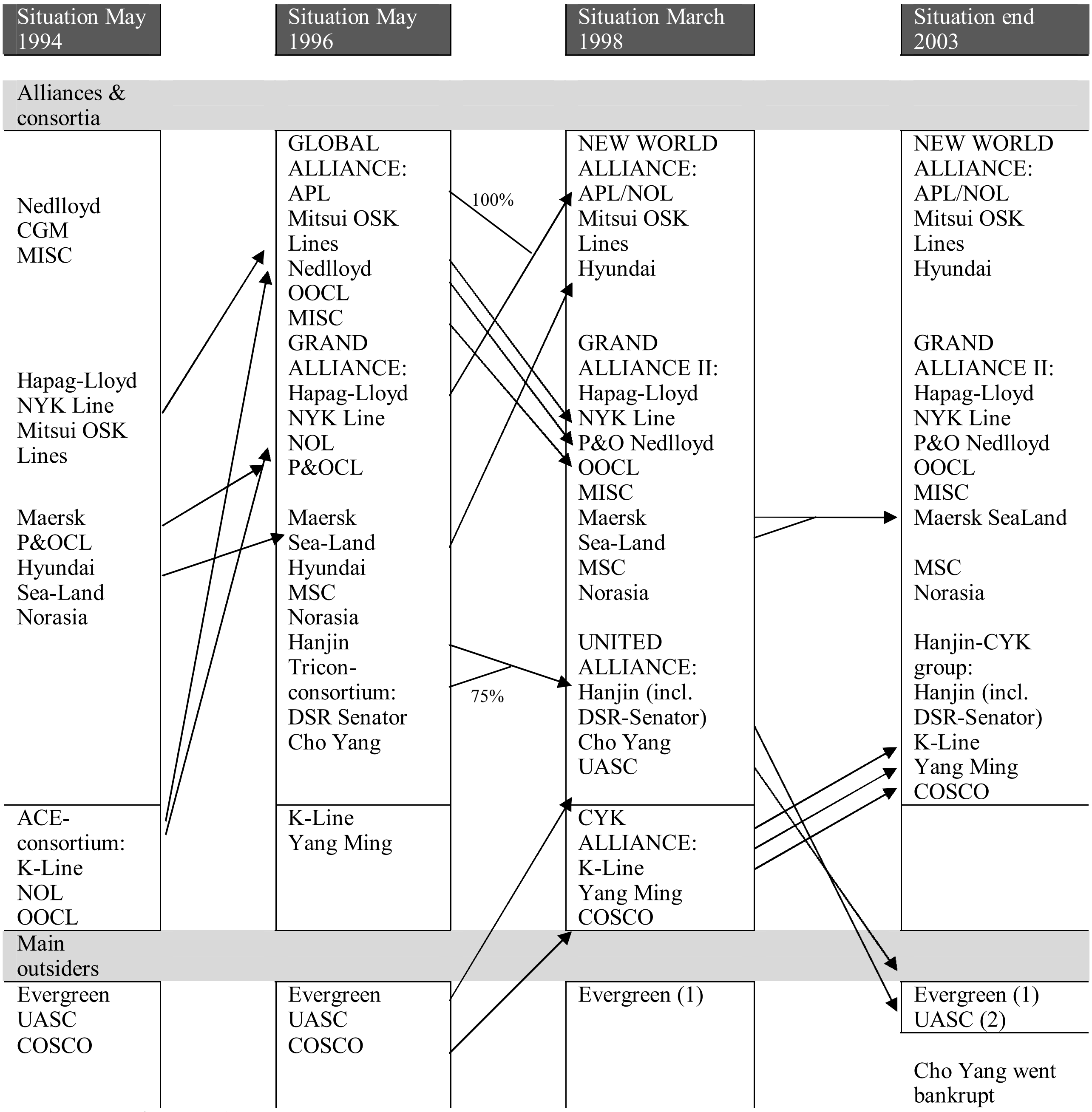
By globalizing transportation services internally through organic growth and externally through cooperating with competitors. Because of competition and over capacity in the industry, carries have pushed casts down by a variety of methods. But carriers have reached the limits of cost savings. In the last decades some of the container operators have been involved in some sort of merger activity. While a wave of mergers and acquisitions in the mid-1980s involved same country carriers, more recent consolidations, such as P&O's acquisition of Nedlloyd, have been transnational; P&O is a British carrier and Nedlloyd is Dutch.

Table 1: Mergers and acquisitions in liner shipping

| Date | Merger or acquisition deal | Details |
|---|---|---|
| March 1995 | CP Ships acquires Cast | CAN$150m |
| January 1996 | January 1996 P&O Containers acquires ANL | Not reported |
| January 1997 | P&O Containers merges with Nedlloyd | Nedlloyd paid US$175m to P&O |
| February 1997 | Hanjin acquired DSR-Senator Line | US$75m |
| July 1997 | CP Ships acquires Lykes Lines | US$34m |
| October 1997 | CP Ships acquires Contship Containerlines | US$110 |
| November 1997 | NOL acquires APL | US$825m |
| February 1998 | P&O Nedlloyd acquired Blue Star Line | US$100 ± 146m |
| May 1998 | CP Ships acquires Ivarans | Not reported |
| July 1998 | Evergreen acquires Lloyd Triestino | Not reported |
| August 1998 | Hamburg Sud acquires Alianca | Not reported |
| September 1998 | CP Ships acquires ANZDL | Not reported |
| January 1999 | Maersk acquires SCL | US$240m |
| July 1999 | Maersk acquires Sea-Land | US$800m |

Source: Panayides, & Gong, 2002

Mergers and acquisitions currently represent the prevalent strategy in the liner shipping industry that is directed towards the achievement of corporate objectives. Mergers and acquisitions may not only have long-term strategic and economic effects; they may also impact directly and immediately on the value of the company as they induce a particular reaction in the stock market with the consequent increase or decrease in share price. The importance of mergers and acquisitions in achieving the financial, economic and strategic objectives of contemporary liner shipping companies is undisputed. The liner shipping industry has been undergoing an unprecedented drive for consolidation in recent years primarily effected through a series of high profile mergers and acquisitions. This may be seen in Table 1, which illustrates a number of high profile mergers and acquisitions occurring in recent years. There is no doubt that liner shipping companies that merge horizontally or vertically may effect an enhancing or reducing outcome on firm value (Panayides, & Gong, 2002).




Source: Notteboom, 2004

Figure 2. Mergers, acquisitions & strategic alliances on the trade Europe-Far East

Strategic alliances implies that members of an alliance are not involved in price-setting (as this is done within the conferences they belong to) but in the rationalization of capacity through such schemes as vessel, terminal and equipment sharing, joint-scheduling, slotchartering and strategic alliances is the ability to undertake "operational synergies" for shipping lines (Cariou, 2006).

Mergers and acquisitions activity aims to achieve the following objectives (Carbone & Stone, 2005):

- Wider geographic coverage and control of major traffic flows through the creation of efficient transport chains. In such cases, often a freight forwarder that operates within specific regional markets is acquired.
- Economies of scope to improve operating margins through business process re-engineering and commercial entry into new market segments.
- Sufficient size to cope with the high investment in physical infrastructure and ICT to operate efficiently.
- Strategic and operational synergies, through the acquisition of specialist capabilities, especially higher value-added services. Increasingly, contract maintenance and repair, post-manufacturing and reverse logistics are found in third-party logistics

During the last decade the liner industry has attempted to return to profitability primarily through cutting costs. Usually this has meant a logical progression of:

- Focus on joint services;
- Restructuring and overhead cost reduction;

- Global alliances; and
- Mergers and acquisitions

The container shipping industry has become increasingly concentrated during recent years as lines have merged with or acquired other lines, and this trend is forecast to continue. As well as low cost entry and risk-sharing, mergers and acquisitions can provide fast access to new markets, by 'borrowing' the already-in-place infrastructure of a partner. For example, mergers and acquisitions combining Asian and European lines have enabled these entities to access terminal facilities and intermodal connections previously put in place by partners in each region (Baird, 2006).

## 4. Conclusions

Technological advances, deregulation, logistics integration and associated new organizational structures, in particular, are constantly reshaping the port and maritime industries, and companies are busily trying to disrupt the status quo rather than preserve it.

Both the maritime industry and the transportation industry have to reinvent themselves. They need smarter people to handle bigger, more sophisticated systems (Harrington & Knee, 1998)

Firms must have a supply chain orientation to effect timely manage the supply chain that could result in lower costs, increased customer value and satisfaction, and competitive advantage.

The establishment of such a supply chain requires the formation of strategic alliances with channel members that include transportation service providers such as shipping companies. Integration of transport activities is essential for the success of a supply chain and a well-integrated transportation system's contributions to the supply chain could include time compression, reliability, standardization, Just-In-Time delivery, information systems support, flexibility and customization (Morash and Clinton 1997).

The ship owner's effort to create a "least cost system" in the maritime business is tantamount to designing a global supply chain based only on least cost channel members. This may lead to a loss of market share and corporate profits for the channel members of a supply chain, deficiencies of the least cost maritime system could have more drastic consequences, ranging from loss of life to environmental degradation that impacts society at large besides the more traditional commercial losses of the business enterprise.

As a result of the acquisition, shipping companies will offer an extended service network, diversified fleet, and enlarged container fleet, as well as enhanced IT support, superior customer service, and improved intermodal options.

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# THE DRY PORT CONCEPT APPLICATIONS IN SWEDEN

Violeta Roso[1]

## Abstract

*This paper deals with dry port applications in Sweden. The dry port concept is based on a seaport directly connected by rail to inland intermodal terminals, where shippers can leave and/or collect their goods in intermodal loading units as if directly at the seaport. The seaport and the inland terminals, here denoted dry ports, are connected with high capacity traffic modes, such as rail, rather than road only. In addition to the transshipments provided by a conventional inland intermodal terminal, services such as storage, consolidation, depot, maintenance of containers, and customs clearance are usually available at dry ports.*

*The purpose of this paper is to describe the dry port concept and to identify and categorize existing and potential dry ports for the Port of Gothenburg. Most of the surveyed terminals can be described as simple road–rail terminals; only two of the terminals can be categorized as more advanced with extra services offered.*

Keywords: Dry port concept, Intermodal transport, Inland intermodal terminals, Seaport inland access, Sweden

## 1. Introduction

"A Dry Port is an inland intermodal terminal directly connected to a seaport, with high capacity traffic modes, where customers can leave and/or collect their goods in intermodal loading units, as if directly to the seaport" (Leveque and Roso, 2001). In addition to transhipment, which a conventional inland intermodal terminal provides, services such as storage, consolidation, depot, tracking and tracing, maintenance of containers, and customs clearance are usually available at dry ports.

With ever-increasing maritime containerized transport, and the doubling of the size of container ships over the last ten years, efficient seaport terminals and inland access are essential for the functioning of the entire transportation chain. The rationale behind the dry port concept is that, as an advanced intermodal terminal, it can increase the use of rail by shifting freight volumes from road, consequently decreasing the amount of road traffic in seaport cities and thereby reducing the environmental impact. In addition to the general benefits to the environment and the quality of life from shifting flows from road to rail, the dry port concept above all offers seaports the possibility to increase their throughput without physical expansion at the site.

The main purpose of this paper is to identify and categorize existing and potential dry port applications in Sweden for the Port of Gothenburg. Empirical data for the study were collected by questionnaire sent by e-mail and conventional mail to 25 road–rail terminals in Sweden that were assumed to handle containers and had a rail connection to the Port of Gothenburg. However, the response was weak and the data insufficient with different reference years; therefore, additional data were collected through archival records and interviews.

The paper starts with a description of the dry port concept and three types of dry port – close, midrange, and distant – based on Woxenius et al. (2004a). The benefits of dry port implementation are defined from the perspectives of the involved actors, such as seaports, rail and road operators, shippers, local authorities, and society as a whole. Furthermore, intermodal (road–rail) terminals with a rail connection to the Port of Gothenburg are identified, described, and categorized.

This research is financed by the Swedish Agency for Innovation Systems (Vinnova).

## 2. The Dry Port Concept

A recent study determined the average speed for container transportation at v=7 [km/h] (Alicke, 2002). For competitive intermodal transport, scheduled and reliable high-capacity transportation to and from the seaport is necessary. In addition, shippers and carriers increasingly rate seaports by their accessibility, for example the frequency of inland transport services and transit times, or because of the public's demands for more environmentally friendly transport. To benefit from the opening up of new markets, seaports need to improve their access to areas outside their traditional hinterland.

Conventional hinterland transport is based on numerous links by road and only a few by rail, as shown in Figure a. The dry port concept is based on a seaport directly connected by rail to inland intermodal terminals, where shippers can leave and/or collect their goods in intermodal loading units as if directly at the seaport. Dry ports are divided into close, midrange, and distant (Woxenius et al., 2004a) – a seaport and all three types of dry ports are presented in Figure b. The main reason for implementing a distant dry port is that the distance and size of the flow make rail viable from a transport-cost perspective. Benefits from distant dry ports also derive from the modal shift

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from road to rail, resulting in reduced congestion at the seaport gates and seaport surroundings. Since one train in Europe can substitute 40 trucks, the external environmental effects along the route are reduced. Apart from environmental benefits, a distant dry port also brings a competitive advantage to a seaport since it expands the seaport's hinterland by offering shippers low cost and high quality services.

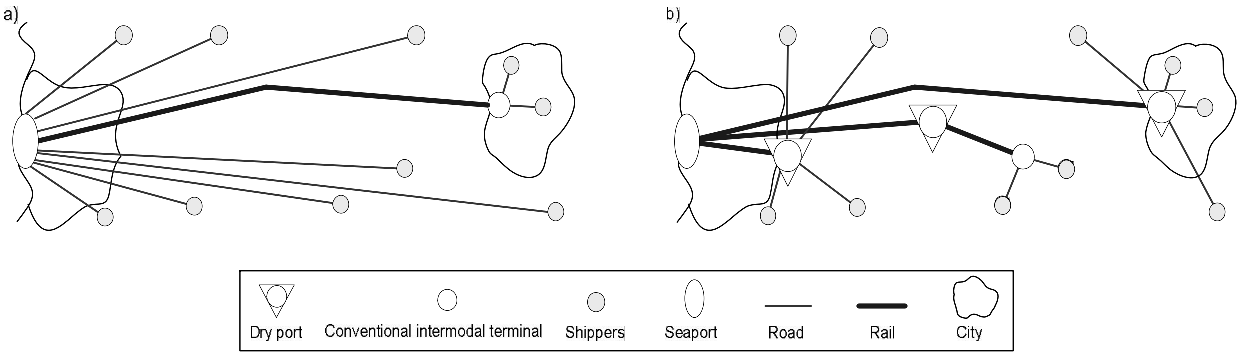


Figure 1. Comparison of a) conventional hinterland transport and b) an implemented dry port concept (close, midrange, and distant dry port) (Woxenius et al., 2004a)

Today, seaports compete not only on tariffs and transshipment capability, but also in the quality of inland access. This competition requires seaports to focus on transport links, on the demand for services in its traditional hinterland, and on development in areas outside their immediate market. Moreover, the quality of the access to a dry port and the quality of the road–rail interface also determines the dry port's performance. Rail operators benefit from distant dry ports simply by the movement of containers from road to rail, which increases the scale of their business. From the shippers' perspective, a well-implemented distant dry port offers a greater range of logistics services in the dry port area. For environmentally conscious shippers, a dry port gives the option of using rail rather than road, thus reducing the environmental impact of their products.

A midrange dry port is situated within the distance from the seaport generally covered by road transport. The benefits are comparable to those of a distant dry port. The midrange dry port serves as a consolidation point for different rail services, meaning that administration and equipment specific to sea transport, for example customs inspections, are needed at only one terminal. The high frequency achieved by consolidating flows, together with the relatively short distance, facilitates loading of containers for one container vessel in dedicated trains. Hence, the dry port can serve as a buffer, relieving the seaport's stacking areas.

The main problems seaports face today as a result of growing containerized transport are lack of space or inappropriate inland access. To meet the demand, seaports can increase their terminal capacity by establishing a close dry port in their immediate hinterland or on the outskirts of the seaport city. With increased terminal capacity comes the potential for increased productivity, since bigger container ships may call at the seaport. Road haulers lose a marginal market share in terms of road-kilometers but still benefit from shorter waiting times at dry port terminals. In cities not allowing long or polluting road vehicles, calling at a close dry port is an alternative to splitting up road vehicles or replacing them with less polluting vehicles.

## 3. Methodology

Empirical data for the study were collected by questionnaire sent by e-mail and conventional mail to 25 road–rail terminals in Sweden. However, the response was weak and the data insufficient with different reference years; additional data were therefore collected through archival records and interviews. A preliminary survey encompassed 19 intermodal (road–rail) terminals that handle containers and are connected by rail to the Port of Gothenburg. However, only 15 were included in this study as a result of their inland location, though seven are in seaport cities but not in dock areas.

After data collection, the main issue was how to organize the observed data into a meaningful structure. Given the relative inconsistency of the data as well as the small sample size (15 terminals), the analysis is primarily qualitative; however part of the analysis is based on the principles of k-Means Cluster analysis as well as on deviation from the trend line analysis. Cluster analysis is an exploratory data analysis tool that aims to sort different objects into groups in a way that the degree of association between objects is maximal if they belong to the same group and minimal otherwise (Everit et al., 2001). K-Means Cluster analysis is used in cases where clusters are already defined – for example in this study where the clusters are distant, midrange, and close dry ports. Since the purpose of the study is categorization of the terminals, analysis based on the principles of K-Means Cluster is a suitable method. Part of the analysis is based on deviation from the trend line with the use of a correlation coefficient, which tells us the degree to which variables are linearly related; correlation coefficient values close to 1 indicate excellent linear reliability (Pavlić, 1985). Although both Cluster and Trend Line are usually used to organize large amounts of information into groups, I found the principles of the methods applicable even for smaller samples of data such as in this study, since the results of the two analyses are used as a complement to the main qualitative analysis.

## 4. Empirical findings – Identification of inland road-rail terminals connected by rail to the Port of Gothenburg

Apart from seaport terminals, there are five different types of freight terminals in Sweden according to the classification of Woxenius et al. (2004b). These are: intermodal freight centers (IFC), conventional intermodal terminals, light-combi terminals, wagon-load terminals, and freeloading sites. They differ according to location, services offered, type of traffic modes, and goods handled. The simplest and most numerous type are freeloading sites that have no stationary lifting equipment. Wagon-load terminals are equipped with lifting equipment but handle only palletized cargo or sawn wood. The light-combi concept is based on a forklift truck transported on the train and operated by the train driver when loading/unloading is required (Barthel and Woxenius, 2003). Conventional intermodal terminals are designed for handling relatively large flows and usually are equipped with gantry crane, reach stacker or forklift trucks. The most advanced are IFCs – according to UN EC for Europe (2001) a freight center is a geographical grouping of independent companies that handle freight transport. Very few areas in Sweden could be classified as IFCs.

As stated above, the preliminary survey for this study encompassed 19 intermodal (road–rail) terminals that handle containers and are connected by rail to the Port of Gothenburg, see Table 1. However, only 15 of these intermodal terminals are analyzed in this paper due to their inland location, see Figure 19.

The Port of Gothenburg, the biggest container seaport in Scandinavia, handled more than 750 000 TEUs in 2005. Despite good rail inland access, only 30% of that quantity is transported by rail to inland destinations, the remainder being transported by road (Port of GothenburgAB, 2006).

Borlange, Gavle, Hallsberg, Jonkoping, Lulea, Malmo, Stockholm-Arsta, Sundsvall, Umea, and Almhult are part of the intermodal operator CargoNet, which has a network of terminals throughout Sweden and Norway serving all major destinations. However, not all terminals in the CargoNet group in Sweden have a direct rail connection to the Port of Goteborg, nor do they all have the same owner or operator, see Table 2. Stockholm-Arsta is the largest of all surveyed terminals, both in the number of units handled per year and in the terminal area; it also offers the most advanced services. The terminal provides customs clearance and storage of containers, and several forwarders, haulers, and shipping agencies are located in the vicinity. In addition, many warehouses are situated next to the terminal.

Eskilstuna, Insjon and Nassjo could be considered separately from other terminals since all three are relatively new, they are not part of the CargoNet group, and they mainly serve the Port of Goteborg. Eskilstuna and Nassjo started operations in 2004, and Insjon in 2002. Eskilstuna is the only terminal in Sweden that actually uses the term dry port in its official name – Eskilstuna Dryport – apparently giving it certain competitive advantages. Apart from transshipment, the terminal offers storage of containers and handling of dangerous goods. Nassjo, although only established at the end of 2004, already provides benefits for its customers/shippers, such as IKEA and Rusta, as it offers fast and effective import and export of their containerized cargo. Insjon terminal was established on a Green Cargo initiative – prior to the terminal implementation 30% of containers were transported by truck to Borlange terminal and then by train to Goteborg; the rest, 70%, were transported directly to the seaport by truck, however. With the establishment of the terminal, carbon dioxide emissions were reduced from approximately 3000 tones/year to 200 tones/year (X-Rail, 2002).

Karlstad-Vanerterminalen, located on the shores of Lake Vanern 277 km from Goteborg, offers the complete range of services that inland ports usually offer, such as customs clearance, storage of containers, handling of dangerous goods, etc. Amal-Varmdal is the most recent terminal, starting operations in January 2005 with plans to handle 2000 units and expectations of doubling this capacity. Before the implementation of the new terminal, Amal had an old road-rail terminal that handled about 2000 containers per year. However, it was situated next to the passenger terminal and due to safety reasons and low capacity had to be moved to another site. Together with Karlstad, it is the only terminal with access to inland waterways.

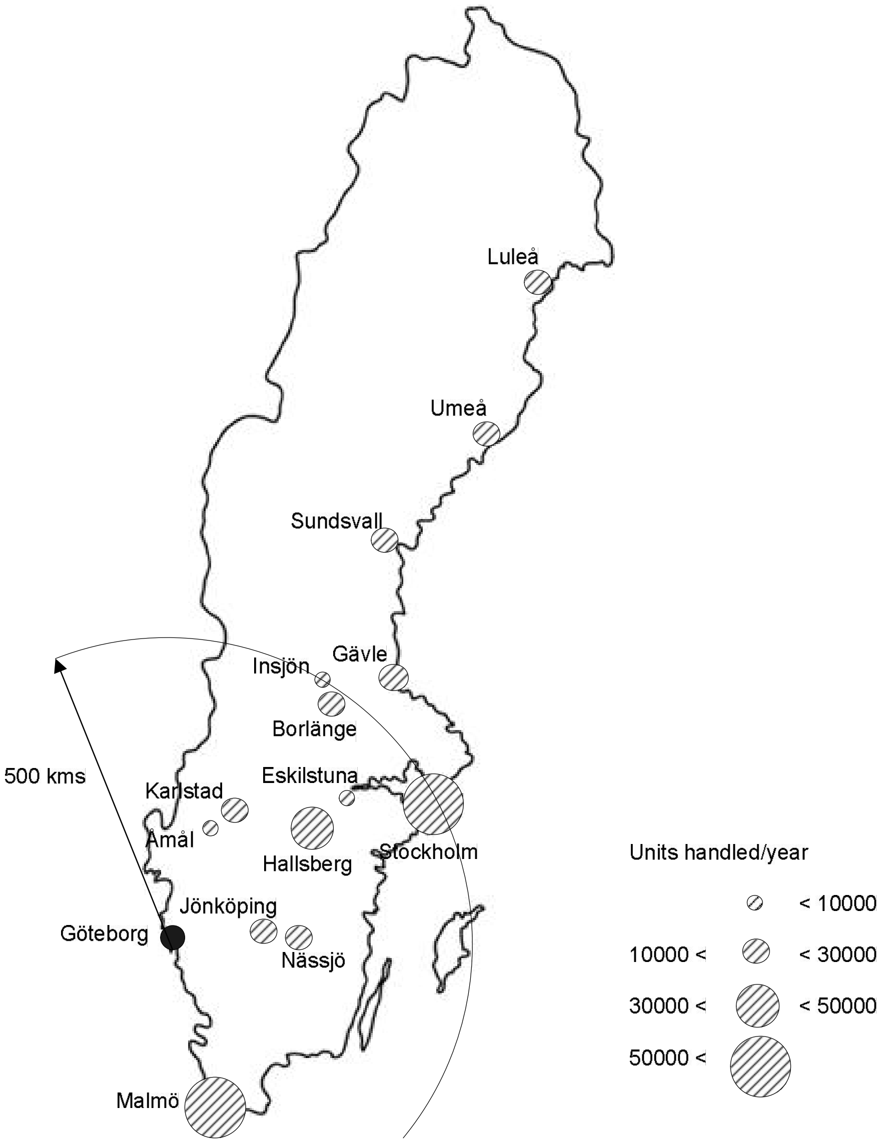


Figure 19. Inland intermodal terminals connected by rail to the Port of Goteborg

There is no certain pattern for the surveyed terminals' ownership. Nine of the surveyed terminals are owned either entirely by a municipality or jointly by a municipality and commercial actor of the system, such as rail operator or a shipper, see Table 2. Even within the same network of terminals, like CargoNet network, ownership differs. CargoNet terminals situated in the ports of Helsingborg, Norrköping and Trelleborg are owned and operated by the ports. Almhult is operated by CargoNet but owned jointly by CargoNet, the municipality and IKEA. On the other hand, their terminals in Gavle, Jonkoping, Malmo, Sundsvall and Umea are operated by CargoNet, the rail tracks are owned and maintained by Banverket, and the land is owned by Jernhusen which is owned by the Swedish State. It has been noticed that certain actors of the transport system, other than seaport, tend to create clusters of the actors and then the same influence implementation of terminals in area of their preference. Such a cluster influence has been noticed at Nassjo terminal where few shippers/customers in the area initiated the implementation since it was much more convenient for them to have a terminal in the vicinity than to use one in Jonkoping. In the case of Eskilstuna, attraction of one big customer in their region was the reason for the terminal implementation. In other words, the big shipper/customer has put a demand on Eskilstuna municipality to build a freight terminal with a rail connection to a seaport. Apart from bringing certain benefits for the shippers, terminals in Nassjo and Eskilstuna are also of interest for the region with the possibility for development of the region. However, the initiator of the terminal implementation is not necessarily the owner of the same. In the case of Almhult, the main shipper initiated the implementation of the terminal but the ownership is divided between the shipper, the municipality and the operator. In the case of Amal, the idea for the new terminal came from local politicians. They saw the implementation of a new, improved terminal as a possibility for development of the municipality; with better logistics services, new industries should be attracted and create new jobs.

Table 1 Road–rail terminals with a rail connection to the Port of Goteborg

| Terminal | Distance from the Port [km] | Population in the area | Rail transport frequency | Units handled per year | Terminal area [m2] |
|---|---|---|---|---|---|
| Borlange CT | 470 | 46 987 | 4 t/w | 12 000 | 16 000 |
| Eskilstuna Dry Port | 380 | 91 635 | 6 t/w | 5 000 | 9 000 |
| Gavle CT | 534 | 92 205 | 5 t/w | 22 000 | 40 000 |
| Hallsberg CT | 273 | 15 315 | 5 t/w | 45 000 | 34 000 |
| Helsingborg Port | 213 | 122 062 | 6 t/w | 63 000 | NA |
| Insjon | 480 | 4 000 | 4 t/w | 5 500 | 8 000 |
| Jonkoping CT | 211 | 120 965 | 5 t/w | 10 000 | 21 000 |
| Karlstad - Vanerterminalen | 277 | 82 096 | 5 t/w | 14 000 | 48 000 |
| Lulea CT | 1258 | 72 751 | NA | 19 000 | 38 500 |
| Malmo CT | 314 | 271 271 | 6 t/w | 56 000 | 84 000 |
| Norrkoping Port | 311 | 124 642 | 4 t/w | 16 000 | 157 000 |
| Nassjo | 249 | 29 314 | 5 t/w | 20 000 | 8 000 |
| Stockholm - Arsta CT | 472 | 771 038 | 6 t/w | 75 000 | 107 000 |
| Sundsvall CT | 756 | 94 044 | NA | 23 000 | 18 500 |
| Sodertalje Port | 417 | 80 553 | 5 t/w | 7 000 | NA |
| Umea CT | 988 | 110 758 | NA | 16 000 | 18 500 |
| Ahus Port | 279 | 9 000 | 1 t/w | 14 000 | 15 000 |
| Amal - Varmdal | 180 | 12 737 | 5 t/w | 2 000 | 1 200 |
| Almhult CT | 237 | 15 346 | NA | 20 000 | 43 000 |

Table 2 The terminals' owners and rail operators

| Terminal | Owners | Rail operator |
|---|---|---|
| Borlange CT | The Municipality | CargoNet |
| Eskilstuna Dry Port | The Municipality | ICS |
| Gavle CT | Banverket and Jernhusen | CargoNet |
| Hallsberg CT | The Municipality and Green Cargo | CargoNet, Euroshuttle |
| Helsingborg Port | The Port | ICS, CargoNet |
| Insjon | The Municipality, Bergkvist AB, Green Cargo | Green Cargo |
| Jonkoping CT | Banverket and Jernhusen | CargoNet |
| Karlstad - Vanerterminalen | Vanerhamn AB | Vanerexpressen AB |
| Lulea CT | Lulea CT AB | CargoNet |
| Malmo CT | Banverket and Jernhusen | CargoNet |
| Norrkoping Port | The Port | ICS, CargoNet |
| Nassjo | The Municipality | Green Cargo |
| Stockholm - Arsta CT | CargoNet, Banverket and Jernhusen | CargoNet |
| Sundsvall CT | Banverket and Jernhusen | CargoNet |
| Sodertalje Port | The Municipality | ICS |
| Umea CT | Banverket and Jernhusen | CargoNet |
| Ahus Port | The Municipality and private persons | BK Tag AB |
| Amal - Varmdal | The Municipality | Vanerexpressen AB |
| Almhult CT | The Municipality, CargoNet, IKEA | CargoNet |

## 5. Analysis – Categorization of the surveyed inland rail–road terminals

The following section offers an analysis of the surveyed terminals and is mainly qualitative. However, part of the analysis is based on the principles of Cluster Analysis and Trend Line. These two analyses are conducted considering the different characteristics of the terminals, such as distance to the seaport, quantity of units handled, terminal area, and area population.

According to Ballis and Golias (2002), road–rail terminals provide the space, equipment, and the operational environment for transferring intermodal transport units (ITUs) between the different traffic modes. Rail–road terminals consist of a wide range of installations, ranging from simple terminals providing transfer between two or three traffic modes, to more extensive centers providing a number of value-added services such as storage, depot, maintenance, repair, etc. Considering Ballis and Golias's definition, a majority of the terminals surveyed for this study can be described as simple intermodal terminals and some as simple dry ports, emphasizing the fact that they are connected to a seaport.

If analyzed only from the perspective of distance from the seaport, see Figure 19 and Figure 20, four of the terminals can be characterized as distant intermodal terminals, with distances from the seaport greater than 500 km, which is the distance above which intermodal (road–rail) transport is considered competitive to road transport (van Klink and van den Berg, 1998). These are Gavle, Sundsvall, Umea, and Lulea – all situated in their respective seaport cities. Stockholm-Arsta, located 470 km from the Port of Goteborg, handles substantial volumes and numerous shippers use the terminal, but only a small portion of the goods is destined for the Port of Goteborg. Therefore, if evaluated from a distance perspective as well as according to its purpose, Stockholm-Arsta would be categorized as midrange. Together with Arsta, the remainder of the terminals may be characterized as midrange due to their characteristics, according to Leveque and Roso (2001), as well as their distance from the seaport, which is less than 500 km. Nevertheless, the quantities of units handled per year differ greatly among the midrange terminals, from 2 000 units at Amal to 56 000 at Malmo. However, none of the surveyed terminals can be characterized as a close intermodal terminal, since even the nearest, Amal, is located 180 km from the seaport.

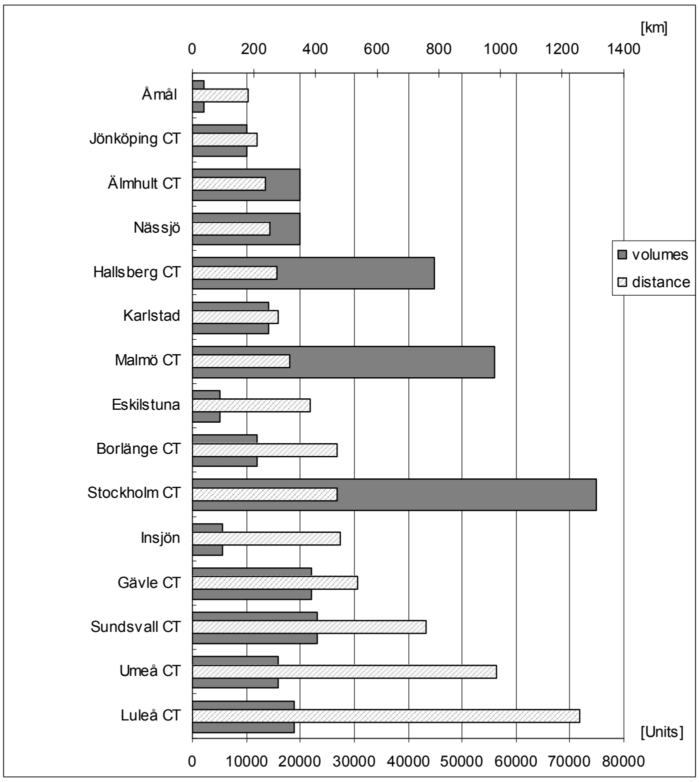


Figure 20. Inland road–rail terminals with volumes handled per year and distances to the port

Categorization of the terminals based only on volumes or types of goods handled is rather difficult, since both differ greatly between terminals, with no apparent pattern. In many cases the terminal operators had no knowledge of the types of goods transported in the containers. Moreover, the data regarding volumes handled at the terminals have a different reference year as well as different ways of presentation. However, with a certain amount of data modification, such as conversion of TEUs into units handled per year, which was based on information collected for certain terminals, analysis was possible.

The conclusion from Figure 21 would be the greater the volumes, the larger the terminal. The correlation factor of r=0.88, from Figure 21 where Eq. (1), for these data indicates that a larger terminal area generally goes with larger volumes. The volumes are dependent on the terminal area with no major deviations, see Eq. (2), and the closer this figure in Eq. (2) is to zero, the smaller the deviations from the trend line – with the exception of Hallsberg and Karlstad, marked as "A" and "B," respectively, on Figure 21.

$$r=\sqrt{R^2}, \quad (1)$$

$$1- R^2=0.22, \quad (2)$$

The explanation for the deviation for Hallsberg is that there is no need for long-term storage at this terminal since the majority of units are transported to warehouses in the vicinity. Karlstad, on the other hand, has a relatively large terminal even though it does not handle high volumes of containers; it does, however, handle high volumes of forestry and petroleum-based products which are not examined in this study.

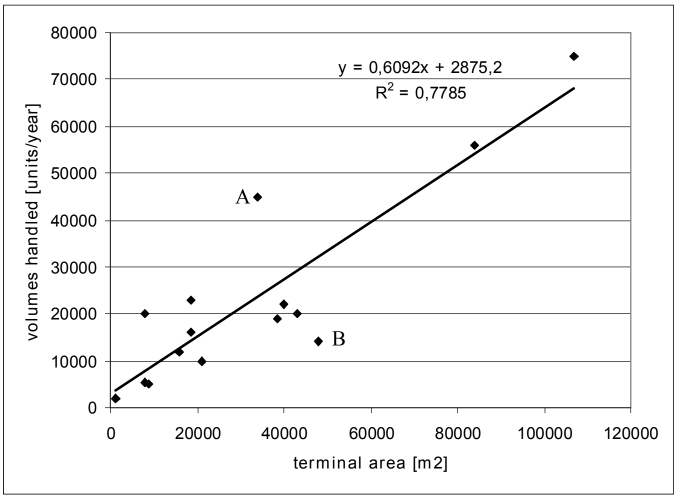


Figure 21. Diagram based on terminal area and volumes handled

The volumes of goods handled at the terminals are dependent on the area's population, see Figure 22, though with larger deviations than in the previous diagram with the terminal area since Eq.(3) from Figure 22 is higher than Eq. (2) from Figure 21.

$$1- R^2=0.37 \quad (3)$$

The volumes generally increase with the increase in population, but the data for Hallsberg and Malmo deviate from the common pattern – they are marked as "A" and "B," respectively, in Figure 22. Explanations for these deviations are that, although Hallsberg is a city with a small population, the terminal handles high volumes of goods that are intended for the region as a whole, whose population is about 275 000 (Statistiska Centralbyran, 2005), almost as high as Malmo. The terminal in Malmo handles far more units than would be expected, given the area's population; however a great majority of these volumes have final destinations in cities far from the Malmo area, such as Umea, Lulea, and Norrkoping, to name a few.

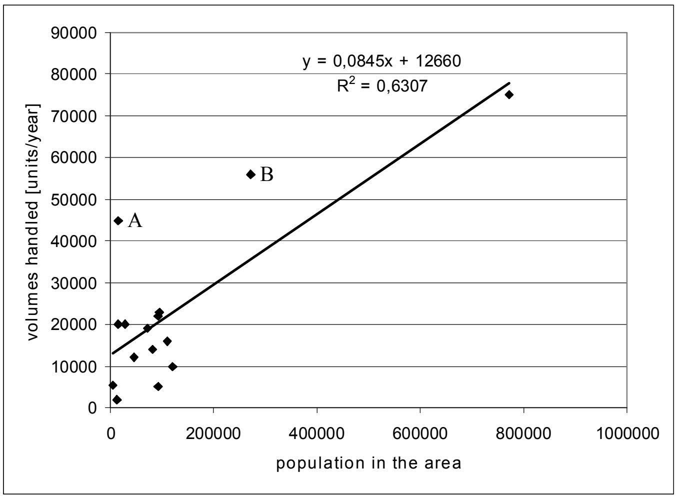


Figure 22. Diagram based on population in the area and volumes handled

Figure 23 shows clustering of terminals based on volumes handled and distances from the seaport. Two groups of terminals are identified, midrange (I) and distant (II). However, midrange terminals may be divided further into midrange terminals with low volumes (Ia), i.e., up to 20 000 units, and those with high volumes (Ib) above 20 000 units. This subdivision relates to the population of the area, as explained above.

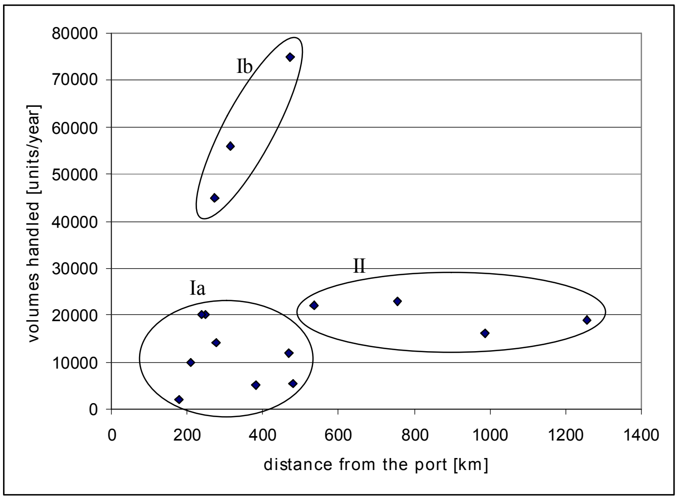


Figure 23. Diagram based on distance from the port and volumes handled

Considering the findings above on distances to the Port of Gothenburg as well as the characteristics of the surveyed terminals, only two terminals can be categorized as dry ports for the Port of Gothenburg: Stockholm-Arsta and Karlstad-Vanerteminalen. Karlstad-Vanerteminalen may be considered a midrange dry port for the Port of Gothenburg because of the distance from the seaport that can generally be covered by road, as well as the quantity of units handled at the terminal and destined for the seaport. The terminal also serves as a consolidation point for goods from different traffic modes and offers the full range of services that inland ports usually offer. Stockholm-Arsta may also be considered a midrange dry port since it is situated approximately 470 km from the Port of Gothenburg and offers the full range of services expected of a dry port. This terminal also serves as a consolidation point for different rail services.

## 6. Conclusion

There are few terminals in Sweden that can be categorized as dry ports. All the surveyed terminals do have a rail connection to the seaport, they handle containers, and offer transshipment services; however, these characteristics do not distinguish them from conventional intermodal terminals. Most can be described as simple road–rail terminals or, given their rail connection to the seaport, as simple dry ports. What would distinguish them from simple intermodal terminals and make them more advanced are extra services offered at the terminals and the quality of their rail access. Therefore, at present, only Stockholm-Arsta and Karlstad-Vanerteminalen may be categorized as dry ports. However, as described earlier, even without these extra services some of the surveyed terminals fulfill the role of a dry port for some actors in the transport system.

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# MARITIME RELATED LOGISTICS SERVICES AND DEVELOPMENTS IN THE PORT INDUSTRY: PORT OF IZMIR CASE

Öznur Yurt[1], I. Özge Yumurtacı[2] and Funda Yercan[3]

## Abstract

*Logistics services have been used to control the flow of goods, services and information in and between plants and distribution networks strategically and in best ways. Therefore, the logistics concept could be regarded as a management and an operational strategy aiming to optimize the quality and the total cost of products by also considering the real time factor. In addition, specialized logistics services and supply chain management provide links between local areas and cities, and the national markets as well as the international markets. These services secure the integration of local production into global services and distribution chains.*

*One of the ways to reflect a company's competitiveness in the market is measured by its capacity in delivering goods of high quality on time. In this respect, availability and costs of transport facilities play an important role. Therefore, transportation infrastructure has been one of the key elements in reaching the targets both in regional development and economic growth as well as in international trade.*

*This study concentrates upon the developments of maritime transport related logistics services. The role of the port industry within the maritime sector is analyzed, in particular, to give a broad idea of the developments as this industry having a crucial role in international transport services. Thus, developments at sea ports are reviewed in more details in this study as they are the major operational nodes and service providing centers in the transport industry within the logistics centers in supply chains. As a result, major developments at the Port of Izmir on the west coast of Turkey are analyzed more specifically by also considering developments in the maritime related logistics services in the region.*

Keywords: Logistics, supply chain, maritime transport.

## 1. Introduction

The development of logistics sector is dependent to the improvements in various logistics functions such as warehousing, transportation, inventory management, demand forecasting, procurement, packaging and order processing. Transportation is one of the most important issues in logistics concept. Although transportation is basically defined as transferring the products from where they are produced to where they are needed, the function of transportation embraces more than its definition. Transportation adds value to the product by place and time utility and plays a critical role on time delivery (Lambert, Stock, Ellram 1998).

Different modes of transport are used while sea transport being the most commonly used transport mode in international trade (Lambert, Stock, Ellram 1998; Murphy Jr, Wood, 2004; Leenders, Johnson, Flynn, Fearon, 2006). There are numerous reasons why sea transport is preferred. Although geographical conditions play vital roles in sea transport, the low cost characteristics of this transport mode, especially in far shipping, brings more importance.

Seaports are the main determinants of seaway effectiveness. Efficient maritime activities can be accomplished by only with the help of developed ports. A port has to have many properties to be called as a 'developed' port. In this study, general overview of the conditions and the factors, which are relevant to development of ports, are examined. In addition, the situation of the Port of Izmir is analyzed according to the model that was proposed during UNCTAD (United Nations Conference on Trade and Development) in 1992. The model basically emphasizes on the port development and improvement. This study aims to emphasize the current situation of the Port of Izmir and how its future potential can be used in order to have more efficiency in logistics activities.

## 2. Ports as the Logistics Centers

There is a common recognition that the ports are the potential logistics centers. Dramatic changes in the market, in which the seaports operate, have lead to changes in the logistics activities that are carried out at ports (Bichou and Gray, 2004). The core aim of the effective logistics management is to achieve competitive advantage for each unit of the supply chain through the cost reduction and accordingly the customer satisfaction. Effective flow of materials, services and information in the supply chain based on the value that is created by the synchronization of the various logistics functions such as transportation, materials handling, warehousing, demand forecasting (Lambert et al.,

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1998). Therefore the logistics centers, nodal points of the supply chain, play important role for the effective flow and harmonization of different logistics activities in the supply chain.

The system approach and supply chain integration lead to the instantaneous need for changes in traditional port management. The outcomes of effective supply chain management such as information sharing, synergy, coordination and cooperation between the units directly related to the successful management of the logistics activities (Christopher, 1998) at the logistics centers such as the ports. Therefore, the port system and management affect the effectiveness of the logistics activities that are held on. However, the logistics and supply chain management perspective forces the ports to change. Changing logistics approach leads to changes for "the actors in transport chain that is shipping lines, forwarders, terminal operators, road haulers, rail operators, and barge operators" as well as for the potential logistics centers such as ports. The changing requirements of logistics and supply chain management force the seaports to become "customer led that is focused on the customer needs and can offer best-in class performance" (Notteboom and Winkelmans, 2001).

## 3. Logistics Services, the Maritime Sector and the Port Industry in Turkey

The logistics activities in Turkey have recently improved due to recent developments that are based on the country's strategic and geopolitical positioning. The transport function of logistics has been provided throughout maritime, land, pipeline and air related logistics services.

All modes of transport – land, sea, air, rail and pipeline, are used in Turkey for a variety of different commodities. The majority of domestic transport activity is conducted by land transport because the country is situated on a wide land mass. The construction of a railway network commenced during the beginning of this century and has been rapidly widened to give access to large parts of the country. However, railways could not develop in all regions because of the high investment costs, mountainous and geographic structure of this sizeable country. Air transport is a rapidly developing transport mode in Turkey with considerable increases during high seasons both in domestic and international lines. The airline service providers have been both state owned and private companies[1]. Pipeline transport is used in Turkey to transport oil either from different countries or domestically.

Inland water transport is limited compared to that in many European countries. The main reason for the undeveloped character of inland waterway transport stems from the variable flow capacity of rivers, which makes transport difficult particularly during warmer seasons. The majority of the foreign trade of Turkey is carried by seaborne transport. The major ports that are used for intermodal transport are the Port of Izmir, and Haydarpaşa Istanbul. Most of the secondary ports as well as these major ports are linked by roads to main highways and airports, and by railways to their hinterlands (Yercan and Roe, 1999).

In 2005, foreign trade of Turkey was more than 189 Billion US Dollars[2]. The global competition all over the world requires a logistical infrastructure, which leads effective management of logistics functions. The role of maritime in movement function of logistics plays a vital role in this global competition. It is clear that the improvement of maritime activities directly affect the other related sectors. When the discussion point is maritime sector in a country, the first idea that comes upon to mind is that the condition and capacity of the ports that the country operates. In this context, Turkey's geographical position plays an important role. Turkey is surrounded by the Aegean Sea, Mediterranean Sea and Black Sea. Due to this position, maritime trade sector has developed rapidly. Table 1 illustrates data on the inputs of maritime trade sector.

There are approximately 100 ports in Turkey. Only 7 of the ports in Turkey are operated by a state owned organization - Turkish State Railways (TCDD), whereas 24 of them are operated by TURKLIM (Port Operators Association of Turkey) and by other organizations. Table 2 illustrates the list of the Turkish Ports in details.

Table 1: Inputs of Maritime Trade Sector in Turkey (in million dollars )

| | 2002 | 2005 |
|---|---|---|
| Transportation | 3.000 | 4.500 |
| Port operations and management | 2.050 | 2.500 |
| Ship construction | 300 | 1.100 |
| Maritime Tourism | 2.000 | 3.500 |
| Marine resources | 500 | 600 |
| Bunkers | 700 | 1.500 |
| Total | 8.550 | 13.850 |

Source: Türklim Port Operators Association of Turkey, cited in Transport and Logistics World Catalogue, 2005 p. 54.

[1] http://www.ubak.gov.tr/dokumanlar/uukap.pdf
[2] http://www.tuik.gov.tr/PreIstatistikTablo.do?istabid=508

Table 2: Ports in Turkey

| |
|---|
| Ports in Black Sea Region<br>Hopa, Rize, Trabzon, Giresun, Ordu, Samsun, Samsun Tügsas, Zonguldak, K.Eregli, Erdemir, Bartin |
| Ports in Marmara Region |
| Haydarpasa, Cubuklu Petrol Ofisi, Zeytinburnu TCDD,<br>Ambarli Kumport, Ambarli Shipowners(Armaport), Ambarli Mardas, Ambarli Soyak, Ambarli Total, Terminals at Haramidere, Maltepe TCDD Pier, Cayirovasi Glass Factory, Gemlik Ports, Gemlik Municipal, Gemport, Bortrans Borusan, Gemlik Azot Tügsas, Gemlik MKS (Marmara Chemicals), Gemlik BP, Mudanya, Bandirma, Bandirma Bagfas, Edincik Etibank, Tekirdag Akport, Tekirdag Silo, Botas LNG Terminal, Martas, Canakkale Municipality, Canakkale Cement (Akcansa) |
| Ports in Izmit Bay<br>Bay of Izmit, Aslan Cement (Lafarge), Diliskelesi Piers, Poliport (Polisan & Izmir Chemical), Colakoglu, Sedef, Alemdar, Altintel, Solventas, Kizilkaya, Total Gebze, Tavsancil Asphalt Plant, Diler-Ok, Nuh Cement, Gübretas Fertilizer, Molasses (Zülfikar), Rota & Körfez Municipality, Yarimca Piers, Petkim(Yarpet), Aygaz, Igsas Fertilizer, Tüpras Refinery, Camar, Derince Port, Rafine Chemical Plant, Terminals at Derince, Petrol Ofisi, Shell, Koruma, Transtürk, Seka, Limas/Pürsan/UM, Yalova Elyaf, Aksa (Akkum) |
| Ports in the Aegean Region<br>Dikili, Güllük, Nemrut Bay, Aliaga Total Terminal, Aliaga Petkim Terminal, Aliaga Tupras, Habas, Cukurova, Limas, Nemtas, Ege Fertilizer, Izmir, Kusadasi, SEKA Göcek Fethiye<br>Ports in Mediterrenean Region<br>Antalya, Mersin, Mersin Tasucu, Mersin Seka, Iskenderun Bay, Iskenderun Port, Sariseki Fertilizer, Toros Fertilizer, Ekinciler, Yazici, Isdemir, Delta Terminal, Botas Oil |

Source: http://www.wowturkey.com/forum/viewtopic.php?t=14053

The seven ports under the control of Turkish State Railways are the most strategic ones in terms of trade volume and container handling. Table 3 illustrates the total amount of dry cargo/ general cargo handling. In addition, Table 4 illustrates the total amount of container handling at major ports, which are operated by Turkish State Railways. As it is seen in Table 3 and Table 4, Port of Izmir has a strategic role amongst the other ports in Turkey.

Table 3: Total Amount of Dry Cargo / General Cargo Handling at Ports in Turkey (2003/ 2004) (in tons)

| Operator | Name of the Port | 2003 | % | 2004 | % | Increase according to 2003 |
|---|---|---|---|---|---|---|
| MARLIM | Diler | 3.091.508 | | 3.503.408 | | |
| | Altınel | 444.357 | | 512.310 | | |
| | Sedefport | 509.216 | | 499.233 | | |
| | Akçansa | 785.512 | | 3.471.871 | | |
| | Borusan Log. | 1.689.649 | | 2.027.140 | | |
| | Rota | 931.500 | | 939.953 | | |
| | Poliport | 1.499.240 | | 1.244.469 | | |
| | Kızılkaya | 1.376.297 | | 1.376.126 | | |
| | Kumport | 413.659 | | 660.120 | | |
| | Kroman | 1.487.000 | | 1.550.600 | | |
| | Mardaş | 2.644.264 | | 2.551.270 | | |
| | Martaş | 1.880.101 | | 1.738.350 | | |
| | Toros Gübre | 2.702.919 | | 2.713.313 | | |
| | Soyakport | 313.202 | | 0 | | |
| | Limaş | 208.920 | | 460.048 | | |
| | İçdaş | 1.190.000 | | 2.117.369 | | |
| | Ege Gübre | 697.000 | | 1.610.033 | | |
| | Gemport | 469.890 | | 630.997 | | |
| | Total | 22.334.234 | 53,35% | 27.606.610 | 45,12% | 23,61% |
| TCDD | Samsun | 2.746.500 | | 3.074.894 | | |
| | Haydarpaşa | 3.219.260 | | 3.328.936 | | |
| | Derince | 1.368.823 | | 1.890.890 | | |
| | Bandırma | 2.559.669 | | 3.059.226 | | |
| | İzmir | 4.379.941 | | 4.620.703 | | |
| | Mersin | 4.231.028 | | 3.744.300 | | |
| | İskenderun | 1.026.179 | | 803.733 | | |
| | Total | 19.531.400 | 46,65% | 20.522.682 | 33,54% | 5,08% |
| Others | Akport | 1.363.841 | | | | |
| | Ortadoğu Antalya | | | 1.226.551 | | |
| | İsdemir | | | 6.134.515 | | |
| | Yazıcı | | | 2.528.439 | | |
| | Ekinciler | | | 1.242.056 | | |
| | Sarıseki | | | 561.388 | | |
| | Total | 1.363.841 | 0,00 % | 13.056.790 | 21,34% | |
| | Aggregate Total | 41.865.634 | 100,00% | 61.186.082 | 100,00% | |

Source: TURKLIM Port Operators Association of Turkey cited in, Transport and Logistics World Catalogue, 2005, p.55.

Table 4: Total Amount of Containerization at Ports in Turkey (between 2001-2006) (in TEU)

| | | CONTAINER TRAFFIC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (LOADING) | | | | (UNLOADING) | | | | | |
| PORTS | YEARS | 20 | | 40 | | 20 | | 40 | | TOTAL UNIT | TEU |
| | | FULL | EMPTY | FULL | EMPTY | FULL | EMPTY | FULL | EMPTY | | |
| HAYDARPAŞA | 2000 | 28.306 | 19.359 | 31.252 | 17.935 | 49.049 | 3.102 | 47.389 | 2.631 | 199.023 | 298.230 |
| | 2001 | 26.838 | 6.754 | 35.635 | 4.058 | 30.121 | 4.771 | 25.359 | 12.978 | 146.514 | 224.544 |
| | 2002 | 24.290 | 11.381 | 32.278 | 6.113 | 36.826 | 2.657 | 28.868 | 7.485 | 149.898 | 224.642 |
| | 2003 | 27.334 | 10.916 | 30.442 | 9.045 | 37.026 | 3.915 | 37.276 | 5.875 | 161.829 | 244.467 |
| | 2004 | 26.952 | 19.146 | 33.810 | 19.824 | 49.461 | 2.293 | 52.865 | 3.066 | 207.417 | 316.982 |
| | 2005 | 31.785 | 21.380 | 36.165 | 19.786 | 56.422 | 2.726 | 53.928 | 4.279 | 226.471 | 340.629 |
| | 2006 | 17.228 | 23.032 | 21.841 | 22.437 | 45.625 | 488 | 46.874 | 716 | 178.241 | 270.109 |
| MERSİN | 2000 | 31.874 | 10.185 | 34.231 | 17.668 | 35.108 | 11.245 | 47.520 | 6.063 | 193.894 | 299.376 |
| | 2001 | 36.889 | 4.619 | 38.970 | 9.175 | 26.512 | 19.778 | 38.275 | 14.858 | 189.076 | 290.354 |
| | 2002 | 46.681 | 6.278 | 45.564 | 15.851 | 33.659 | 21.494 | 54.437 | 12.052 | 236.016 | 363.920 |
| | 2003 | 62.213 | 7.836 | 55.865 | 24.588 | 39.592 | 30.958 | 67.176 | 15.627 | 303.855 | 467.111 |
| | 2004 | 68.862 | 3.515 | 66.053 | 28.365 | 39.676 | 33.074 | 85.409 | 14.109 | 339.063 | 532.999 |
| | 2005 | 79.936 | 5.470 | 67.712 | 38.775 | 50.868 | 35.729 | 94.295 | 11.361 | 384.146 | 596.289 |
| | 2006 | 59.490 | 4.958 | 46.263 | 22.624 | 37.390 | 28.900 | 64.137 | 8.005 | 271.767 | 412.796 |
| İSKENDERUN | 2000 | 0 | 0 | 0 | 80 | 34 | 0 | 260 | 0 | 374 | 714 |
| | 2001 | 1 | 0 | 0 | 0 | 9 | 0 | 9 | 1 | 20 | 30 |
| | 2002 | 0 | 0 | 0 | 0 | 6 | 0 | 12 | 1 | 19 | 32 |
| | 2003 | 1.036 | 0 | 0 | 0 | 593 | 0 | 58 | 0 | 1.687 | 1.745 |
| | 2004 | 138 | 0 | 16 | 0 | 207 | 0 | 115 | 0 | 476 | 607 |
| | 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2006 | 26 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 52 | 52 |
| SAMSUN | 2000 | 0 | 0 | 0 | 405 | 0 | 0 | 507 | 0 | 912 | 1.824 |
| | 2001 | 11 | 0 | 0 | 107 | 50 | 0 | 564 | 0 | 732 | 1.403 |
| | 2002 | 0 | 0 | 78 | 23 | 34 | 0 | 69 | 0 | 204 | 374 |
| | 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DERİNCE | 2000 | 495 | 161 | 4 | 66 | 210 | 26 | 79 | 2 | 1.043 | 1.194 |
| | 2001 | 3 | 61 | 6 | 52 | 199 | 22 | 143 | 0 | 486 | 687 |
| | 2002 | 225 | 21 | 34 | 4 | 120 | 0 | 100 | 1 | 505 | 687 |
| | 2003 | 253 | 30 | 432 | 52 | 392 | 7 | 140 | 3 | 1.309 | 1.936 |
| | 2004 | 201 | 3 | 296 | 65 | 161 | 0 | 187 | 24 | 937 | 1.509 |
| | 2005 | 71 | 0 | 89 | 0 | 123 | 0 | 88 | 1 | 372 | 550 |
| | 2006 | 31 | 26 | 15 | 18 | 140 | 13 | 76 | 18 | 337 | 464 |
| BANDIRMA | 2000 | 130 | 429 | 24 | 35 | 405 | 103 | 101 | 15 | 1.242 | 1.417 |
| | 2001 | 137 | 356 | 27 | 35 | 342 | 77 | 37 | 0 | 1.011 | 1.110 |
| | 2002 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 4 |
| | 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2004 | 0 | 0 | 9 | 0 | 0 | 0 | 9 | 0 | 18 | 36 |
| | 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| İZMİR | 2000 | 93.749 | 5.348 | 63.424 | 7.678 | 29.090 | 58.479 | 42.932 | 27.921 | 328.621 | 470.576 |
| | 2001 | 101.409 | 4.573 | 70.728 | 3.176 | 24.498 | 72.693 | 32.242 | 37.956 | 347.275 | 491.377 |
| | 2002 | 114.177 | 4.962 | 85.855 | 3.476 | 32.997 | 74.469 | 40.497 | 43.475 | 399.908 | 573.211 |
| | 2003 | 130.341 | 4.625 | 104.417 | 4.728 | 38.577 | 92.790 | 51.983 | 56.103 | 483.564 | 700.795 |
| | 2004 | 147.126 | 12.099 | 112.933 | 8.901 | 53.966 | 104.640 | 66.816 | 54.716 | 561.197 | 804.563 |
| | 2005 | 152.624 | 3.358 | 111.466 | 8.605 | 49.861 | 104.216 | 66.759 | 50.329 | 547.218 | 784.377 |
| | 2006 | 99.946 | 4.844 | 78.824 | 5.181 | 38.731 | 65.368 | 49.647 | 35.280 | 377.821 | 546.753 |
| TOTAL | 2000 | 154.554 | 35.482 | 128.935 | 43.867 | 113.896 | 72.955 | 138.788 | 36.632 | 725.109 | 1.073.331 |
| | 2001 | 165.288 | 16.363 | 145.366 | 16.603 | 81.731 | 97.341 | 96.629 | 65.793 | 685.114 | 1.009.505 |
| | 2002 | 185.373 | 22.642 | 163.809 | 25.469 | 103.642 | 98.620 | 123.983 | 63.014 | 786.552 | 1.162.870 |
| | 2003 | 221.177 | 23.407 | 191.156 | 38.413 | 116.180 | 127.670 | 156.633 | 77.608 | 952.244 | 1.416.054 |
| | 2004 | 243.279 | 34.763 | 213.117 | 57.155 | 143.471 | 140.007 | 205.401 | 71.915 | 1.109.108 | 1.656.696 |
| | 2005 | 264.416 | 30.208 | 215.432 | 67.166 | 157.274 | 142.671 | 215.070 | 65.970 | 1.158.207 | 1.721.845 |
| | 2006 | 176.721 | 32.860 | 146.943 | 50.260 | 121.912 | 94.769 | 160.734 | 44.019 | 828.218 | 1.230.174 |

Note: As of the end of August 2006
Source: http: // www. tcdd.gov.tr/liman/konteyner.htm

## 4. Port of Izmir

### 4.1. Port Characteristics

Port of Izmir, which was built in 1954, has been owned and operated by the Turkish State Railways (TCDD). The Port has been one of the major container ports in Turkey. The Port is currently under privatization actions. The port's berthing capacity is 3650 vessels per year. Table illustrates the recent statistics for the Port of Izmir.

Table 5: Statistics for the Port of Izmir

| | 2001 | 2002 |
|---|---|---|
| Container handled(TEU) | 491.277 | 573.231 |
| Number of vessels berthing | 2574 | 2645 |
| Number of container vessels berthing | 1566 | 1672 |
| Total number of equipment (including gentry cranes, side loaders, berth cranes, transtainers, forklift, mobile cranes etc.) | 255 | 255 |

Source: Chamber of Shipping, Izmir Branch; Logistics and International Shipping cited in Bates et al., 2004

Location: City of Izmir is situated in the western coast by the Aegean Sea . Izmir is the third largely populated city of Turkey and it is a business center as it was in the past. The port has a huge agricultural and industrial hinterland. It is the port for the Aegean Region's industry and agriculture and it plays a vital function in the country's exports. All different types of commodities and cargo groups are handled in the port and port expansion studies are still being continued in the view of privatization process. The port is also connected with state railway and highway network.

Pilotage: is compulsory for vessels entering or leaving the port. Pilotage and towage services are provided by the Turkish Maritime Organization (TDI) round the clock.

Sea Crafts: comprise one floating crane of 90 tons capacity and 1 mooring boat

Handling Equipment: Operations at the quays are carried out by 5 gantry cranes of 40 tons capacity. The operations at the container yard are carried out by 19 rubber tired transtainers and 20 reach stackers of 25 to 42 tons capacity together with 20 empty container forklifts of 8 to 10 tons capacity. 7 shore and yard cranes of 3 to 25 tons, 12 mobile cranes of 5 to 25 tons capacity and 20 small masted forklifts are also available. Reefer facilities for refrigerated containers are also available. The capacity of container washing facility is 20 TED per day. The equipments that are being used at Port of Izmir are shown in Table 6.

Table 6: Equipments of the Port of Izmir

| Cranes | Forklifts | Other Equipment |
|---|---|---|
| 5 gantry cranes with the capacity of 40 tons | 23 container forklift with the capacity of 10-12 tons | 20 reach stackers with the capacity of 25-42 tons |
| 7 berth cranes with the capacity of 3-10 tons | 30 general cargo forklift with the capacity of 1-5-5 tons | 19 transtainers with the capacity of 40 tons |
| 12 mobile cranes with the capacity of 6-25 tons | | 34 side movers with the capacity of 25-50 tons |
| | | 31 trailers with the capacity of 15-40 tons |

Source: http://www.tcdd.gov.tr/Liman_Izmir.htm; TCDD Ports, 2002 and Annual UTA Turkey-Ports, 2002 cited in Bates et al,2004

3rd Party Handling Equipment: 2 MHC of 100 tons capacity.

Bulk Cargo Facilities: Two reinforced concrete grain silos belonging to TMO (Turkish Grain Board) of having a total 70.000 tons capacity are available and there is a conveyor system connection with the quay.

Passenger Facilities: Because Izmir is very close to the tourism and historical places on the Aegean coast, the port has substantial passenger traffic, especially in the summer season[1].

[1] http://www.tcdd.gov.tr/tcdding/izmir_ing.htm

## 4.2. Privatization Actions at the Port of Izmir

Similar to many governments in today's world, privatization has been a key policy element and was adapted in Turkey after rapid progress in many industries and economic liberalization policies after 1980s. The Government adopted a privatization policy as a major tool to reduce the role of the public sector. Main considerations have been the need for improved services and projects to be managed better by the private sector. The privatization action of state owned institutions is largely based on Law no.4046 dated 24.11.1994 and Law no.4105 dated 02.05.1995. The major objective of these laws is to privatize the institutions thus increasing productivity, efficient use of resources and current capacity, increasing competitiveness in international and domestic markets, increasing contribution to the regional and national economy and reducing the continuous increase in the costs and heavy administrative loads of state institution (Demirbas, 2000; Yercan and Yeni, 2001).

One of the recently developments in the logistics area is the "motorways of the sea''. The aim of the concept is to develop the new inter-modal maritime- based logistics chains in Europe. Thus, it will enable a strategic change in transport organization in Turkey within the future[1].

The policy for the privatization program adopted in Turkey mainly concentrates upon the idea of leasing the assets of a port to a private company under a long-term agreement, where land and basic infrastructure are owned by the state institution. The privatization action commonly covers the leasing of the operation for 30 years and fully transferring the operation to a private company after the completion of this period; however, this does not involve the transfer of the ownership of land (Yercan and Yeni, 2001). Based on above-mentioned reasons, privatization of the Port of Izmir has been on the agenda of the public and other governmental authorities. Privatization of Izmir Port will also enable the port to have some more new technology. Privatization process of 6 Turkish State Railways (TCDD) ports (Mersin–İskenderun–İzmir–Bandırma–Derince–Samsun) started on August 2005. Privatization of Mersin & İskenderun ports are completed. Port of Izmir would have been privatized on 7th of June 2006 but the date for submission of bids was extended until September 21st of 2006. The Turkish Government has been decisive to finish three other ports at the earliest[2].

## 5. Port Development Model of UNCTAD

During the United Nations Conference on Trade and Development (UNCTAD), it was appreciated that port activities are tended to be change radically (Beresford et al, 2004). It is also recognized that the new roles of the ports and the main reasons of the port development should be investigated to determine the ways to transform the ports to "logistics service centers". A conceptual model (UNCTAD Model) was proposed in 1992 which characterized ports as belonging to one of the "three generations". The categorization criteria are; "port development policy, strategy and attitude, the scope and extension of port activities, and the integration of port activities and organization (Beresford et al, 2004). Table 7 illustrates the main characteristics of three generations which were seen to exist respectively in the pre-1960's, post 1960's and post 1980's. However, the proposed model does not allow for some critical factors such as; the port size, geographical location or the extent of public/private sector involvement. This paper accepts the model as a framework for the port development evaluation and also concentrates on the aforementioned factors.

## 6. Application of UNCTAD's Three-Generation Port Model to the Port of Izmir

Although the increasing trend of foreign trade in the recent years in Turkey[3] promising the problems of Turkish Ports is still affecting the foreign trade in a negative way The situation of Port of Izmir is a typical example. The main problems about the Port of Izmir are (Bates et al, 2004, Yercan and Yeni 2001, and…[4]):

-inadequate capacity,
-physical inadequacy,
-the lack of qualified personnel,
-the lack of dredging related equipment,
-port services are provide by many different agencies,
-lack of computerized system,
-draft problems,
-the complexity and inadequacy of legal regulations related to port services,
-marketing problems,
-port positioning problems,
-lack of storage area in terms of volume in TEU in comparison to other ports of TCDD
-infrastructure problems,
- large ships can not come alongside the port (depth problems),
-lack of efficiency within the management role of the state agency ,

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[1] http://www.unece.org/trans/doc/2006/wp5/ECE-TRANS-WP5-2006-07a2e.doc
[2] http://www.unece.org/trans/doc/2006/wp5/ECE-TRANS-WP5-2006-07a2e.doc
[3] http://www.tuik.gov.tr/PreIstatistikTablo.do?istabid=508
[4] http://www.eclac.cl/transporte/perfil/iame_papers/proceedings/Akarsu_et_al.doc

-cost of service provided at the Port of Izmir is higher than the cost of service that is provided by other ports in Aegean Region,

-although the road transport is combined with the maritime transport by the Port of Izmir, the entry of trucks to the city is prohibited after 6 o'clock on workdays and during the entire weekend,

-lack of information sharing and information flow between ship operator's agencies and the Port Authority.

Table 7: UNCTAD Three-Generation Port Model (Beresford et al 2004 )

| Period of the Development | First Generation | Second Generation | Third Generation |
|---|---|---|---|
| | Before 1960's | After 1960's | After 1980's |
| Main Cargo | -Break bulk cargo | -Break bulk and dry/liquid bulk cargo | -Bulk and unitized containerized cargo |
| Attitude and strategy of port development | -Conservative<br>-Changing point of transport node | -Expansionist<br>-Transport, industrial and commercial center | -Commercially oriented<br>-Integrated transport center/logistics platform for international trade |
| Scope of activities | -Cargo loading, discharging, storage, navigational service<br>-Quay and waterfront area | -Cargo loading, discharging, storage, navigational service<br>-Cargo transformation; ship-related industrial and commercial services<br>-Enlarged port area | -Cargo loading, discharging, storage, navigational service<br>-Cargo transformation; ship-related industrial and commercial services<br>-Cargo and information distribution; logistics activities<br>-Terminals and distribelt towards landside |
| Organization characteristics | -Independent activities within port<br>-Informal relationship between port and port users | -Closer relationship between port and port users<br>-Loose relationship between activities in port<br>-Casual relationship between port and municipality | -United port community<br>-Integration of port with trade and transport chain<br>-Close relationship between port and municipality<br>-Enlarged port organization |
| Production characteristics | -Cargo flow<br>-Simple individual service<br>-Low value added | -Cargo flow<br>-Cargo transformation<br>-Combined services<br>-Improved value added | -Cargo/information flow<br>-Cargo/information distribution<br>-Multiple-service package<br>-High value added |
| Decisive factors | Labor/capital | Capital | Technology/know-how |

Although there have been some problems regarding logistics activities at the Port of Izmir, currently existing general characteristics of the port based on UNCTAD Three-Generation Model are summarized as below in Table 8. As also seen in the Table, it is illustrated that Port of Izmir is displayed as modern type of a port related to the up-to-date activities and services however because of some logistics and operational characteristics of port it is positioned under the other generations.

Table 8: General Characteristics of the Port of Izmir based on UNCTAD Three-Generation Model

| Period of the Development | Second Generation | Third Generation |
|---|---|---|
| | After 1960's | After 1980's |
| Main Cargo | | -Dry bulk cargo / General cargo / containerized cargo |
| Attitude and strategy of port development | | -Commercially oriented<br>-Integrated with industrial trade and free zones<br>-Integrated transport centre<br>- Logistics centre for international trade |
| Scope of activities | | -Cargo loading, discharging, storage, navigational service<br>-Cargo transformation; ship-related industrial |

| | | |
|---|---|---|
| | | and commercial services<br>-Cargo and information distribution; logistics activities<br>-Terminals and distribution lines towards landside<br>-Integrated with industrial free zones |
| Organization characteristics | -Closer relationship based on personal contacts between port and port users | -Integration of port with trade and transport chain |
| Production characteristics | -Combined services<br>-Improved value added | -Cargo/information flow<br>-Cargo/information distribution |
| Decisive factors | Capital | Technology/know-how |

## 7. Conclusion

Logistics activities play an important role to control the flow of goods, services and information within different elements of the supply chain. Therefore, the logistics concept could be regarded as a management and an operational strategy aiming to optimize the quality and the total cost of products by also considering the real time factor. All modes of transport are used in Turkey and much of this transport activity is based upon the country's geographical and strategic situation. The development of further inter-modal transport services for the distribution of goods will undoubtedly continue to occur with the continuing dynamism of the region.

As a result, the maritime sector has rapidly developed as one of the leading industries in Turkey. The development stems from the improvement of foreign trade after the liberalization policy in the economic reform the beginning of 1980s. In addition, dynamism within the private sector has also helped the development of the industry. Rapid development within the maritime industry in general has occurred particularly in the shipping industry, including the ports sector as well. Consequently, maritime related logistics activities and services in Turkey have rapidly been improving and continue to be crucial and important contributor to the country's economy at present. In this regard, the privatization process of Port of Izmir and related consequences in maritime industry lead to a great improvement in foreign trade of Turkey. This study can be extended after Port of Izmir is privatized.

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# SHIFTING CONCEPT OF PORT AND HINTERLAND: THE CASE OF MERSİN PORT

Senay OĞUZTİMUR[1]

## Abstract

*The most effected mode is maritime transport of which has been growing up within the increase of global trade amount and quantity. Ports are required increasingly role in transportation economy. The affects of ports have always been an increasing issue for regional economics. However the definitions of both region and hinterland have been modified because of the developments in the transportation technology. The borders of regions and hinterlands may go beyond national boundaries due to globalization. Although there is long distance between two (or more) ports, they would compete for common hinterland or more than one hinterland would be served by one port. Yet a simple question remains: How does a port affect its immediate region within national boundaries?*

*This paper is composed of two main parts. The first part focuses on ports, shifting concept of hinterland, containerization and multimodal transportation. The second part is consists of Mersin Port which will be evaluated according to recent concept of hinterland and regional economy. Physical abilities, free trade zones, intermodal transportation facilities and existing order in port hierarchy will be compared.*

Key words: Hinterland, Regional Economy, Combined Transportation

## 1. Literature Survey

### 1.1. Historical Evolution and Concept of Ports

Ports are a component of freight distribution as they offer a maritime/land interface for export and import activities. They are points of convergence of inland and coastal transportation systems, defining a port's hinterland. This function may be direct, as freight reaches a port directly through road transportation, or indirect as freight reaches a port though a freight distribution center or through traffic being consolidated at a regional port and shipped by coastal transportation. Likewise, ports are points of distribution to inland and coastal transportation systems, defining a port's foreland.

Today, port is not simply landing places or just a group of terminals, but a sophisticated and integrated system to provide a full range of services for the maritime industry and more widely logistics activities Rodrigue, 2002).

Before going further, let us take a quick overview of the historical development of ports. Port can be traced back to the ancient periods of 2,000-4,000 B.C. Even in such early days, natural harbors were not always sufficient for the needs of mariners and became increasingly inadequate. Thus there were built a number of artificial or semi-artificial ports, constructed at first primitively, but later with full appreciation of scientific methods and technical skills. In the Medieval Period, many coastal cities were developed around ports, particularly in the regions along the Mediterranean Sea. As the trade grew significantly across the sea, traders owned their cargo ships and moored ships to the banks in front of their buildings, where goods were stored and traded while they were living upstairs. Ports at that time therefore were made up with a raw of these traders' buildings and long banks as mooring places. Since the advent of the Industrial Revolution, the great expansion of industrial activities brought enormous increases in the trade at then major ports with sea-trade networks rapidly extending to Asia, Africa and America. It was against this background that ship owners became independent from traders around the 18th and 19th century, leading to the development of ports or at least terminals in a modern sense where various port services were provided to ships and cargo such as cargo handling, mooring line handling, water supply, lighterage, and warehousing.

The social function of ports is getting blurred with technological, economical and organizational changes of maritime transport. So the concept of ports as public services providers is being replaced for the concept of ports as a economic agent although it is considered strategic yet (Hoyle and Pinder 1992).

The globalization of the world economy has brought about tremendous increases in exchange of goods across the world. In pursuit of economical and competitive manufacturing, production centers of nearly all industries have been rapidly shifting their basis beyond national borders. Consumers also have started to bring in agricultural and manufactured goods for their daily life from all over the world so long as price and quality are offered within reasonable ranges. As the globalization is most likely to further develop, the world trade and in particular seaborne trade will continue to grow in the foreseeable years. To effectively handle the ever-growing world trade and rapidly

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deploying of larger vessels, ports have to continuously upgrade or expand their facilities without delay if they are to be a reliable partner of the maritime industry.

International transport of goods has been rapidly changing from fragmented approach by respective players to integrated logistics systems to better meet individual needs of customers. Ports are increasingly required to play more active roles as value adders, not value subtractors in the seamless chain of logistics, while continued efforts are needed to provide better services with lower cost as critical nodes in the logistics system. A growing range of value-added activities in logistics, therefore, will be concentrated in and around port areas. By so doing, ports are expected to be not just a transferring point between different modes of transport but also logistics hubs and centers in global transport chains. In particular, further advancement of information technology will be accelerating the far-reaching integration of transport systems centering on ports.

### 1. 2. The Hierarchy of Ports

The progress of transportation technology, has been causing to increase the amount of cargo. One of the effect of multimodal transportation and containerization is to increase transit trade. To use less number of ports becomes more efficient and economic. This phenomenon have caused a new hierarchy between ports. The natural result of this process, ports which are on the main shipping routes has become greater. As a conclusion, maritime transportation optimizes the costs, serves on time (including intermodal transportation functions)

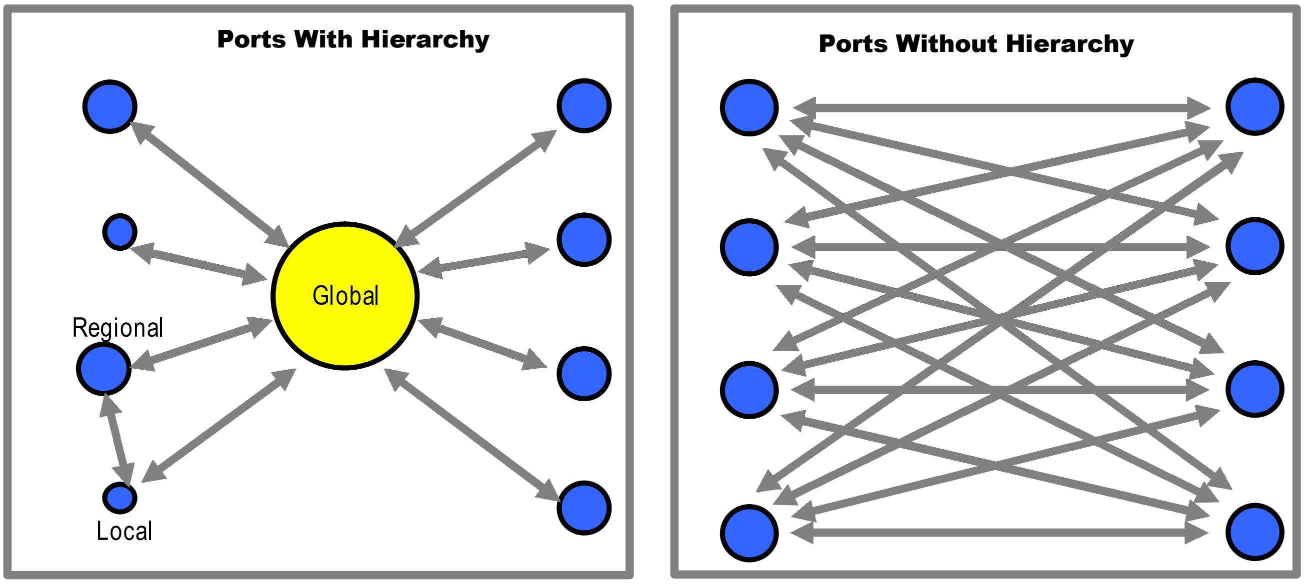



Figure 1: Ports With and Without Hierarchy

It's possible to identify ports into three level: global, regional and local. (Fageda 2000, OCDI 2000, http://www.people.hofstra.edu/geotrans, 2006)

*Global Ports* are on the way of main shipping routes and serve to the great scale ships. These ports have great possibilities for intermodal transportation. Global ports are divided to "maritime hub" and "gateway" (Taafle (1963), Slack (1990), Barke (1986) Hayuth (1981)). Maritime hubs are available for the intermodal transportation and for transit transportation like Gioia Tauro, Damietta. Generally gateways are very close to production and consumption centers. Barcelona, Marsilya, Port Said would be examples. The superior factor of being a global port is the deviation from the main shipping route.

*Regional Ports* have a limited hinterland related with its geographic region. These ports are generally for domestic transport. Mother ships load/discharge only if sufficient demand occurs. Other kind of regional ports are feeder ones. Mother ships could never load/discharge because of their physical ability. Thus regional ports serve with feeder cargo vessels. Most of the ports in Turkey are in this category. The only regional port which has a strong relation with global shipping agencies is Mersin and İzmir.

*Domestic Ports* are little ones and only they could is handling with small cargo vessels inside its own national borders.

### 1. 3. Increasing Usage of Container

It is known that approximately 70% of maritime cargo handles with container. Container causes to widen hinterland concept because of its availability for the intermodal transportation. The table above shows the ratio of both containerized and general cargo.

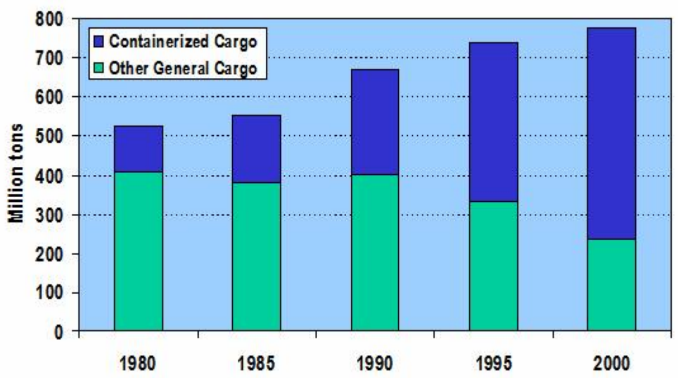


Figure 2: The Distribution of Containerized and Other General Cargo
Source: www.people.hofstra.edu/geotrans, last accessed: July 2006

The increasing usage of container as standardized cargo unit in maritime transport, which has involved an important technological shift, is the most outstanding phenomenon that has taken place in this sector last thirty years. The world container throughput has changed from 37 millions of TEUS in 1980 to 175 millions in 1998 (World Bank, 1999), which involves an annual average increase about nine per cent Above all, there is a point to focus on container throughput because of being the kind of cargo that contributes to major extent in generating added valor. So this is the conclusion of several empirical studies undertaken in this field. We must not undervalue the provision of raw material to heavy industries that is concerned with dry and liquid bulk throughput but their handling make less economic activities, employment and rents in ports and its cities than most part of general cargo components.

The high growth showed by container world trade is consequence of its advantages. The most important are these:

Packing and handling savings to the merchandise.

Container carriers are faster than general cargo conventional carriers and its stay in ports is more reduced (12 per cent of its time compared to 50 per cent of general cargo carrier time).

The easier surface access encourages just in time practice.

The high growth of elaborated and half-elaborated merchandise trade which is consequence of the economic globalization. We have to keep in mind container is the best system in maritime transport at moving this kind of cargo and is almost exclusive in overseas movements.

The increasing weight managed by general cargo (and specially containers) is involving a change in ports secondary function (commercial and industrial function) although the primary function(transport function) remains the same. Global ports are shaped as platforms with specialized facilities in storage, handling and freight distribution, where are located services operators and firms related to transport sector. In these ports there are transport and logistic activities such as the next: maintenance, cargo load an unload, modal interchange, grupage, storage and stock management on behalf of clients and so on. This process is a specific outcome of the more general trend referred to the increasing weight of services in the world economy.

## 1. 4. The Concept of Hinterland

Hinterland is a land space over which a transport terminal, such as a port, sells its services and interacts with its clients. It accounts for the regional market share that a terminal has relative to a set of other terminals servicing this region. It regroups all the customers directly bounded to the terminal. The terminal, depending on its nature, serves as a place of convergence for the traffic coming by roads, railways or by sea/fluvial feeders. But, it must have been underlined that the hinterland concept is getting obsolete, it might be better if it'll be called as influence area.

Above in the scheme, each terminal (A and B) has its own hinterland, representing a set of customers (manufacturing and retailing activities) with who they have transactions. These transactions involve movements of freight or people. The main hinterland illustrates an area where the terminal has a dominant, if not an exclusive, share of the flows. The competition margin represents an area where a terminal can be competing with other terminals. For instance, on the above figure terminals A and B are competing over two clients. An island within the hinterland of another terminal can also exist, mainly due to either a privileged relationship between the terminal and a client and/or because of an efficient inland distribution system (corridor).

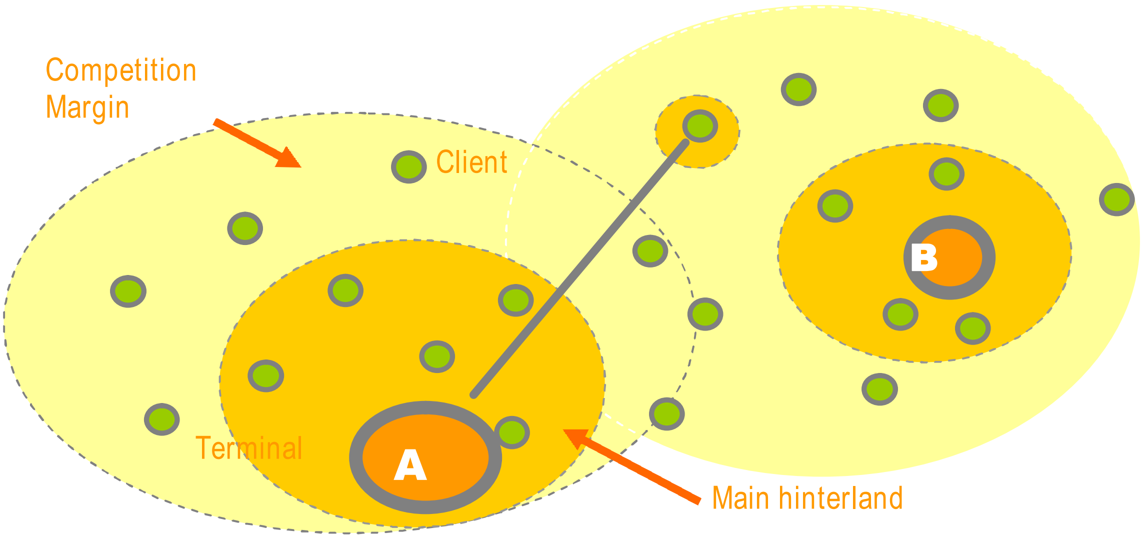



Figure 3: Hinterland and Competition Margins of Ports

Transport terminals are within a system of freight distribution, which includes the notions of hinterland binding imports and exports activities. One of the most enduring concepts in transport geography is the hinterland. It refers to the market area of ports, the land areas from which the port draws and distributes traffic. It is assumed that this zone's traffic will normally pass through the port, because of proximity. The competitive hinterland is used to describe the market areas over which the port has to compete with other terminals for business.

In recent years the validity of the hinterland concept has been questioned, especially in the context of contemporary containerization (Slack 1993). The mobility provided by the container has greatly facilitated market penetration, so that many ports compete over the same market areas for business. The notion of discrete hinterlands with well defined boundaries is questionable therefore. Nevertheless, the concept is still widely employed, and port authorities continue to emphasize their port's centrality to hinterland areas in their promotional literature (Notteboom and Winkelmans 2001, Robinson 2002).

### 1.5. Port Competition

The broadening of container use has involved deep changes in the maritime transport, especially with regard to port competition. Containers as transport cargo unit improves the intermodality so that it becomes common that different ports shares the same hinterland (Hoare 1986), whose borders now will depend on the development of intermodal transport corridors and not on exclusive market areas of each port. So it takes places a direct competition between ports far away one of each other. Secondly and associated to that, port competition is now not only referred to widen the neighboring influence area but as well to its transshipment function, that is, attracting those throughput whose origin or destination is not the own port. Shippers manages container throughput in regular lines, that is, those involves fixed routes and regular calls, with the objective of covering commercial area Round-the world services are replacing traditional system routes. The underlying logic to these services is to be using ships of great size to call in quite a few ports strategically placed and since them by means of feeders ships(whose size is medium) undertake transshipments since/to his origin/destination ports. This allows to take advantage of scale economies to the maximum extent related with the use of overseas ships(which has a capacity from four thousand to six thousand TEUS) reducing the number of its less productive hours.

Lastly, the throughput concentration around huge intermodal platforms by main shipping lines is taking to a few ports concentrate more and more major share of world maritime trade of containers. So top ten ports in container throughput moved the 31% of total throughput in 1990 while in 2000 was 48 per cent. In fact, the world total of container trade has increased by 140 per cent from 86.5 million TEUs for 1990 to 209.7 million TEUs for 2000. According to a report of OECD, it is therefore forecast to increase to 400-460 million TEUs in 2010 and further to 510-610 million TEUs in 2015. For the future, in addition to continued growth of the world trade, rapid developments of transshipment will further accelerate the growth in container trade with an increasing number of inter-port moves involved in serving regional transshipment markets. Also continuing containerization of cargoes on secondary routes is expected.

## 2. Case Study: The Port Of Mersin

The total amount of containers handled in Mediterranean ports has been increasing rapidly in the world. Besides this, the container handling ratio of Northern European is decreasing. The projections point that this trend will be going on increasingly. Therefore many academicians focus on this region, especially to the eastern side for the lack of a hub port.

To be evaluated in boundaries of Turkey, Mersin Port is the unique "container port" in the Mediterranean Sea coast. In addition to this attribute, it has a great potential of growing up thanks to its location. Because, Mersin is the easiest and most rational way to reach to the main shipping route for both Turkish Republic and Middle East Countries. That's why this paper has been focused on Mersin as a case.

2. 1. Physical Transportation Possibilities

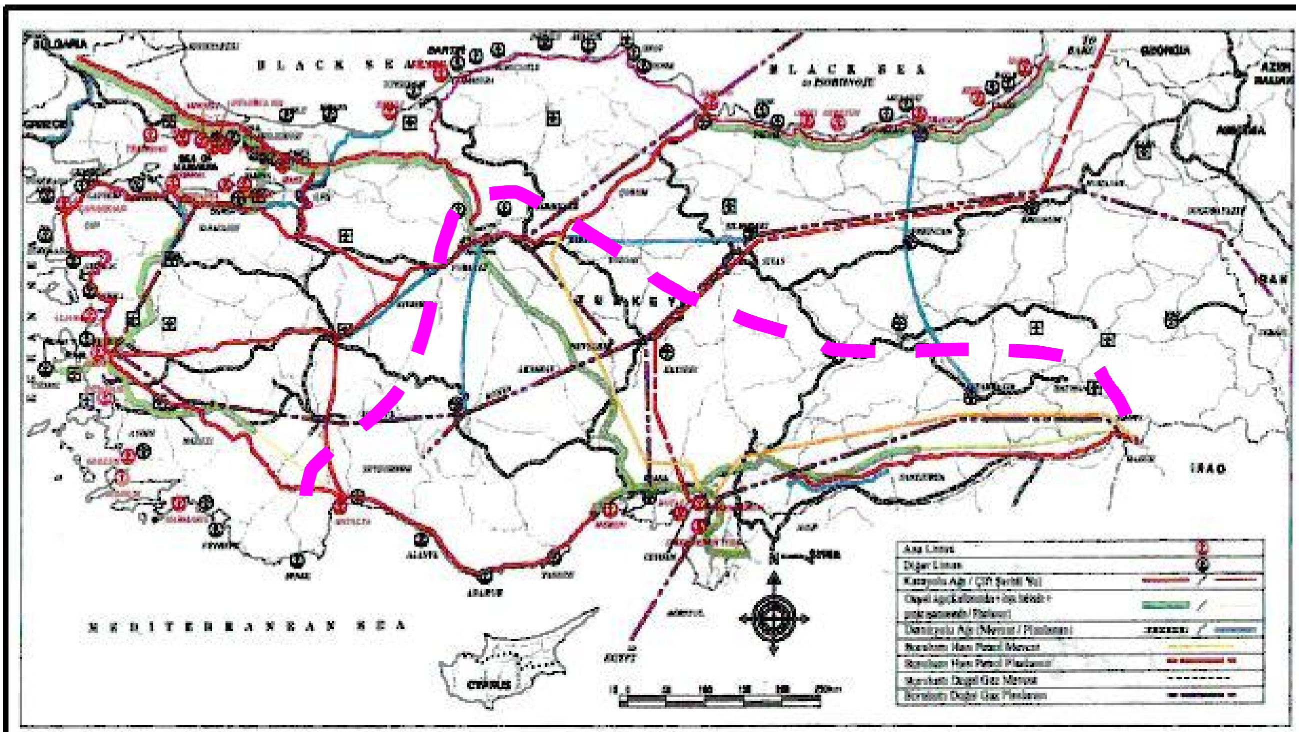
Pilotage is compulsory for vessels entering or leaving the port. Sea crafts comprise one floating crane of 60 tons capacity, one pilot boat, 4 tug boats and 3 mooring boats. The Port of Mersin contains a large handling equipment. Container handling operations are carried out by 3 quayside gantry cranes of 40 tons capacity, 18 rubber tired transtainers of 40 tons capacity, 12 reach stackers of 40 to 42 tons capacity and 12 empty container forklifts of 8 to 10 tons capacity. 17 shore and yard cranes, 15 mobile cranes, 15 standard and 26 small masted forklifts are available. New container berth has 14 m. Depth and gives to service for containers with 2 post panamax gantry cranes. Another facility available for the third party handling equipment.

The rail ferry terminal has 253 m quay length and 12 m depth alongside. It has 10 km maneuvering lines behind the quays for marshalling wagons. These facilities are the best in Turkey with Izmir Port. Mersin port both serves to passengers and cargo. Totally it has 21 piers. The deepest pier is 14 m, average pier depth is more then 10 m. At the same moment 30 vessels would be served by the port.

Dry bulk cargo handling capacity is 3.440.000 tons. Last five years the average usage ratio is 80%. Dry liquid cargo are not handled in the port but oriented towards ATAŞ and MESBAŞ(Mersin Free Zone Operator Inc.) ports. The capacity of container terminal is 934.000 TEU. Every passing year the amount of handling container is getting bigger. Last years it has reached to the 50 % of the capacity. Not only container but in all kinds of cargo (dry bulk, ro-ro) and passenger vessels have increased. The only decrease is at the ships which carries general cargo. The size of container terminal is the biggest in Turkey besides İzmir Port. Warehousing possibilities are in a considerable frame among other Turkish ports. Among the ports in Mediterranean Region, it is the largest in Turkey and one of the biggest in region. Both liquid and bulk waste would be unloaded and oil and water would be gained to the vessels. These properties make port much more competitive.

Mersin port has intermodal transportation facilities with all kinds of transport. The users of port can easily use the sea, highways, railway and air ways. It's connected to all world ports with sea links due to its location as a stop for 40 regular shipping lines. The Port is connected to inland and European Countries and to Middle East and Turkish Republics with the land road. Goods can be easily transferred to East-West Europe, Middle East Countries by Turkish Republic State Railway Lines (TCDD). International Adana Şakirpaşa Airport is 65 km far from the port enables air links to all world countries.

Direct connection with its hinterland makes port in a strong competitive structure. As mentioned above, Port of Mersin has a wide hinterland with the advantage of intermodal facilities.




Türk Limanları ve Ulaşım Ağı

Figure 4: Turkish Ports and Transport Network
Source: OCDI 2000, volume II

### 2.3. Mediterranean Container Traffic and Port of Mersin

Mother container vessels, which are loading/discharging at the global ports, enter to the global maritime routes and move between Europe-Far East, East Asia. Therefore, feeder service is necessary to deliver containers to smaller ports. To analyze and understand the container traffic in Mediterranean, 10 major maritime cargo carriers had checked out. The conclusion are in order below;

1. The superior factor of being a global port is the deviation from the global (main) maritime route. Global ports are generally located at the western/eastern end and center of the Mediterranean Sea. These global ports have a distribution function for the smaller Mediterranean ports. But a regional segregation occurs. The ones in western especially serve to ports in the west and ones in eastern serve to ports in the east.

2. The biggest 10 maritime cargo carrier between Asia/Far East and Europe usually enter to these global ports: In Asia/Far East: Singapore, Hong Kong, Kobe, Bussan, Yokohama, Nagoya. In Mediterranean Region: Fos-Marseilles, Gioia Tauro, Genoa, Port Said-Damietta, Algeciras, Barcelona, Valencia.

The figure above shows the main container ports from/to Asia-Far East and Europe. The points shows not only the starting or/and end points, the most used 6 ports on each contents.

Figure 5: Some of Global Ports in Asia/Far East and Mediterranean

3. 5 global ports, that is usually used by 10 major container company in Mediterranean region are, Gioia Tauro, La Spezia, Damietta, Piraeus and Algeciras. In the figure below, the bigger points show the global ports which mother vessels enter. The less little points show the feeder ports of these 5 global ports. Every color represents its own container traffic. Besides this, Piraeus and La Spezia are also feeder ports of Gioia Tauro, Algeciras is also one of the feeder port of Damietta for some of container companies.

Figure 6: Ports Hierarchy in Mediterranean

4. The biggest container ports in Turkey are Ports of Haydarpaşa, İzmir, Mersin and Gemlik. The major container traffic of these Turkish ports and global ones are between Damietta, Gioia Tauro, La Spezia, Piraeus ports.

5. There is only one firm (of 10 biggest maritime cargo carrier) which has direct container route to/from Turkey and this unique port is Mersin. This proves the importance of Port of Mersin in region.

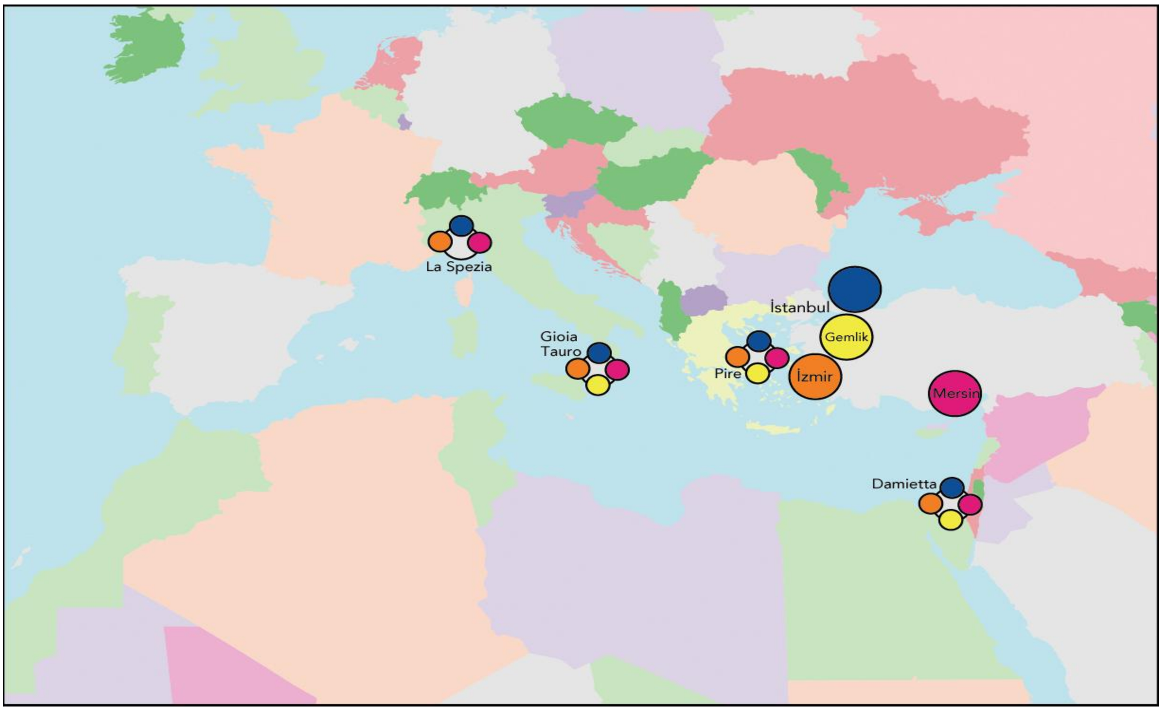


Figure 7: Global Mediterranean Ports and Main Turkish Ports

2.4. The Hinterland of Port of Mersin

As the summary of litterateur survey, it's pointed out that the borders depend on the development of intermodal transport corridors and not on exclusive market areas of each port. So, port of Mersin will be evaluated from this view.

The method of this research is that; first of all, goods traffic between cities inland has determined. As the second step, railway, roadway and cabotage maritime routes has identified and cities inside hinterland has checked.

According to goods and region flow is below:

Table1: Handling to/from Hinterland of Port of Mersin

| Handling From Hinterland | | | Handling to Hinterland | | |
|---|---|---|---|---|---|
| Goods | Tonage | Region | Goods | Tonage | Region |
| Cereals | 1.100.000 | Ankara, Mersin | Cereals | 390.000 | Konya, Karaman, İstanbul, Ankara |
| Cement | 385.000 | Adana, İstanbul, Mersin | Oil | 105.000 | Adana, İstanbul |
| Legumes | 77.000 | İstanbul, Gaziantep, Mersin | Rice | 39.000 | İstanbul, Adana |
| Sodium Ca | 60.000 | İstanbul, Adana | Cotton | 37.000 | Antep, Kayseri, Adana |
| Big-Bag | 36.000 | İstanbul, Adana | Chemicals | 32.000 | Antep, Kayseri, Adana, Ankara |
| Pipe | 21.000 | Kayseri | Iron | 27.000 | Kayseri, İstanbul, Ankara |
| Klinker | 17.000 | Adana, Mersin | Paper | 23.000 | İstanbul, Adana |

Source: Ministry of Transport, Undersecretariat of Maritime, 2005

As the second step; transportation facilities are identified: Cabotage traffic (almost all of them is petrolium) between Port of Mersin and other ports are;

Table 2: Cabotage traffic of Port of Mersin

| Discharge From the port of Mersin | | Load to the port of Mersin | |
|---|---|---|---|
| PORT | % | PORT | % |
| Antalya | 56 | İzmir | 64 |
| İskenderun | 35 | Taşucu (Mersin) | 26 |
| Botaş (Mersin) | 3 | Bandırma | 4 |
| Trabzon | 2 | İzmit | 3 |
| Other Ports | 4 | Other Ports | 3 |

Source: Ministry of Transport, Undersecretariat of Maritime, 2005

Table 3: Railway and Motorway Facilities of Mersin

| Hinterland | Transport facilities | | Hinterland | Transport Facilities | |
|---|---|---|---|---|---|
| | Railway | Motorway | | Railway | Motorway |
| İstanbul | • | • | Adana | • | • |
| Ankara | • | • | Niğde | • | • |
| Kayseri | • | • | Gaziantep | • | • |
| Konya | • | X | Kilis | • | • |
| Karaman | • | X | Hatay | • | • |

Cities which have strong flow with Mersin are all in efficient transportation network. Intermodal transport corridors and hinterland are intersecting. This area is shown (with purple circle) in the map of Physical Transportation Possibilities.

The whole goods of which will be transferred to Iraq ve Iran from Turkey, are accessing these countries by Mersin. But it's really difficult to identify the exact borders of Mersin's hinterland. Especially the global effects, like as wars, political crisis sometimes force neighboring countries to use or to go away from Mersin. Recently, the situation of Haifa Port and the restructuring process of Iraq is going to be widen the borders. The transit transportation data point to Iraq (with the biggest ratio), Syria and Iran. But great potential must have been mentioned that port of Mersin will be one of the biggest transit point to the neighboring countries.

## 3. Conclusions and Recommendation

The Port of Mersin has a great competitive advantage by its geographical position. Being inside of Çukurova Region and locating close to Southeast Anatolia Project(GAP) cities, achieve Mersin a great potential of agriculture and industry of agriculture. Besides this, Mediterranean Sea's ratio in global trade is increasing. It is forecasted that, regional reconstruction will effect positively and the hinterland will be widened. Tourism, as an another important potential for regions' economy, would fasten development of the hinterland.

Mersin would become as a transit hub port for neighboring, northern and Turk Republic countries, due to the convenient location to access Mediterranean and global world. Also, endless crisis in Middle East would provide Mersin a new regional occasion since Mersin has sufficient possibilities to provide service. But of course, geographical position is not unique factor for a port's development. Despite trade development, management and operations are important aspects of a well functioning port, the key to competitive advantage is infrastructure. Port of Mersin is now facing with a number of pressing needs for expanding its facilities and enhancing productivity. First, the continued growth of seaborne trade, particularly rapid growth of container traffic, forces to develop its facilities and capacities without delay. Secondly, the introduction of the mega-container ships, is another force to compel all of the ports to expand their infrastructure to safely and efficiently accommodate such mega vessels, if they are considered as a hub port. Thirdly, vessel operators and shippers are exerting more than ever severe pressures on port authority to improve productivity of port services, namely reduction in charges and enhancement of efficiencies.

As a result, port of Mersin is now aggressively challenging these paramount demands not only by utilizing its own capability, experience and local funds available but also by introducing advanced technologies, innovative concepts and new partnerships.

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# OPTIMIZATION OF ORDERING QUANTITY IN STEEL INDUSTRY – SUPPLIERS HAVING RANDOM SUPPLY YIELD

O. Serkan Ileri[1]

## Abstract

*Even the giant industrial firms might have wrong inventory and material ordering policies. EOQ concept provides a robust methodology for these manufacturing firms to optimize their inventory and ordering expenses. There are certain points to be considered when formulating an EOQ model for a firm. In addition, there are certain assumptions. Most of the EOQ models, as does the one formulated in this study, consider some of the factors constant (such as demand, material price per unit). In reality, none of these factors is constant in most cases. Demand for a good fluctuates as a consequence of many factors and unit raw material price declines due to volume discounts, as the amount ordered per unit period of time increases. The model within this study is also built on the assumption that the yields of the suppliers are independent from each other. However, it can confidently be defended that supply yields of raw material suppliers (steel suppliers in this case) are highly dependent on each other in many unusual cases – i.e. when the economy booms or when there is a shortage in the world steel supply. Despite all these constraints and limitations of the model, EOQ concept still provides a sound basis for cost optimization for manufacturing firms. To start with, a constraint is released in this case study; the supply yields of suppliers are not considered constant.*

*Keywords: Steel industry, EOQ, Multiple suppliers, Random supply yield*

## 1. Steel Industry

Steel is one of the most widely traded commodities in the world. Global crude steel production, according to estimates made by the International Iron and Steel Institute (IISI), increased for the sixth consecutive year, rising by 6.7% in 2003 to a record 963.6 million tons. An increase was recorded in all regions of the globe in 2003 with the exception of North and Central America, where the production level remained unchanged from 2002, and the United States, where production fell 1.3%. Without China, which accounts for more than one fifth of world production, the growth in production would have been 2.4% (Arcelor, 2003).

Some of the key issues which will impact the global steel industry include the levels of worldwide steel production and consumption, the recent volatility of steel prices, the recent steep increase in the cost of purchased raw materials, the level of unfunded pension and other postretirement benefits (OPEB) liabilities, the magnitude and durability of the world economic recovery which appears to be in progress, and the impact of production and consumption of steel in China, which has led to much of the recent volatility in steel raw material supplies and global steel pricing (Arcelor, 2003).

## 2. Supply Cost Drivers for a Manufacturer

Industrial Engineering practice defines the total cost of supply for a manufacturer as follows:

Total Cost = Cost of materials + Order cost + Inventory holding cost[2]

When setting cycle inventory[3] levels in practice, a common hurdle is estimating the various costs that have been defined. The materials cost is typically the easiest to identify. The average price paid per unit purchased is a key cost in the lot sizing decision. A buyer may increase the lot size, if this action results in a reduction in the price per unit purchased. For example, if a steel manufacturer is charged 700 €/ton for orders under 500 tons and 620 €/ton for larger orders, this manufacturer may find it beneficial to order in lots of at least 500 tons. The price paid per unit is referred to as material cost and is denoted by C and measured in €/unit. In many situations material cost displays economies of scale and increasing the lot size decreases the unit material cost (Chopra, 2004). However, in this

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[2] Calculation of these costs will be provided in the forthcoming sections in detail.

[3] Cycle inventory means the average level of inventory that a firm holds in a fixed period of time (generally a year). If a firm orders Q amount of materials periodically, then the cycle inventory for that firm is Q/2, since the demand is considered constant. That is; there are Q materials each time an order is received and 0 materials by the beginning of the next ordering period. Accordingly, the average cycle inventory on hand is (Q+0)/2=Q/2.

analysis, the material cost will be considered constant for all lot sizes, and the emphasis will be on order and inventory holding costs.

The *fixed ordering cost* includes all costs that do not vary with the size of the order but is incurred each time an order is placed. For example, a fixed administrative cost may be incurred to place an order, a trucking cost may be incurred to transport the order, and a labour cost may be incurred to receive and unload the order. Given that this cost is fixed for each order, the manufacturer tries to increase the amount it orders at each order to have a lower fixed ordering cost per a ton of steel. The fixed ordering cost per order is denoted by Kn (commonly thought of as a set-up cost) and is measured in €/order (Chopra, 2004).

*Inventory holding cost* is the cost of carrying one unit in inventory for a specified period of time, usually one year. It is a combination of the cost of capital, the cost of physically storing the inventory, and the cost that results from the product becoming obsolete. The holding cost is denoted by H and is measured in €/unit/year. It may also be obtained as a fraction, h, where h is the cost of holding 1€ (or 1 ton in our case) in inventory for one year. Given a unit cost of C, the holding cost H is given by

$$H = hC \quad (1)$$

In calculating these costs, it should be noted that incremental costs are the ones that should be counted; that is, costs that change as the lot sizing decision is changed. Costs that are unchanged with a change in lot size should be disregarded in the lot sizing decision. For example, if a factory is running at 50% of capacity and all labour is full time and not earning overtime, it can be argued that the incremental set-up cost for labour is actually zero. Reducing the lot size in this case will not have any impact on the on set-up cost until either labour is fully utilized (and earning overtime) or machines are fully utilized (with a resulting loss in production capacity) (Chopra, 2004).

The primary role of cycle inventory is to allow different stages in the supply chain to purchase product in lot sizes that minimize the sum of the material, ordering, and holding cost. If a manager were considering the holding cost alone, he or she would reduce the lot size, thus the cycle inventory. Economies of scale in ordering, however, motivate a manager to increase the lot size and place orders less frequently. A manager must make the trade-off that minimizes the total cost when making the lot sizing decision (Chopra, 2004). This phenomenon can be clearly visualized as shown in Figure 1.

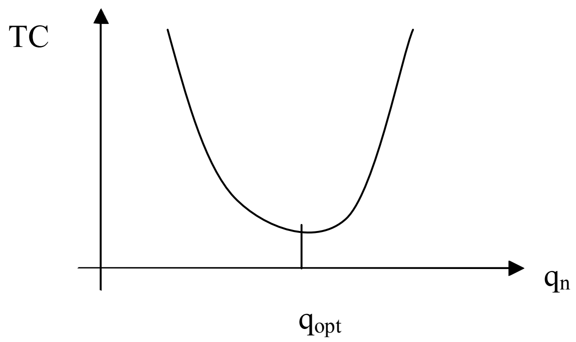


Figure 1. Total cost curve for order quantities

## 2.1 Inventory Holding Cost

Holding cost is estimated as the sum of the following major components, not all of which are applicable to every type of situation. Holding cost is usually estimated as a percentage of the cost of a product.

- *Cost of capital:* This cost is often the most important component of holding cost. The appropriate approach is to evaluate the Weighted Average Cost of Capital (WACC). This cost takes into account the return demanded on the firm's equity and the amount firm must pay on its debt. These are weighted by the amount of debt and equity financing that the firm has (Chopra, 2004).
- *Obsolescence (or spoilage) cost:* The obsolescence cost estimates the rate at which the value of the product you are storing drops either because market value of that product drops or because the product quality deteriorates.
- *Handling cost:* Handling cost should only include receiving and storage costs that vary with the quantity of product received. Quantity-independent handling costs that vary with the number of orders should be included in the order cost (Chopra, 2004).
- *Occupancy cost:* The occupancy cost should reflect the incremental change in space cost due to changing cycle inventory (Chopra, 2004).
- *Miscellaneous costs:* The final component of holding cost deals with a number of other relatively small costs. These costs include theft, security, damage, tax, and other insurance charges that may be incurred (Chopra, 2004).

### 2.2 Order Cost

The order cost includes all incremental costs associated with placing or receiving an extra order that are incurred regardless of the size of the order. Components of order cost include:

- *Buyer time:* Buyer time is the incremental time of the buyer placing the extra order. This cost should be included only if the buyer is utilized fully. The incremental cost of getting an idle buyer is zero and does not add to the order cost (Chopra, 2004).
- *Transportation costs:* A fixed transportation cost is often incurred regardless of the size of the order. For instance, if a truck is sent to deliver every order, it costs the same amount to send a half empty truck as it does a full truck (Chopra, 2004).
- *Receiving costs:* Some receiving costs are incurred regardless of the size of the order. These include any administration work such as purchase order matching and any effort associated with updating inventory records. Receiving costs that are volume dependent should not be included here (Chopra, 2004).

## 3. An EOQ Model with Multiple Suppliers and Random Capacity

### 3.1 Problem Definition

Most of the manufacturers have multiple suppliers for majority of their input materials, as shown in Figure 2 (This is also the case for distribution centers, warehouses etc.). This is mainly due to the desire of the manufacturers to keep the supply risk as low as possible. Accordingly, there are certain equations about how much to order from each supplier derived for simple cases. These equations are named as Economic Order Quantity models (EOQ). The main objective of this formulation is to minimize the total cost of ordering supplies. The concerning two[1] cost drivers are:

- *Cost of ordering materials (administrative costs, loading unloading costs, transportation costs etc.);*
- *Cost of holding inventory.*

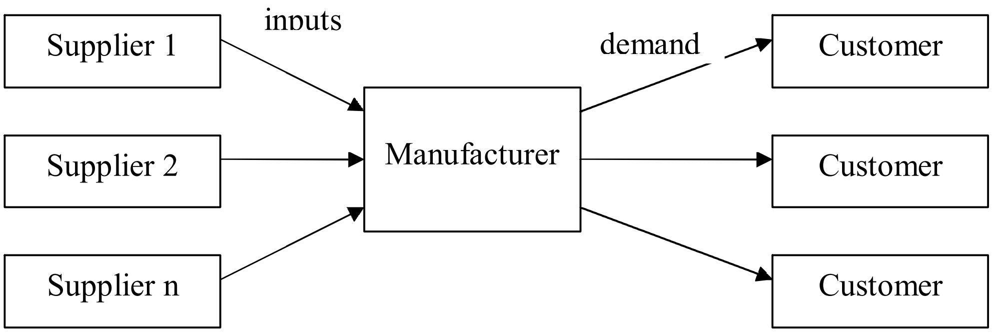


Figure 2. Supply - demand network for a manufacturer

There is always a trade-off between ordering less and more from a certain supplier (or from the network of suppliers). If a higher amount of materials is ordered in each order, the manufacturer will end up with a lower cost of ordering (since it will issue fewer orders), however it will have a higher level of inventory during the year, and thus a higher inventory holding cost. In the other case (ordering a lower amount of materials), inventory cost will decline, while the cost of ordering increases (since the manufacturer will issue more orders). The main objective of the EOQ models is to find an optimum order quantity where the total cost (joint cost of ordering materials and holding inventory) will be minimized. As one can recall, this was the case illustrated in Figure 1.

These cases assume that demand for the output of the manufacturer as well as the supply for the inputs are constant. However, in reality neither the demand nor supply is constant. In most cases suppliers are not able to supply the essential amount of materials needed for production; but they can only produce in accordance with their capacities (there might anytime be production inefficiencies or shutdowns etc. It should also be noted that the suppliers need to allocate their production among all their customers). Therefore there is a yield uncertainty as a consequence of random capacity. In this study, it will be assumed that the supply from the suppliers is exponentially distributed and the aim will be to create an EOQ system for this case (supply capacities of the suppliers will not be identical). The variations in demand are disregarded for this case and it is considered constant. Another assumption is that whenever an order is placed, it is allocated between all of the available suppliers; none of the suppliers is taken out of the ordering list each time an order is placed.

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[1] Material unit cost is considered constant as was explained previously. Therefore it is not included in the formulation.

3.2 Methodology

3.2.1 Overall View of EOQ Model

First step in the course of preparation of this report has been to find data from a supplier of a steel manufacturer that approximately has an exponential supply capacity distribution. In reality, the obtained steel manufacturer supplies its steel demand only from one company, which is its mother company. Therefore, the data provided by the procurement department of the concerning steel manufacturer, in fact, is the historical record of the steel procurement of the firm from its mother company. The second and third suppliers are fictitious suppliers. The supply data belonging to these suppliers has been determined by multiplication of the data by some constants, so that:

Supply from Supplier 2 = 1.30 x Supply from Supplier 1 (for each month)
Supply from Supplier 3 = 1.45 x Supply from Supplier 1 (for each month)[1]

As a next step, time histories of the supply provided by the suppliers over the 25 years time horizon are plotted on the time domain. These time histories can be seen in Figure 3.

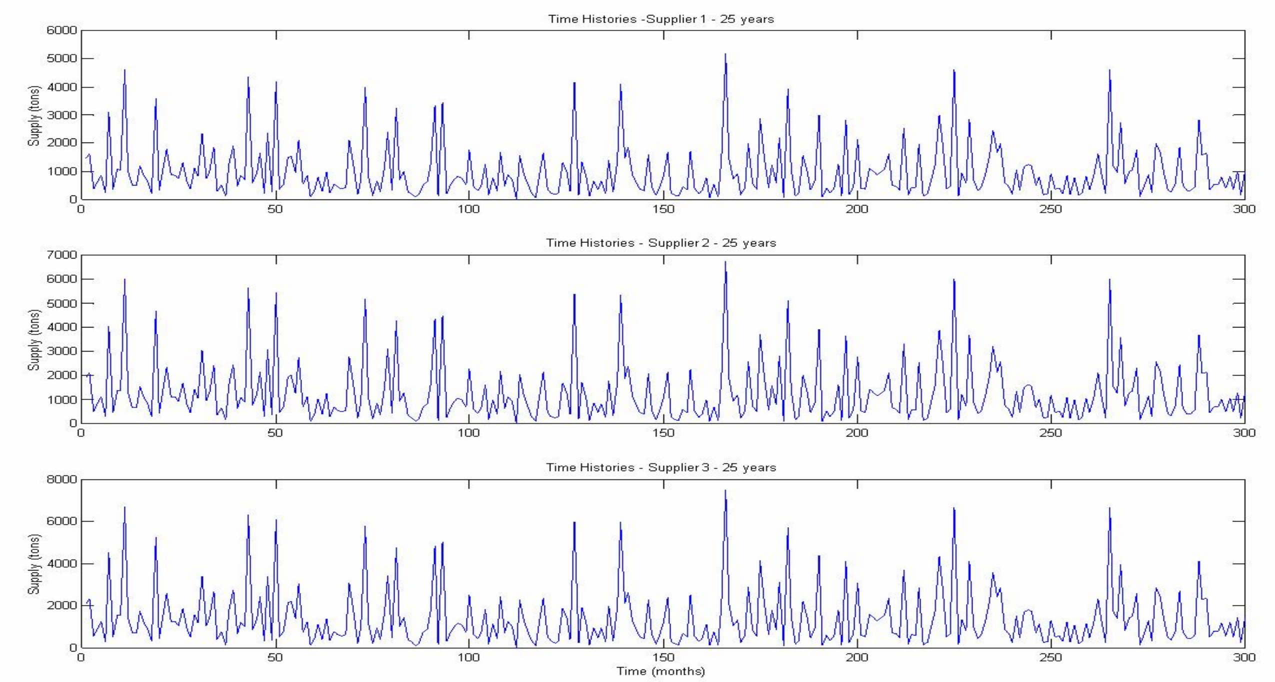


Figure 3. Time histories of the supply data from Suppliers 1, 2, and 3 - monthly

From Figure 3, it can easily be seen that there is no periodic (cyclical) pattern for the steel supply from all three suppliers. This result is in fact natural because the orders from the steel manufacturer depend on the projects that the company gets from its customers – the concerning steel manufacturer supplies steel for construction projects. There is no guarantee that projects of same scales will be contracted each year in the same month.

Accordingly, a need arises to show the time histories of supplies for each month separately over the 25 years time horizon. These time histories for each month are provided in Figures 4, 5, and 6.

1 These constants, 1.3 and 1.45, are determined via pure intuition.

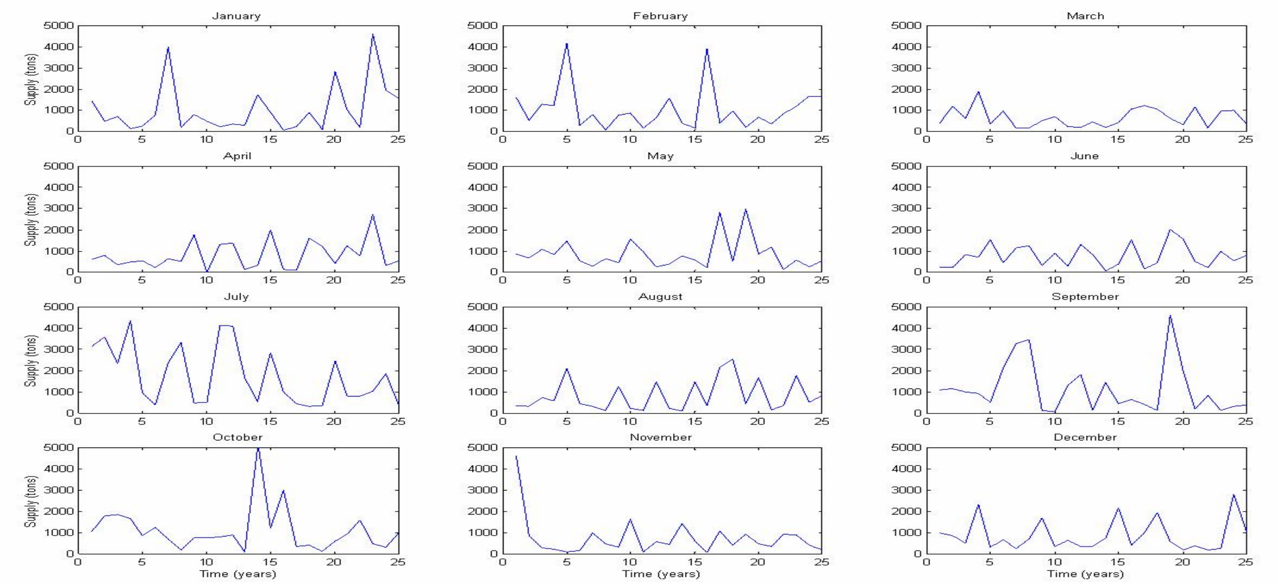


Figure 4. Supplier 1 - Time histories for each month over the 25 years horizon

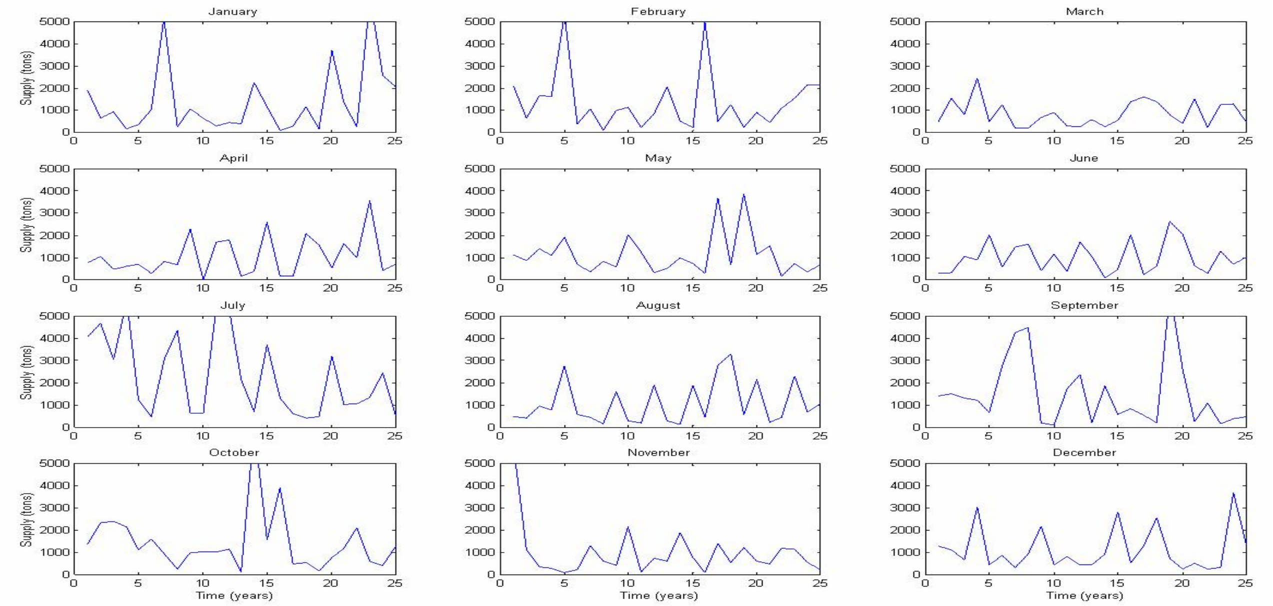

Figure 5. Supplier 2 - Time histories for each month over the 25 years horizon

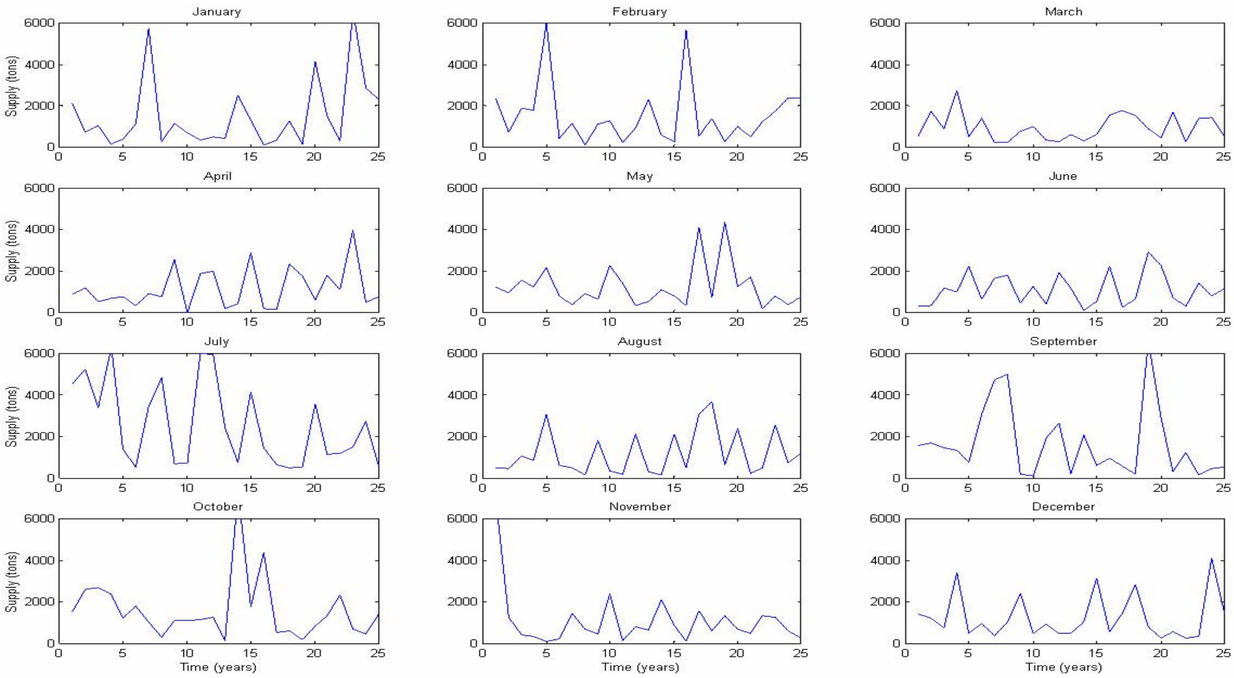

Figure 6. Supplier 3 - Time histories for each month over the 25 years horizon

It was thought that supplies from all three suppliers would be distributed exponentially. To test this hypothesis, the histograms of supplies are computed via Matlab and provided in Figures 7, 8, and 9.

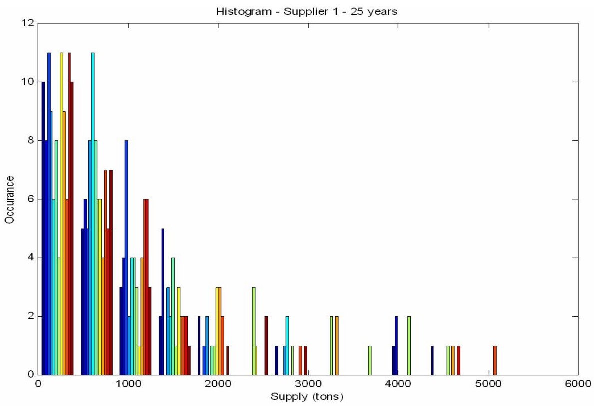

Figure 7. Histogram of the supply data for Supplier 1

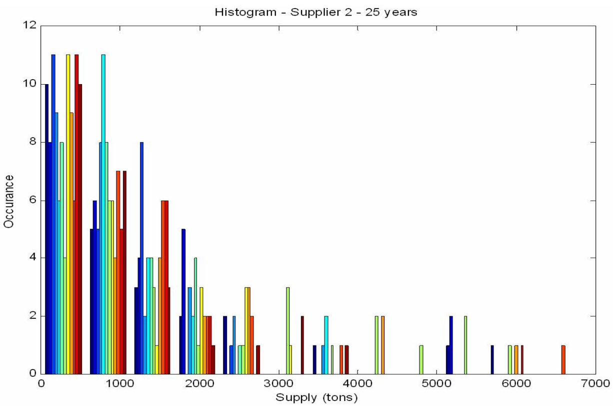

Figure 8. Histogram of the supply data for Supplier 2

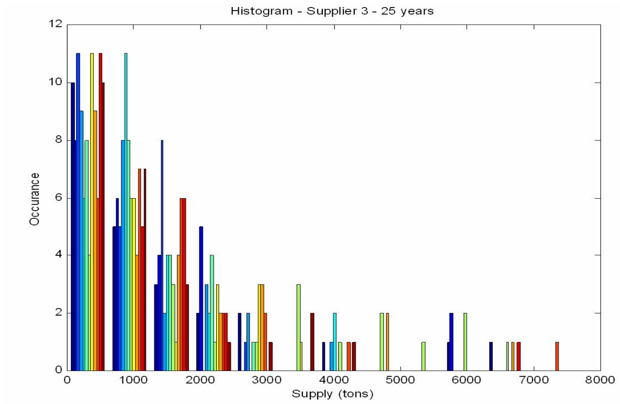


Figure 9. Histogram of the supply data for Supplier 3

As seen in the histograms, the supply data closely fits to exponential distribution. Therefore, exponential distribution diagrams are drawn for μ values of $1.00 < \mu < 1.50$ (for each 0.01 increment). The best fit has been observed with $\mu = 1.12$. Accordingly, the formulation for the EOQ model will be based on exponentially distributed supply data with $\mu = 1.12$.

As one can recall from the previous chapter, the total cost formula will be as follows;

$$Total\ Cost = TC = \frac{Kn + cE\left[Yq1 + Yq2 + \ldots + Yqn\right] + hE\left[\left(Yq1 + Yq2 + \ldots + Yqn\right)^2\right] / (2D)}{E\left[Yq1 + Yq2 + \ldots + Yqn\right] / D} \qquad (2[1])$$

$$Y_{qi} = min\{q_i, A_i\} \qquad (3)$$

*where:*
$K_n$ = *Joint order cost (cost of giving an order to all of the n available suppliers, n = 3 in our case) (€/order)*
$c$ = *Unit material cost (€/ton)*
$h$ = *Unit inventory holding cost (€/year/ton)*
$q_i$ = *Order quantity for the $i^{th}$ supplier (quantity ordered by purchaser, purchaser is Rannila in our case) (tons)*
$A_i$ = *Independent random capacities of suppliers having an exponential distribution function $F_i$ and density $f_i$*
$Y_{qi}$ = *Actual amount received from each supplier (minimum of the capacity of the supplier and the order quantity) (tons)*
$D$ = *Total yearly demand (tons/year) (Erdem, Fadiloglu, & Ozekici, 2005)*

Since the random capacities of the suppliers are assumed to be independent, we can derive the following formula:

$$E\left[\left(Yq1 + Yq2 + \ldots + Yqn\right)^2\right] = \sum_{i=1}^{n} E\left[Y_{qi}^2\right] + \sum_{i'j=1' j\neq i}^{n} E\left[Y_{qi}\right] E\left[Y_{qj}\right] \qquad (4)$$

If we insert Eq. (4) in Eq. (2),

$$TC = cD + \frac{KnD + h\left(\sum_{i=1}^{n} E\left[Y_{qi}^2\right] + \sum_{i'j=1' j\neq i}^{n} E\left[Y_{qi}\right] E\left[Y_{qj}\right]\right)/2}{\sum_{i=1}^{n} E\left[Y_{qi}^2\right]} \qquad (5)$$

Since cD is a constant we can remove it from the equation to be optimized, and that results in:

$$TC_{modified}(q_1\, q_2 \ldots q_n) = \frac{KnD + h\left(\sum_{i=1}^{n} E\left[Y_{qi}^2\right] + \sum_{i'j=1' j\neq i}^{n} E\left[Y_{qi}\right] E\left[Y_{qj}\right]\right)/2}{\sum_{i=1}^{n} E\left[Y_{qi}^2\right]} \qquad (6)$$

[1]This formulation and the following ones are derived from the paper of the advisor of this project, Dr. Asli Sencer Erdem.

Where;

$$E\left|Y_{qi}\right| = \int_{0}^{+\infty} \min\{q_i, y\} dF_i(y) = \int_{0}^{q_i} y dF_i(y) + q_i \overline{F}_i(q_i) \tag{7}$$

$$E\left|Y_{qi}^{\ 2}\right| = \int_{0}^{+\infty} \min\{q_i, y\}^2 \, dF_i(y) = \int_{0}^{q_i} y^2 \, dF_i(y) + q_i^{\ 2} \, \overline{F}_i(q_i) \tag{8}$$

Accordingly the EOQ formula for n random capacity suppliers is derived via the solution of:

$$2q_i \sum_{i=1}^{n} E\left|Y_{qi}\right| + 2\sum_{i=2}^{n} \sum_{j=1}^{n} E\left|Y_{qi}\right| E\left|Y_{qj}\right| - \sum_{i=1}^{n} E\left|Y_{qi}^2\right| = 2K_n D / h \tag{9}$$

$$q_1 - E\left|Y_{q1}\right| = q_2 - E\left|Y_{q2}\right| = ....... = q_n - E\left|Y_{qn}\right| \tag{10}$$

These formulations were for the general case of suppliers with random capacities. We now need to analyze the special case of suppliers with exponential distributions.

3.2.2 EOQ Model for Suppliers with Exponentially Distributed Capacities

Exponentially distributed capacity of a supplier means that the random capacities are exponentially distributed with rate μ so that F(x) = 1 – exp(-μx), x $\geq$ 0.

Accordingly, when the random capacity of a supplier is exponentially distributed, from Eq. (7) and Eq. (8):

$$E\left|Y_q\right| = \frac{1}{\mu}\left(1 - e^{-\mu q}\right) \tag{11}$$

$$E\left|Y_q^2\right| = \frac{2}{\mu^2}\left(1 - (1 + \mu q)e^{-\mu q}\right) \tag{12}$$

When we consider the case with n suppliers (n = 3 in our case) where the capacity $A_i$ of supplier is exponentially distributed, the procedure to find the optimal order quantities for each supplier is as follows:

n suppliers with Ai ~ Exponential ($\mu_i$) for some $\mu_i$ > 0 and i = 1, 2, 3, ....., n. The optimal order quantities can be found as the unique nonnegative solution of the equations:

$$\frac{2}{\mu^2}(\mu_1 q_1 + e^{-\mu_1 q_1} - 1) + \sum_{i=2}^{n} \frac{2}{\mu_1 \mu_i}(\mu_1 q_1 + (1 - e^{-\mu_1 q_1}) W(-e^{-1-\mu_i f(q_1)})) + 2\sum_{i=2}^{n-1} \sum_{j=i+1}^{n} \frac{1}{\mu_i} \frac{1}{\mu_j} (1 + W(-e^{-1-\mu_i f(q_1)}))(1 + W(-e^{-1-\mu_j f(q_1)})) = \frac{2K_n D}{h} \tag{13}$$

*and*

$$q_k = f(q_1) + \frac{1}{\mu_k}\left[1 + W(-e^{-(1+\mu_k f(q_1))})\right] \tag{14}$$

*for k = 1, 2, 3, ......, n.*

where,

W(x) represents the Lambert W function that satisfies; $W(x)e^{W(x)}$=x.

3.2.3 Solution

In order to solve the above equation and find the optimum order quantity for the steel manufacturer, a Matlab code was developed.

The inputs for the formula are $K_n$, D, and h. $K_n$ is the joint order cost, which is the cost of giving an order to all of the n = 3 available suppliers. To have a realistic result, this value was asked from the Managing Director of the Istanbul Office of the steel manufacturer. He estimated this cost to be 5000 €/order. Our next input, h, is the unit inventory cost, whose value was received from the same source. Accordingly, the value used by the steel manufacturer is 70 €/ton/year. Our last input D, which is the average annual demand for steel manufacturer's steel, is calculated by the code itself, taking the arithmetical average of the available data for 25 years.

When we enter these values, our code calculates $q_1$, $q_2$ and $q_3$ values such that;

$q_1$ = 1,210 t / order
$q_2$ = 1,763 t / order
$q_3$ = 2,085 t / order

Summing up these values, we find out that the optimum cumulative order lot is 5,058 t /order. To be able to find our order frequency we need to calculate:

n = order frequency = 43,850 / 5,058 = 8.66 orders / year.

From the same source, it was learnt that the steel manufacturer currently has the policy of making one order per month. In addition, it was also provided that the average inventory the steel manufacturer holds for the time being is approximately 2790 tones. This information would give one the chance to compare the EOQ policy with the current one.

Accordingly the total order and inventory costs that the steel manufacturer incurs in both scenarios are determined as[1]:

Current policy: 12 x 5,000 + 2,190 x 70 = 255,300 €

EOQ policy: 8.66 x 5,000 + 5,058 / 2 x 70 = 220,330 €

## 4. Conclusion

Even though, there exist some limitations for the optimization models and it is not possible to apply all the factual situations in an optimization model, optimization models, such as EOQ model, still provide beneficial results with the manufacturers. Depending on the needs and the specific characteristics of the supply chain of the manufacturer, custom EOQ solutions can be developed and the manufacturer can enjoy lower costs due to optimized supply chain. Throughout this study, a steel manufacturer with suppliers having stochastic supply yields was under consideration, and the ordering quantity of this steel manufacturer was investigated. Certain modifications were applied to the EOQ formula to take the stochastic behavior of the supply yields of the suppliers into account and a case study was conducted. The results of the case study can also be shown as evidence for the lower cost of supply once when the EOQ model is applied.

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[1] As was the case in the beginning of our analysis, the material cost is disregarded in this calculation, since that is constant and leads to the same figure in both cases.

# ANALYZING MILK RUN AND CROSS DOCK SYSTEMS AS A TOOL OF LEAN LOGISTICS

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## Abstract

*Fierce competition in today's global markets has motivated the continuous evaluation of the supply chain and of the techniques to manage it.*

*Lean logistics is a developed perfection that is designed to control the settlings and the movements of stocks in process and finished products and is used to form the directed systems. The ultimate goal of lean logistics is to reduce material storage and logistics costs by delivering the right part, in the right packaging, in the right place, in the right quantity and quality, at the right time.*

*Milk run and cross dock are two of the applications of lean logistics. Milk run is a system that executes the collection of components with minimum vehicles in determined routes and orders from suppliers that separated to districts before. In cross dock system, the components received from suppliers are sent according to requirements of costumers. This system provides products to move from suppliers to receivers without stockpiling.*

*In this study, logistics management, lean thinking, milk run and cross dock systems and milk run and cross dock systems' cost and effectiveness analysis are mentioned and explained with applications.*

Key Words: Lean Thinking, Logistics Management, Milk Run, Cross Dock, Effectiveness Analysis.

## 1. Introduction

The management of supply chains in today's highly competitive environment requires that logistics managers respond quickly to competitive challenges, inventory shortages, customer complaints, inaccurate order processing, and unreliable transportation situations (Smith, 2004:1).

Logistics and Supply Chain Management literature indicates that customer service management has become a strategic issue for companies in the new millennium. By improving logistics performances, companies increase customer satisfaction and gain market shares (Bottani, Lizzi; 2005:1).

This article is about the newest methods becoming popular that is used in lean logistics; milk run and cross docking and organized as follows. Section 2 explains supply chain management. Section 3 and 4 define lean thinking, logistics and lean logistics concepts. Section 5 and 6 mention milk run and cross docking systems respectively. In the following section, section 7, we investigated a logistics firm which has a subsection in Turkey. The last section; section 8 contains the conclusion.

## 2. Supply Chain Management

Supply Chain Management is a recent movement in logistics research that has been defined in various ways. The Global Supply Chain Forum defines SCM as "the integration of business processes from end-user through original suppliers that provides products, services, and information that add value for customers". Kotzab and Schnedlitz define SCM as a special form of strategic partnership between retailers and suppliers, with positive effects on the overall performance of the channel. The key element of SCM is activity integration. In fact, Bechtel and Jayaram present an integration-continuum between "pure awareness" and "pure integration" of supply chain activities. They champion the view of SCM as a "seamless demand pipeline" with the end-user as the driving force in the entire system (Alvarado, 2001:3).

Kotzab goes further and places SCM in the "metalogistical" level of business logistics. The "metalogistical" level includes all possible forms of cooperation between economic organizations. And, according to Ihde, this cooperation occurs between institutions of different levels within a channel and can be either shortor long-term in orientation. Inspired by Cooper, Lambert and Pagh, Kotzab presents a schematic of an SCM model in Figure 1 (Alvarado, 2001:3).

It is important to note that the basic SCM model in Figure 1 suggests the orchestration of activities at the inter-organizational level as well as the departmental level. Instead of focusing on the management of interfirm inventory and transportation capacities, SCM aims to integrate the activities of an entire set of organizations from procurement of material and product components to deliver completed products to the final customer. These activities refer to

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marketing-dominated areas such as new product development, customer relationship management and/or customer service management. Consequently, SCM leads to improvements in channel performance among all channel members and not solely within the focal firm (Alvarado, 2001:3).

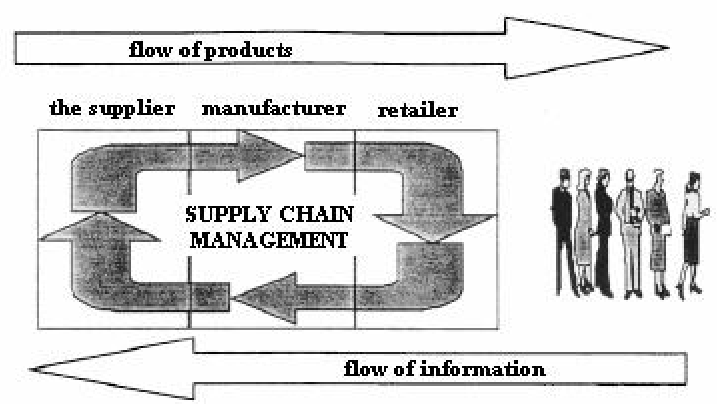


Figure 1. Basic supply chain management model (Alvarado, 2001:3)

Prominent examples of these positive effects include the supply chains of the Dell Corporation, Wal-Mart, Digital Equipment Corporation, the personal computer supply chain, and the Hewlett-Packard Corporation. All of these examples report cost reductions with simultaneous improvements in customer service. It is exactly this effect that is seen as a "paradigm shift" in existing logistics thinking, where improvements in customer service would typically have resulted in increased cost levels. Keebler, Manrodt, Durtsche, and Ledyard refer to the re-arrangement of the way business is conducted within supply chains, "improving business performance requires improving the way work is done in a business activity". Basically the improvements are due to the following:

- Avoidance of duplication effects by concentrating on core competencies;
- Use of inter-organizational standards like ABC (activity based costing) or EDI (electronic data interchange)
- Elimination of unnecessary inventory levels by postponing customization towards the end of the supply chain (Alvarado, 2001:3).

It is interesting to note that these positive effects can apply to a variety of industries, as well as direct and indirect resellers (Alvarado, 2001:4).

Beyond the definitions and examples discussed above, our perspective on SCM is extended by describing it as a strategy that brings together the application of logistics and its focus on transactions between channel members with that of channel management and its focus on relationships within the channel (Alvarado, 2001:4).

## 3. Lean Thinking

In the 1980's, a massive paradigm shift hit factories throughout the US and Europe. Mass production and scientific management techniques from the early 1900's were questioned as Japanese manufacturing companies demonstrated that 'Just-in-Time' was a better paradigm. The widely adopted Japanese manufacturing concepts came to be known as 'lean production'. In time, the abstractions behind lean production spread to logistics, and from there to the military, to construction, and to the service industry. As it turns out, principles of lean thinking are universal and have been applied successfully across many disciplines. Lean principles have proven not only to be universal, but to be universally successful at improving results (Poppendieck, 2002:1).

Lean thinking is sometimes called lean manufacturing, the Toyota production system or other names (Nave , 2002:1). Lean manufacturing methods pioneered by Toyota are replacing conventional methods in both manufacturing and service industries (Venkat, & Wakeland , 2006:1). Lean focuses on the removal of waste, which is defined as anything not necessary to produce the product or service (Nave, 2001:1). Lean thinking is a systematic approach to developing business processes with the aim of doing more with less while coming as close as possible to providing customers exactly what they want, when and where they want it. It is already the dominant paradigm in manufacturing today, and it is also being applied to supply chains; therefore its environmental sustainability impacts are important to understand (Venkat, & Wakeland, 2006: 1).

Lean thinking is a five-step thought process proposed by James Womack and Daniel Jones to guide executives and managers through a lean transformation. The five steps are:

1) Specify value from the standpoint of the end customer by product family.
2) Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
3) Make the value creating steps occur in tight sequence so the product will flow smoothly toward the customer.
4) As flow is introduced, let customers pull value from the next upstream activity.

5) As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste (Womack, & Jones; 1996).

## 4. Logistics and Lean Logistics

The universal definition of logistics is; distributing correct material in correct quantity, in correct conditions, at correct place, in correct time, to the correct consumer with correct price.

The following definition emerged from numerous discussions of the subject with practitioners. Logistics is comprised of all the operations needed to deliver goods or services, except making the goods or performing the services.

The word “deliver” characterizes the activity by its outcome. “All the operations” then refers to everything that has to be done with goods, information and money in order to affect this outcome. Without the “except” clause in the definition, it would encompass all of business, and we know logistics doesn’t. Logistics encompasses everything that happens outside the factory walls.”

In manufacturing, it covers the material flows between plants and between production lines within a plant. It also includes the information flows generated by the processing of transactions associated with the material flows, the analysis of past activity, forecasting and the planning and scheduling of future activity, as well as the funds flows triggered by the movements of goods and information (Baudin, 2004: 9).

Lean logistics is the logistics dimension of lean manufacturing. Its first objective is to deliver the right materials to the right locations, in the right quantities and in the right presentation; its second, to do all of it efficiently. Lean logistics tailors approaches to the demand structures of different items, as opposed to one-size-fits-all. It is a pull system: materials move when destination signals that is ready for them. Moving small quantities of many items between and within plants with short, predictable lead times requires pickups and deliveries at fixed times along fixed rotes called ‘milk runs’. In turn, this supports the use of returnable containers (Baudin, 2004: 27).

The objectives of lean logistics can be stated as follows:

1) Delivering the materials needed, when needed, in the exact quantity needed, and conveniently presented, to production for inbound logistics to customers for outbound logistics.
2) Without degrading delivery, pursue the elimination of waste in the logistics process (Baudin, 2004: 30).

Milk run and cross dock are two of the applications of lean logistics. Milk run is a system that executes the collection of components with minimum vehicles in determined routes and orders from suppliers that separated to districts before. In cross dock system, the components received from suppliers are sent according to requirements of costumers. This system provides products to move from suppliers to receivers without stockpiling.

## 5. The supplier milk run concepts

A supplier milk run is a scheduled pickup of parts from multiple suppliers in matching quantities, and is a more sophisticated approach than a hub, reducing inventories of incoming materials, making lead times predictable even for items with variable consumption, smoothing the receiving workload, and providing an infrastructure for the transmission of pull signals (Baudin, 2004:131).

A supplier milk run is a scheduled pickup of parts from multiple suppliers designed to support a given production level. Instead of using the plant as a hub with trucks each shuttling back and forth to a single supplier bringing the same items by the full truckload, you have trucks making the rounds of multiple suppliers, returning empty containers and picking up less-than-truckload matching quantities of many different items, adding up to a full truckload (Baudin, 2004: 132).

The differences between the two approaches can be seen from working out the implications of the patterns shown in Figure 2. Milk runs are a more sophisticated system than a hub, and require more work to implement. Their advantages justify the extra effort (Baudin, 2004:132).

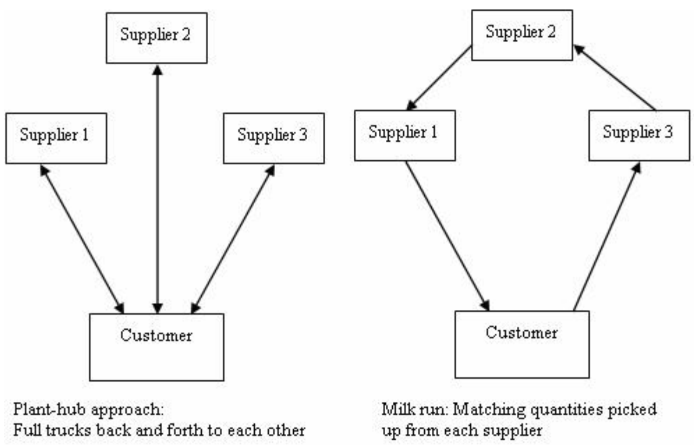


Figure 2. Supplier milk run versus traditional approach (Baudin, 2004:132)

Milk run work primarily with local suppliers, but a local milk run can include a remote supplier who maintains a local warehouse. Clusters of remote suppliers can also be served by milk runs, with cross docks or consolidation centers providing an interface to long-haul transportation by truck or intermodal railroad (Baudin, 2004:131).

Milk runs should not involve more than four or five suppliers, who are usually chosen for geographical proximity. If many are close to one another, then destination within the plant can also be used as a grouping criterion. Milk run routes can be planned using online mapping services, but taking into consideration factors like border crossings, traffic and weather conditions, and road work in progress requires a more dynamic analysis (Baudin, 2004:131).

One decided, the supplier sequence can be turned into a milk run schedule, with arrival and departure times at each site. The execution of milk run is then tracked against the schedule to refine it and to prevent schedule drift from affecting the supply of materials to the plant (Baudin, 2004:131).

The advantages of milk runs;

- Milk runs reduce inventory
- Predictable replenishment lead times
- Better inventory visibility
- Improved supplier communication (Baudin, 2004: 134-136)

## 6. Current cross-docking operation

To improve the overall operational efficiency in a supply chain, it is important to enhance the operations involved in warehousing, which are labor and cost intensive. Improving all functions of warehousing which include receiving, storing, picking, and shipping, can bring a higher level of efficiency in the supply chain. The ideal situation is not to keep any stock, but it is obviously very difficult to achieve. Cross-docking is a good alternative approach to product replenishment since it has the potential to decrease storage and carrying costs as well as improve customer services, increase the speed of operation and improve the operation of products distribution.

Cross-docking means handling products from a manufacturer to a retailer without the need to warehouse products in the distribution center. With the cross-docking system, the distribution center receives products, which can be on mixed pallets from a manufacturer for several destinations, and then, consolidates them with products from other manufacturers. The operation of cross-docking is summarized in Figure 3.

In cross-docking operation, each manufacturer gets electronic customers' orders for individual stores and delivers goods to the distribution center on the due date (arrow 1 in Figure 3). Then the manufacturer sends an advance shipping notice (ASN) to the distributor, which is an electronic document describing what is being shipped before products arrive (2). With the ASNs information, distributor's warehouse management system (WMS) makes a decision about what to do with the incoming products (3). Products can be directed to the outbound door in order to ship to the retailer or can be kept temporarily to be delivered together with the next group of trailers from other manufacturers. Another possibility is that products may need to be temporarily stored due to a lack of distribution center's trailer (Abdolvand, 2004 :3).

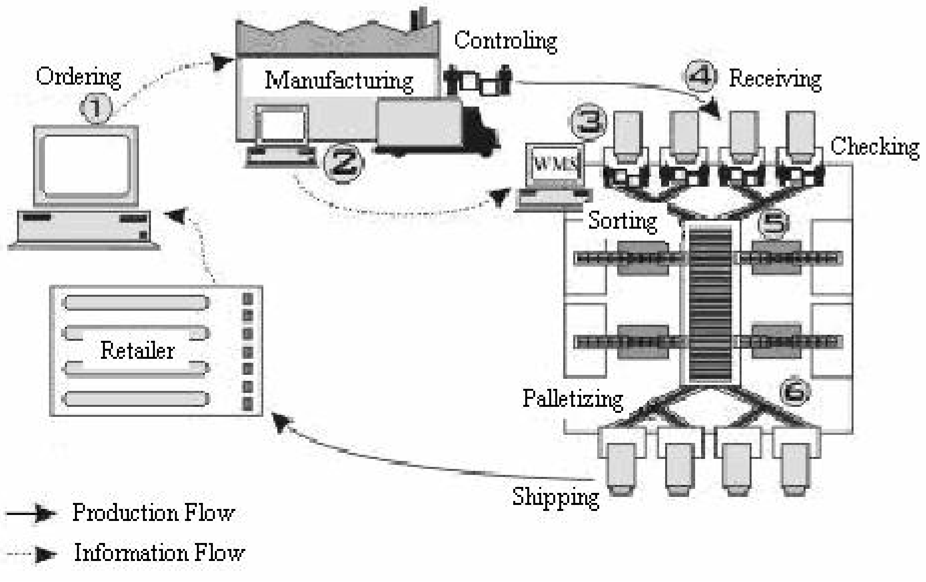


Figure 3. Summary of Current Cross-Docking Operation (Abdolvand, 2004 :4)

Upon receiving products at the distribution centre, products are unloaded from trailers, depalletized, and then checked manually or automatically through scanning the barcodes and verify them against the ASNs information (4). Then pallets received are sorted based on their destination (5). Manual sorting is a labor-intensive process, which has a high error rate. An automatic sorter is normally used at distribution centers, which reads the barcodes one each pallet that indicates the destination and then directs it to short term storage or outbound trailer. Since the reader can scan barcodes from one direction, operators should ensure that each case has a correct position on the conveyor belt. At the end of sort line, sorted items are palletized and loaded to trailers, or stored temporarily (6).

Cross-docking has different requirements for and various impacts on manufacturers, distributors and retailers. For manufactures, it enables them to have high visibility of individual store demands, since they get the individual store requirements. This allows them to have more stable production planning and lower inventory level, and to perform more efficient promotion. Dealing with individual store orders, however, may put manufacturers at risks of reducing the quantity of batch production, depending on stores demands (Abdolvand , 2004:4).

For distributors, the cross-docking operation is very efficient, since it does not require a large distribution centre area, complex computer systems, and reduces non-value added handling activities. Thus, it involves low overhead costs in handling cartons, low IT infrastructure requirements and reduced risk of overloading warehouse capacity. Other cost savings can be attained from reduced damaged products as a result of reduced double handling and reduced expired products since warehousing is eliminated (Abdolvand, 2004 :4).

For retailers, since most products are not stored in the warehouse, they will have longer shelf life, which is beneficial for retailers. Lower logistics costs as the result of higher efficiency operation at the distribution centre can be obtained only if cost savings obtained by the distributor (distribution centre) are passed on to the retailer (individual stores) through reduced service charged in delivering products to the stores (Abdolvand, 2004 :5).

## 7. Application

### 7.1. An Overview of Milk Run and Cross Docking Systems

According to theoretical information stated before and to the investigations of milk run and cross docking system in logistics firms, it is obvious that milk run and cross docking systems are more effective and even easier than traditional logistics applications. In spite of efficiency of these two methods, we have to decide in which situations milk run and cross docking systems are productive and effective. Cross docking system is suitable for transportation of products which are fast violable, big size and has predictable demand; but applying milk run system to these kinds of products is not possible, or if it is possible it will cost much and will create difficulties. In the same way, transporting big size-low volume products by big cross docking trucks also causes waste of capacity usage and fuel costs.

To make efficiency analysis of milk run and cross docking systems in application, first of all, it is necessary to determine the transportation cost items. These cost items are determined regardless of deviant cases for transportations.

1) Fuel cost of a vehicle
2) Minimum wage paid to driver
3) Payment for booth, bridge, highway, travel expense, etc.
4) Renovation costs
5) Costs per forwarding
6) Insurance costs

Vehicle fuel cost indicates fairly differences according to type of vehicle used. Nevertheless, it is necessary to standardize and determine average fuel consumption. To find out total fuel cost of a vehicle, some data is required. These are;

- The distance between two locations,
- Fuel consumption worth according to type of vehicle
- Fuel cost per meter,

Minimum wage is given to the vehicle driver. In addition to this, some requirements like food and etc. is also paid to the drivers of trucks and pickups.

Booth, bridge, travel expense, highways vary according to destination point. These costs are determined averagely.

Annual vehicle renovation costs are mentioned as an average value. If average number of forwarding of vehicles during a month is considered, annual number of forwarding can be found, and in this situation renovation outgoings are different for trucks and pickups.

Cost per forwarding can be calculated by dividing costs of vehicles for a month to the estimated forwarding number.

Insurance cost per forwarding can be calculated by dividing total annual bounty to the total forwarding number. Lead logistics providers determined insurance costs for the trucks and pickups.

Besides all of these cost items, number of the drivers to be kept in the vehicles should be decided. Another restriction that the logistics firm should take under consideration is the prohibition of driving a vehicle continuously more than 8 hours according to the traffic laws. Because of this prohibition, if it is necessary to drive more than 8 hours, 2 drivers should be assigned to this transportation. That’s why the transportation cost is increased.

Average capacity and speed of the trucks and pickups to be used in transportation process is also determined.

7.1.1. Cost Analysis of Milk Run and Cross-Docking Systems

In this part of the study, to find out in which situations milk run and cross docking systems are productive and effective; we have investigated two different transportation applications for total costs and productivity analysis.

7.1.1.1 First Transportation Process: Application of Milk Run and Cross Docking Systems to Transport High Demand-Big Size Products

Application of milk run and cross docking systems in x firm is shown in Figure 4. The firm has 5 suppliers in Bursa, İzmir, Aydın, Afyon and Eskişehir. One of the products to transport is diaper as an example. Diaper is an high demand-big size product, so it is suitable for our profile.

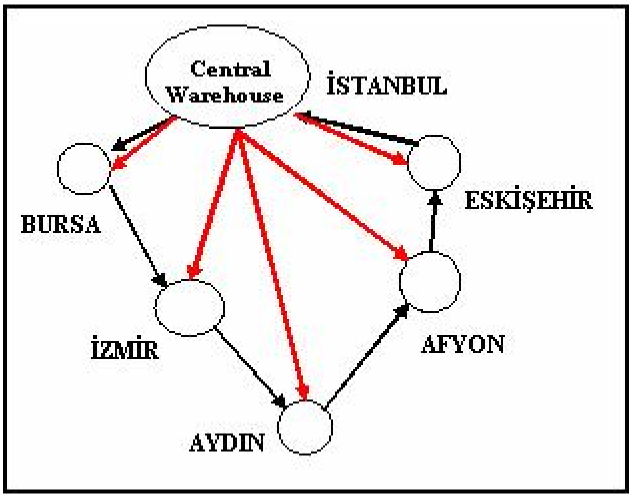


Figure 4. Central Warehouse and Distribution Centers

In this transportation process, 11 $m^3$ from Bursa, 12 $m^3$ from İzmir, 8 $m^3$ from Aydın, 11$m^3$ from Afyon and 12 $m^3$ from Eskişehir is required to transport. First of all we should define the distances between the cities and to the main distribution center in İstanbul. The distances required are given in Table 1.

Table 1. The distances between distribution centers

| | İSTANBUL | BURSA | İZMİR | AYDIN | AFYON | ESKİŞEHİR |
|---|---|---|---|---|---|---|
| İSTANBUL | - | 243 | 564 | 684 | 456 | 330 |
| BURSA | 243 | - | 321 | 441 | 275 | 149 |
| İZMİR | 564 | 321 | - | 127 | 323 | 412 |
| AYDIN | 684 | 441 | 127 | - | 347 | 489 |
| AFYON | 456 | 275 | 323 | 347 | - | 146 |
| ESKİŞEHİR | 330 | 149 | 412 | 489 | 146 | - |

Average speed is assumed as 70 km/hour so we can calculate transportation time. Transportation time is shown in Table 2.

Table 2. Transportation time between the distribution centers

| | İSTANBUL | BURSA | İZMİR | AYDIN | AFYON | ESKİŞEHİR |
|---|---|---|---|---|---|---|
| İSTANBUL | - | 3.5 | 8 | 10 | 6.5 | 5 |
| BURSA | 3.5 | - | 4.5 | 6.5 | 4 | 2 |
| İZMİR | 8 | 4.5 | - | 2 | 5 | 6 |
| AYDIN | 10 | 6.5 | 2 | - | 5 | 7 |
| AFYON | 6.5 | 4 | 5 | 5 | - | 2 |
| ESKİŞEHİR | 5 | 2 | 6 | 7 | 2 | - |

7.1.1.1.1. Using Milk Run Application in first transportation process

In logistics firm, the maximum volume of a truck which can be used in milk run transportation is 40$m^3$. But in this example it is necessary to transport 53$m^3$ as total. That's why only one truck is not enough to carry for this transportation. In this cycle, first truck leaves the milk run system when it is full loaded and turns back to İstanbul. Then the second one continues the transportation wherever the first one leaves.

First truck loads up 11$m^3$ in Bursa, 12$m^3$ in İzmir, 8 $m^3$ in Aydın. The total volume of these products which is taken from three cities is 31$m^3$. The next point is Afyon, there are products which has 11$m^3$ volume at this point. But since these products are overcapacity for the first truck, it can not take anymore product and turns back to central warehouse. All the products that have to be taken from Afyon are loaded to second truck which had already sent.

Second truck is loaded up 11m$^3$ in Afyon and 12 m$^3$ in Eskişehir, which then turns back to central warehouse. The time between Aydın and İstanbul is 10 hours; therefore it is necessary to have two drivers in both trucks. One driver is enough for the second truck for Eskişehir. After all of these, all deficient cost items for the transportation process that used milk run system were calculated step by step. Total cost for this process calculated as 1.458,285 YTL. Our new route is shown in Figure 5.

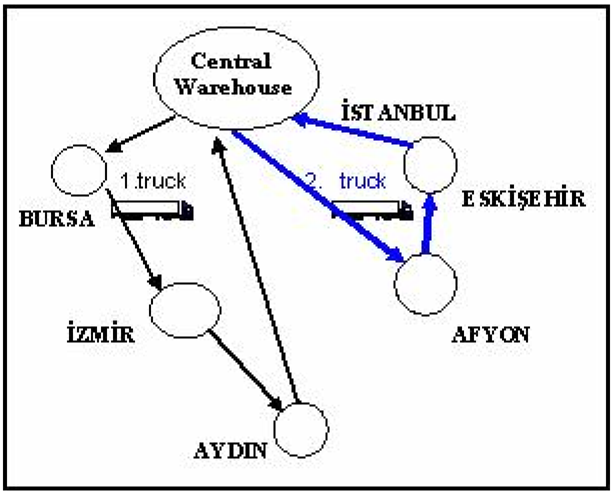


Figure 5. Application Of Milk Run System in First Transportation Process

As a result of applying milk run system for this transportation fairly high cost has occurred. Also the capacity of milk run trucks could not be used efficiently.

7.1.1.1.2. Using cross docking system in first transportation process

If we actualize this transportation process with cross docking system; sending only one pickup truck to suppliers in each city is enough. Fuel costs and all the other outgoings are calculated using data as we stated before. Total cost for this process is calculated as 1.116,9 YTL. Our route is shown in Figure 6.

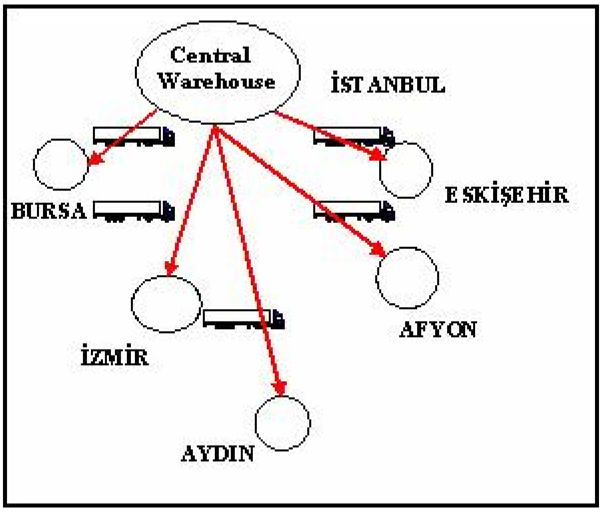


Figure 6. Application of cross docking system in first transportation process

As we see that using milk run system to transport products which have high volume, fairly high costs; especially fuel costs has occurred. But using cross docking systems decreases costs and provide an optimal cost.

7.1.1.2. Second Transportation Process: Application of Milk Run And Cross docking Systems to Transport Medium Or Low Demand-Small Size Products

Second transportation process which applied in x firm is shown. In this transportation process, 9 m$^3$ from Bursa, 7 m3 from İzmir, 11m3 from Aydın, 5m3 from Afyon and 7 m$^3$ from Eskişehir is required to transport. We can give an automotive industry manager as an example who has a basic industry factory in İstanbul, and take spare part of an engine from suppliers in that five city. Spare parts which required in automotive industry are suitable for this profile. In this example, application costs of these two transportation systems are found and efficiency analysis is made.

7.1.1.2.1. Using Milk run System in Second Transportation Process

Total volume of the products is $39m^3$; that's why we can use only one milk run truck which has capacity of $40m^3$ for this process. All cost items are calculated and total cost for this process is found out as 745.125 YTL. The milk run system is shown in Figure 7.

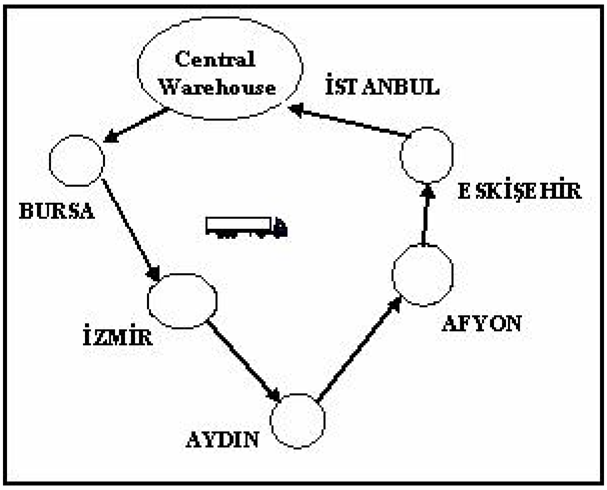


Figure 7.Application of milk run system in second transportation process

7.1.1.2.2. Using cross docking system in second transportation process

If we actualize this transportation model with cross docking system, a pickup truck with 12 $m^3$ capacity is assigned to each city for transportation from central warehouse to cities.

In this case, costs are the same with cross docking system which is applied in the example before (distances and the facts that affecting costs are the same for both.). Thereby, total cost of this transportation using cross docking system obtained as 1.116,9 YTL.. Our route is shown in Figure 8.

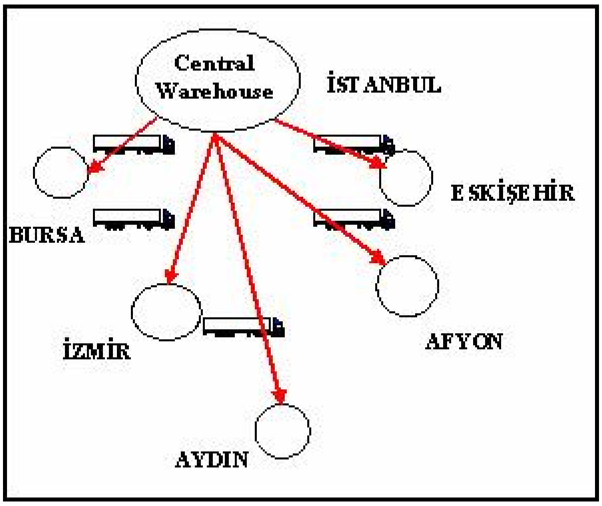


Figure 8. Application of cross docking system in second transportation process

As a result, to transport big volume- high demand products, cross docking is a low-cost method; while transporting small size-low demand products except food, milk run system creates opportunity cost. These two systems are both productive and effective methods which are applied in logistics management. The important thing is to apply these methods in right transportation processes.

## 8. Conclusion

In this study, milk run and cross docking system were investigated which are used in recent years. Their definitions, theoretical and practical applications, advantages and disadvantages, application forms, efficiency and productivity in transporting diverse products were mentioned.

Milk run and cross dock are two of the applications of lean logistics. Milk run is a system that executes the collection of components with minimum vehicles in determined routes and orders from multiple suppliers that separated to districts before. In cross dock system, the components received from suppliers are sent according to requirements of costumers. This system provides products to move from suppliers to receivers without stockpiling.

Owing to cross docking system, traditional storing system which caused fairly high warehouse area requirement is left and inventory level is lowered to zero without stocking. By this way storage cost decreased and even eradicated. This situation provided decreasing of production costs on account of decreasing transportation cost. While cross docking system is suitable for transportation of big-size, high-demand products having short lifetime; milk run system brings quiet positive results for transporting small-size, low-demand and durable products. So it can be said that milk run and cross docking systems provide so many advantages to reach lean logistics and production goals in different ways.

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# MULTI-ECHELON AND MULTI-TRANSPORT MODE PRODUCT DISTRIBUTION NETWORK DESIGN: AN APPLICATION

Umut R. Tuzkaya[1] and Semih Önüt[2]

## Abstract

*Distribution network systems are complicated organizations that involve many human and material resources and also display complex relationships and tradeoffs among the various decision policies affecting their different components. Hence classifying these policies due to the planning levels will be convenient in strategic, tactical and operational levels. Strategic issues are related with design of the physical network and the acquisition of the resources; tactical issues include design of service network and; operational issues concern with the implementation and adjustment of schedules. Multi-echelon and multi-transport mode distribution networks are commonly used for consumer products and other packaged good industries. These networks also include all decision levels, but this study includes only strategic and tactical decision issues. The used model is a mixed integer problem which assumes a distribution network consisting of main transshipment warehouses, major regional warehouses and local depots. This model tries to meet the customer demands while minimizing sum of the transportation cost and, variable and annual fixed costs of warehouse operations. Finally the model is applied for a distribution network and the results are discussed.*

*Keywords: Network Design, Multi-Echelon, Multi-Transport Mode*

## 1. Introduction

A typical supply network involves two main processes integrated with each other: the production planning and inventory control process which deals with manufacturing, warehousing and their interfaces, and the distribution and logistics process which determines how products are retrieved and transported from the warehouse to retailers (Tsiakis, Shah & Pantelides, 2001). The supply network components basically consist of a number of manufacturing plants; zero, one or more distribution echelons with distribution centers; the customers; the suppliers of components and raw materials, and the transportation channels that link all of the above components (Goetshalckx, Vidal & Dogan, 2002). Distribution network systems are complicated organizations that involve many human and material resources and also display complex relationships and tradeoffs among the various decision policies affecting their different components. Hence classifying these policies due to the planning levels will be convenient in strategic, tactical and operational levels. Strategic level involves the design of the physical network and decides the location, capacity and optimal number of suppliers, manufacturers and distributors in the network. Tactical level includes planning the supply to optimize the flow for purchasing, processing and distribution of goods and services through the network. Operational level concerns with the production scheduling at the all plants. A distribution network design problem is a strategic level network design problem where multiple products are delivered through distribution facilities to satisfy requirements at multiple locations. In such a network, suppliers may be warehouses or plants, while the destinations may be distribution centers or retailers. These kinds of distribution networks have multi-echelon and multi-transport mode.

A large number of mathematical and heuristic model have been developed for design, planning and optimization of distribution networks. Most of them are related with the design of the multi-echelon distribution networks, but a few of them are focused on the integration of the specific functions, like warehouses and transport modes in multi-echelon concept. Khouja, (2003) modeled and solved a three-echelon, multi-customer, non-serial supply inventory system by using an integer multipliers mechanism. Nozick, & Turnquist, (2001) focused on the integration of discrete choice location models, inventory analysis and multi-objective techniques to model the overall logistics impacts of locating distribution centers. Tsiakis, Shah, & Pantelides, (2001) modeled a multi-product, multi-echelon supply network by using mathematical programming approach. Nagurney, Dong, & Zang, (2002) developed an equilibrium model of competitive supply networks and established a finite-dimensional variational equality formulation. In the same time a supply network problem formulated by 0-1 mixed integer programming model and then proposed the spanning tree-based genetic algorithm as the solution method (Syarif, Yun, & Gen, 2002). In another study, Jayaraman, & Pirkul (2001) designed a production and distribution systems model and evaluate its performance using a mixed-integer programming and heuristics solution procedure. Tang, Yung, & Ip, (2004) discussed an integrated decision system for production assignment, lot sizing, transportation and order quantity in a multiple-supplier/multiple-destinations supply network using two heuristics based two-layer decomposition method.

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Yeh (2005) recently proposed a revised mathematical model to analyze a multi-stage supply network and identified a hybrid heuristic algorithm by combining a greedy method, the linear programming technique and three local search methods. As a different modeling approach, a stochastic programming model and solution algorithm proposed for large-scale supply network design problems under uncertainty (Santoso, Ahmed, Goetshalckx, & Shapiro, 2005). Nagurney, (2006) considered the relationship between supply chain network equilibrium and transportation network equilibrium and formulated them as a transportation network equilibrium model with elastic demands in the case of known demand functions.

There also exist a number of studies focused on the warehousing and distribution or transportation functions specifically. Snow, Miles, & Coleman, (1992) made a different explanation for dynamic network and illustrated three different types of network which were internal, stable and dynamic. A global supply chain model was presented by Arntzen, Brown, Harrison, & Trafton, (1995) for designing a production, distribution and vendor network. They used MIP for minimizing the cost and/or weighted cumulative production and distribution times subject to a variety of demand and capacity constraints. Jayaraman, (1998) presented a mixed-integer programming model for examining the effects of facility location, transport modes and inventory related issues in a distribution network design environment. An evaluation and design approach based on integrating the analytical hierarchy process and mixed-integer programming for a warehouse network was proposed by (Korpela, & Lehmusvaara, 1999). Melkote, & Daskin, (2001) developed a model that simultaneously optimizes facility locations and the design of the underlying transportation network by considering mixed-integer programming formulation of the uncapacitated facility location/network design problem. Hwang, (2002) formulated the design problem using stochastic set-covering problem to determine the minimum number of warehouse and distribution centers among a discrete set of location sites so that the probability of each customer to be covered is not less than a critical service level and solved this problem using 0-1 programming method. Yan, Yu, & Cheng, (2003) proposed a strategic production–distribution model for supply chain design with consideration of bills of materials (BOM). Logical constraints were used to represent BOM and the associated relationships among the main entities of a supply chain such as suppliers, producers, and distribution centers. They showed how these relationships were formulated as logical constraints in a mixed integer programming (MIP) model. Another important study focused on the integration concept mainly emphasized the potential advantages gained by integrating and simultaneously optimizing the performance of both the warehousing and transportation functions of the SN by using a discrete event simulation methodology (Mason et al., 2003). Jarayaman, & Ross, (2003) defined a production, logistics, outbound and transportation system which is characterized by multiple product families, a central manufacturing plant site, multiple distribution center and cross-docking sites, and retail outlets. As a solution procedure of this kind of distribution network design problem, an integer programming and simulated annealing methodology was proposed by the authors. Teo, & Shu, (2004) proposed an integrated model for the optimal distribution network design problem taking into account warehouse-retailers echelon inventory replenishment costs and formulated the problem as a mixed-integer set-portioning problem. Wee, & Yang, (2004) also presented a single-producer, multi-distributors and multi-retailers inventory system as a distribution network and compared mathematical and heuristic solutions of this network. Shu, Teo, & Shen, (2005) considered a stochastic transportation-inventory network design problem involving single supplier and multiple retailers and analyzed under uncertain demand condition. Amiri, (2006) studied the distribution network design problem that involves locating production plants and distribution warehouses, and determining the best strategy for distributing the product from the plants to the warehouses and from the warehouses to the customers. A mixed-integer programming model and a heuristic solution procedure were used to solve the problem.

Additionally Wasner, & Zapfel, (2004) proposed a model that enables conclusions about the optimal network design with respect to the number and locations of depots and hubs, depot boundaries and type of network. They also described why optimal design of depot and hub transportation networks for parcel service providers makes it necessary to develop a generalized hub location and vehicle routing model. Ozdemir, Yucesan, & Herer, (2005) considered coordination among stocking locations through replenishment strategies taking into consideration transshipments, transfer of a product among locations at the same echelon level. Chan, Carter, & Burnes, (2001) formulated a multiple-depot, multiple-vehicle, location-routing problem with stochastically processed demands.

In this study, a multi-echelon and multi-transport mode product distribution network consisting of a main port, three major transshipment warehouses, eight regional warehouses and twelve local depots as the demand points is considered. The proposed model tries to meet the customer demands while minimizing sum of the transportation cost, and annual fixed cost of warehouse operations by using mixed-integer programming. This study is organized as follows: The definition of the proposed model is described in section 2. The numerical example is presented and the results are discussed in section 3. Finally the main conclusions are summarized in section 4.

## 2. Model Design

The presented model, designed by inspiring from Miller (2001), integrates multi-echelon distributions and transportation planning problem. Firms can order different product types in different amounts which are convenient for transporting as full truckload or less-than-truckload (LTL). These demand patterns of the firms related with volume, frequency, continuity, product variety of orders and distances between points in the network influence the length, structure and working style of the network. The numbers, capacities, functions of the warehouses and financial budgets that will be separated for warehouse openings are strategic decisions. Also routings, truck sizes or transportation mode decisions are tactical decisions. Considering these decisions in the different hierarchical levels constitutes complex models and solution techniques.

In this study, a multi-echelon and a multi-mode planning model is constituted to choose the right places, to build the warehouses among alternative places and to satisfy the demands of firms by convenient transportation modes under the capacity and financial constraints. The proposed model can be assumed as the last part of an inter-modal transportation network structure which starts with the end of long-haul in a port. The first echelon consists of the transportation of containers to main (transshipment) warehouses, consolidation the palletized products and transportation to second or third echelon. The second echelon warehouses serve as regional depots and generally are used for temporarily holding products for a few days instead of stocking them for long terms. Finally, in the third echelon, products are transported to demand points by local delivery trucks. The function of the third echelon warehouses is mainly to consolidate the smaller orders of the firms requested from different first echelon warehouses that destined for the same ultimate customer receiving location. Below, the notation of the three echelon network model is given;

Notations:

$l$ : Indices for the product types
$i$ : Indices for the transshipment warehouses
$k$ : Indices for the demand point
$j$ : Indices for the regional warehouses
$s_{il}$ : Quantity of product $l$ transported from port or main (intermodal) transshipment point to transshipment warehouse $i$.
$t_{ikl}$ : Quantity of product $l$ transported by direct truckload from transshipment warehouse $i$ to demand point $k$
$d_{kl}$ : Product $l$ demand of demand point $k$
$u_{ijl}$ : Quantity of product $l$ transported by direct truckload from transshipment warehouse $i$ to regional warehouse $j$.
$x_{jkl}$ : Quantity of product $l$ transported by local delivery from regional warehouse $j$ to demand point $k$.
$z_{ikl}$ : Quantity of product $l$ transported by less than truckload (LTL) from transshipment warehouse $i$ to demand point $k$

$$yt_i = \begin{cases} 1, & \text{if transshipment warehouse } i \text{ is opened} \\ 0, & \text{otherwise} \end{cases}$$

$$yr_j = \begin{cases} 1, & \text{if regional warehouse } j \text{ is opened} \\ 0, & \text{otherwise} \end{cases}$$

$a_{il}$ : Transportation cost from port to transshipment warehouse $i$ per unit product $l$
$b_{ikl}$ : Direct truckload transportation cost from transshipment warehouse $i$ to demand point $k$ per unit product $l$
$c_{ijl}$ : Direct truckload transportation cost from transshipment warehouse $i$ to regional warehouse $j$ per unit product $l$
$e_{jkl}$ : Local delivery truck transportation cost from regional warehouse $j$ to demand point $k$ per unit product $l$
$g_{ikl}$ : LTL transportation cost from transshipment warehouse $i$ to demand point $k$ per unit product $l$
$Ft_i$ : Annual fixed cost for operations in transshipment warehouse $i$
$Fr_j$ : Annual fixed cost for operations in regional warehouse $j$
$It_i$ : Investment cost to open a transshipment warehouse $i$
$It_j$ : Investment cost to open a regional warehouse $j$
$C_l$ : Capacity of product $l$ shipped to port for one year.
$U_i$ : Maximum number of transshipment warehouses that the firm opens
$U_j$ : Maximum number of regional warehouses that the firm opens
$B^O$ : Maximum financial investment that the firm wants to make for opening new transshipment warehouses
$B^N$ : Maximum financial investment that the firm wants to make for opening new regional warehouses
$B$ : Maximum total financial investment that the firm wants to make for opening new transshipment and regional warehouses
$Tti$ : Annual product holding capacity for transshipment warehouse $i$
$Tr_j$ : Annual product holding capacity for regional warehouse $j$

The formulation of the multi-echelon and multi-modal distribution model can be found in Eqs. (1) ~ (14)

$$\min = \sum_{i=1}^{I}\sum_{l=1}^{L} a_{il}s_{il} + \sum_{i=1}^{I}\sum_{k=1}^{K}\sum_{l=1}^{L}(b_{ikl}t_{ikl} + g_{ikl}z_{ikl}) + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{l=1}^{L} c_{ijl}u_{ijl} + \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{l=1}^{L}(e_{jkl}x_{jkl})$$
$$+ \sum_{i=1}^{I} yt_i(Ft_i + It_i) + \sum_{j=1}^{J} yr_j(Fr_j + Ir_j) \quad (1)$$

Subject to

$$\sum_{i=1}^{I} s_{il} \le C_l \qquad l = 1,\dots,L \quad (2)$$

$$\sum_{l=1}^{L} s_{il} \le Tt_i \qquad i = 1,\dots,I \quad (3)$$

$$\sum_{i=1}^{I}\sum_{l=1}^{L} u_{ijl} \le Tr_j \qquad j = 1,\dots,J \quad (4)$$

$$\sum_{i=1}^{I}(t_{ikl} + z_{ikl}) + \sum_{j=1}^{J}(x_{jkl} - d_{kl}) = 0 \qquad k = 1,\dots,K; \quad l = 1,\dots,L \quad (5)$$

$$yt_i s_{il} \ge \sum_{k=1}^{K} t_{ikl} + \sum_{k=1}^{K} z_{ikl} + \sum_{j=1}^{J} u_{ijl} \qquad i = 1,\dots,I; \quad l = 1,\dots,L \quad (6)$$

$$yr_j \sum_{i=1}^{I} u_{ijl} \ge \sum_{k=1}^{K} x_{jkl} \qquad j = 1,\dots,J; \quad l = 1,\dots,L \quad (7)$$

$$\sum_{i=1}^{I} s_{il} \ge \sum_{i=1}^{I}\sum_{k=1}^{K} t_{ikl} + \sum_{i=1}^{I}\sum_{k=1}^{K} z_{ikl} + \sum_{i=1}^{I}\sum_{j=1}^{J} u_{ijl} \qquad l = 1,\dots,L \quad (8)$$

$$\sum_{i=1}^{I}\sum_{j=1}^{J} u_{ijl} \ge \sum_{j=1}^{J}\sum_{k=1}^{K} x_{jkl} \qquad l = 1,\dots,L \quad (9)$$

$$\sum_{i=1}^{I} yt_i \le U_i \quad (10)$$

$$\sum_{j=1}^{J} yr_j \le U_j \quad (11)$$

$$\sum_{i=1}^{I} yt_i It_i \le B^N \quad (12)$$

$$\sum_{j=1}^{J} yr_j Ir_j \le B^O \quad (13)$$

$$\sum_{i=1}^{I} yt_i It_i + \sum_{j=1}^{J} yr_j Ir_j \le B \quad (14)$$

The proposed model tries to satisfy the demands of firms (ultimate customers) while minimizing the all kind of transportation costs among echelons, warehouse opening (investment) costs and fixed costs for warehouses. The obtained decisions are to open the transshipment and regional warehouses in adequate number and in convenient alternative location and also to determine the best routes while transporting the products through port to ultimate customers. Another result of the model is to choose the mode of transportation among the alternative transportation-modes including: (1) direct truckload shipments from transshipment warehouses to regional warehouses or to demand points, (2) direct less than truckload (LTL) from transshipment warehouses to demand points, and (3) local deliveries from regional warehouses to demand points. Due to the some model constraints and some part of the objective function, model can be assumed as both strategic and tactical decision support tool.

As the first constraint of the model, Eq. (2) ensures to not violate the capacity of port in terms of coming product quantities. Eq. (3) and Eq. (4) constraint to not violate the stock holding capacity of transshipment warehouses and regional warehouses, respectively. Eq. (5) satisfies the demand of a firm for a certain product type by using one of the transportation-mode through the echelons. Eq. (6) ensures that a transshipment warehouse is being reached the product types in sufficient amounts from port for shipping to regional warehouses or demand points. And also, the decision of opening a transshipment warehouse is provided in this constraint by using binary variable. Eq. (7) ensures that a regional warehouse is being held a product type in sufficient amount to meet the product orders of a firm by pulling from transshipment warehouses. Eq. (8) and Eq. (9) ensure to have sufficient amount of a product type for all echelons while transporting orders to lower echelons. Eq. (10) and Eq. (11) put an upper bound for the number of echelon 1 and echelon 2 warehouses that a firm making the decision of opening and operating on its network. Eq. (12) is another bounding constraint to put an upper bound for the maximum investment cost opening a warehouse in echelon 1, while Eq. (13) performs the same limitation for opening a warehouse in echelon 2. The last constraint represented by Eq. (14) ensures to not exceed a financial investment for echelon 1 and echelon 2 in total.

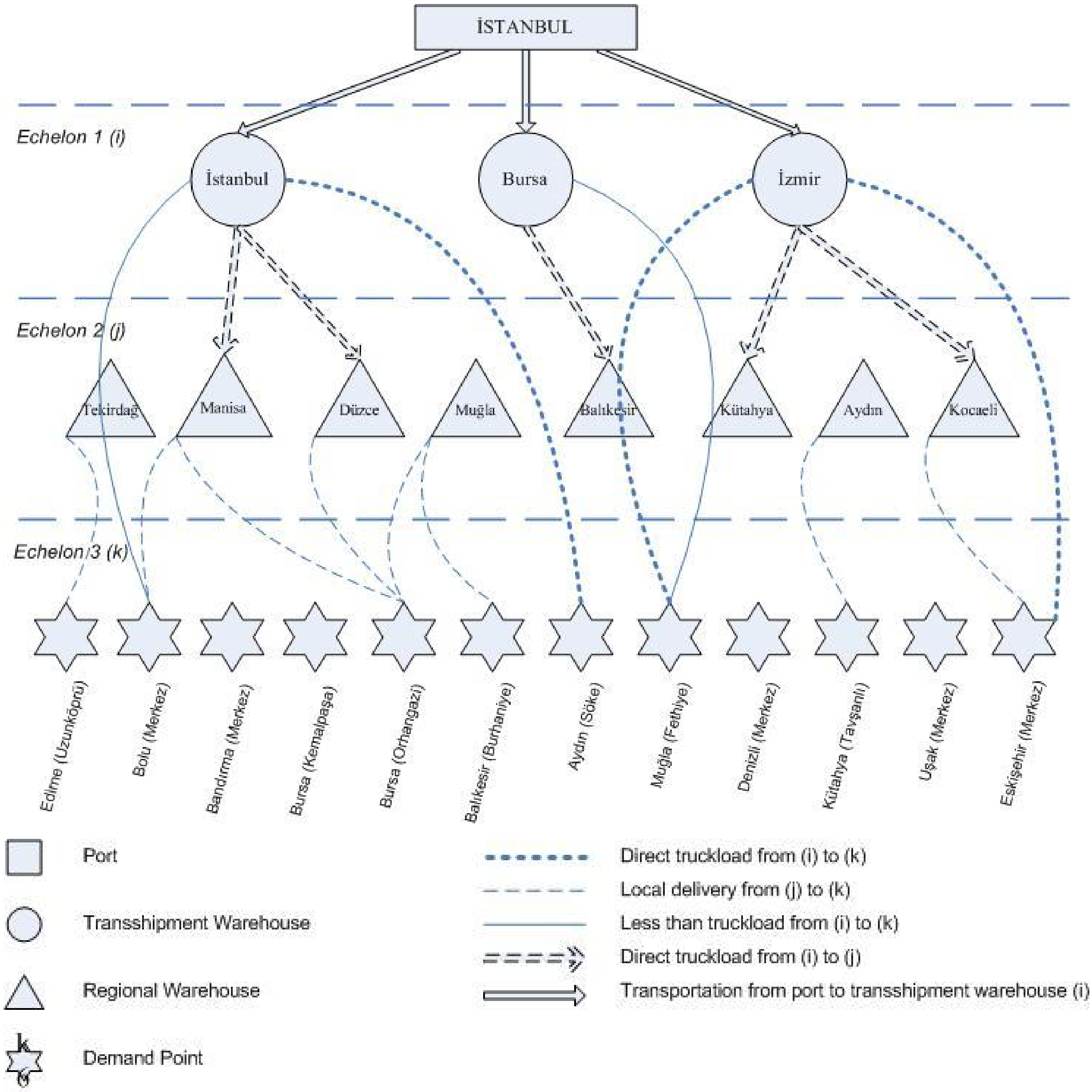


*Figure 1. A multi-echelon and multi-mode distribution example*

It must be noted that in applying the model for a real situation, amortized annual costs can be expressed in the model instead of using investment costs. Also some budgeting constraints can be extracted or some additional constraints which are not described in this formulation can be employed to the model.

## 3. A Numerical Example

For illustrative purposes, a numerical example is given which includes a logistics firm that uses some quantitative data, such as transportation, warehousing, investment costs to constitute a transportation network. The transportation network tried to establish has a top-down hierarchical relationship. Some strategic and tactical distribution planning activities are also considered in that decision process. The firm will be performing its activities in West Anatolia and Marmara regions. The distribution network, which starts with a port in Istanbul, has 3 echelons and in each echelon there are alternative warehouse places; 3 alternatives for transshipment warehouses and 8 alternatives for regional warehouses to realize the orders of 12 different firms (Figure 1). Beside the financial investment limitations, the firm is planning to open transshipment warehouses in the two of the alternative places and regional warehouses in the seven of the alternative places at most.

Transportation of the three kind of palletized products through the network is considered. Capacity of a truck is 42 units, 21 units, and 14 units for product 1, product 2, and product 3, respectively. The data on the transportation cost parameters of the model are gathered considering the distances between the port and warehouses or warehouses and demand points. This distance values are multiplied by some variable costs such as depreciation rates, fuel consumption rates and fixed costs, such as salary of drivers, maintenance expenditures, etc. Eventually, the transportation cost of a truck between transshipment warehouses and regional warehouses or demand points is 1.8 YTL/km for full truck loads and 2.34 YTL/km for LTLs. The transportation cost of a local delivery truck between regional warehouses and demand points is 1.3 YTL/km. Another data set related with the capacities of coming products to the port and capacities of the warehouses is given in Table 1.

Table 1. Capacities of coming products to the port and the warehouses (in pallets)

| l | Capacity of coming products to the port ($C_l$) | i | Capacity of transshipment warehouse ($Tt_i$) | j | Capacity of regional warehouse ($Tr_j$) |
|---|---|---|---|---|---|
| 1 | 15,000 | 1 | 18,000 | 1 | 6,000 |
| 2 | 10,000 | 2 | 20,000 | 2 | 5,000 |
| 3 | 10,000 | 3 | 15,000 | 3 | 5,000 |
| | | | | 4 | 6,000 |
| | | | | 5 | 6,000 |
| | | | | 6 | 5,000 |
| | | | | 7 | 6,000 |
| | | | | 8 | 5,000 |

According to the feasibility studies, the investment costs of opening a warehouse in each alternative location and annual fixed costs for them are determined considering the regional conditions (Table 2). The firm organizing the distribution network plans to open at most two transshipment warehouses and seven regional warehouses to the alternative locations. Budgets in different amounts are planned to allocate considering both the echelon levels and entire network like as 4,900,000 YTL for transshipment warehouses, 4,500,000 YTL for regional warehouses and 9,000,000 YTL for entire network at most.

Table 2. Investment and annual fixed costs for warehouses in echelon one and two (YTL)

| i | Annual fixed costs of warehouses in echelon 1 ($Ft_i$) | j | Annual fixed costs of warehouses in echelon 2 ($Fr_j$) | i | Investment cost for opening a warehouse in echelon 1 ($It_i$) | j | Investment cost for opening a warehouse in echelon 2 ($Ir_j$) |
|---|---|---|---|---|---|---|---|
| 1 | 1,450,000 | 1 | 365,000 | 1 | 2,500,000 | 1 | 500,000 |
| 2 | 1,300,000 | 2 | 370,000 | 2 | 2,000,000 | 2 | 600,000 |
| 3 | 1,200,000 | 3 | 375,000 | 3 | 1,000,000 | 3 | 600,000 |
| | | 4 | 350,000 | | | 4 | 500,000 |
| | | 5 | 370,000 | | | 5 | 580,000 |
| | | 6 | 350,000 | | | 6 | 500,000 |
| | | 7 | 350,000 | | | 7 | 500,000 |
| | | 8 | 380,000 | | | 8 | 650,000 |

The model having the above given input data is solved by using Industrial LINGO/PC Release 3.1 and a feasible solution is obtained. The results show that opening one transshipment warehouse is not sufficient in terms of capacity constraints. Therefore opening two warehouses in echelon 1 in Bursa and Izmir will be convenient to meet the total demands of firms for all product types. However, opening warehouses in regional points is not a preferred situation and only one regional warehouse is opened in Kocaeli. The main reason of this situation is the shortness of the distances between warehouses and demand points. Although local deliveries have lower costs than full truck and LTL transportation, they can not tolerate investment and annual fixed costs of regional warehouses. Besides, solving the model for longer periods can give different results that have more regional warehouses. Another result is full truck loads are preferred to LTL. Because of not considering the holding inventory cost in demand points, all orders are shipped as full truck loads. The entire transported amount for all product types among echelons are given in Table 3 and Table 4.

Table 3. Transported amount for all product types from the port to echelon 1 warehouses (in pallets)

| Product type (l) | Transshipment warehouse 2 (Bursa) | Transshipment warehouse 3 (Izmir) |
|---|---|---|
| 1 | 7560 | 6552 |
| 2 | 6224 | 3100 |
| 3 | 6216 | 2856 |

Table 4. Direct truckloads from transshipment warehouses to demand points (in pallets)

| Demand Points | Transshipment Warehouses | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 2 | | | 3 | | |
| | Product Types | | | | | | | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 1512 | 504 | 672 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 1008 | 1008 | 840 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 504 | 504 | 336 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 1260 | 1008 | 1008 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1512 | 1008 | 840 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 2520 | 1260 | 1344 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1008 | 504 | 672 |
| 10 | 0 | 0 | 0 | 1008 | 1008 | 840 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 180 | 840 | 504 | 324 | 0 |
| 12 | 0 | 0 | 0 | 1512 | 756 | 840 | 0 | 0 | 0 |

Beside this transportations, transshipment warehouse in Bursa transports from each product types to regional warehouse in Kocaeli in the sizes of 2016, 1008, and 840 pallets, respectively. And these products are transported to the first demand point in Edirne (Uzunköprü) in the sizes of 1008, 756, 336 pallets, respectively and also to the second demand point in Bolu (Merkez) in the sizes of 1008, 252, 504 pallets, respectively.

## 4. Conclusions

This study aims to design a distribution network as a drayage part of an inter-modal transportation structure. The main contribution of this study is to consider both strategic and tactical decisions. If the sufficient data is obtained, solving the model for different period lengths will generate different scenarios for decision makers. The validation of the model is realized by solving a hypothetical data set and the results are discussed. However, the model has non-linear variables and the obtained results are local optimum. Therefore, using a heuristic to get a near optimal solution can overcome this problem in future studies.

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# GDANSK, GDYNIA, SZCZECIN AND SWINOUJSCIE AS THE DISTRIBUTION-LOGISTIC CENTRES

Adam Salomon[1]

## Abstract

*In the article is pointed that Polish seaports - particularly Gdansk, Gdynia and Szczecin with Swinoujscie - are able in the near future to offer the logistic platforms for the combined transport: sea-train and marine-land. Forming the logistic Centre is the main condition of Polish seaports competitiveness on the supermarket of port services. The port of Gdansk has the very good location, because the A1 motorway still designed, and access to the seaport thanks of six branches of the transport such as: road, sea and river, as well as transmission, rail and air. Near Gdansk seaport is located the pipeline with the domestic net and the airport in Rebiechowo (Lech Wałesa Airport). West-Pomeranian province has the profitable geographical situation as well, mainly because of location of two seaports (Szczecin and Swinoujscie). Forming the logistic-distribution centres in Polish seaports is an investment-organizational undertaking about important and positive consequences for the entire economy of Poland.*

Keywords: Distribution-logistic centre, Polish seaports, Gdansk, Gdynia, Szczecin, Swinoujscie, Matitime transport, Seaborne trade.

## 1. Introduction

By the logistic centre we should understand the self-reliant economic subject possessing the allocated land tied together with communications surroundings, the infrastructure, equipping for transferring and storing and for managing the flow of charges, the staff and the organization. This subject is rendering logistic services (the transport, handling, storing, distribution and collecting), carrying out supply and distribution posts into this way of area (of region). These services are being carried out in frames of agreements or temporary instructions from national and foreign companies. Forming the logistic-distribution centres in Poland, peculiarly in seaports, it is coming across a lot of problem being the result, among others, of the step of integration of individual branches in the Polish transport system. Lack of modern organizational structures adapted for rendering logistic services, lack of the advanced standardization of port-commercial documentation and appearing are also feeling themselves of huge capital-intensive nature of construction from bases of logistic centres (Klimek 1998: 119).

The research on spatial structures of the biggest seaports of the world is pointing explicitly, that in spite of the difficulties replaced higher up, it is possible to create the zones of distribution services. The result of experience of West-European ports, is that peculiarly profitable conditions to the development of the distribution function are creating existing conventional packaged wharves, wealthily equipped with storage spaces. As a result of the long-lasting trend of lowering amounts of handling of the conventional cargo part of wharves (together with the storage surface) serving the personnel of this cargo is unused or poorly used. And so it is possible as the part of the conversion to allot it up to the development of the distribution function. Foreign experience demonstrated, that adaptation of old port areas is economically justified and cheaper action, than depositing objects serving for this activity in new, unarmed places.

## 2. Strategy of construction of the logistic centres of distribution

The strategy of construction of the logistic centres of distribution must be based on the deepened market analysis taking into consideration conditions of the hinterland, the need and the possibility, the economic potential, existing and potential distribution and logistic channels, conditions of realization of distribution and logistic tasks as well as conditioning physical distribution. For formulating the strategy of construction of the centre marketing analysis based on the team of methods and marketing-mix tools is useful (the product, the distribution politics, the promotion, the pricing policy, the staff).

In order to formulate the strategy of the undertaking, SWOT analysis, enabling the epithet and analysis of outside and internal conditioning, weak and strong elements has basic meaning and of chances and taking risks. Resulting marks in carried analyses should take the liberty of describing the strategy using strong pages and the chance and improving weak sides and the neutralization of risks.

The strategy of construction of the centre should take into consideration area and the specialization of action also what will help the centre for describing the rank (international, regional reach about the universal or trade characterization, based processes on unitization of cargoes, the processes based on the conventional and unitized

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packages, subordinating to the main cell the logistic chain. The strategy of construction of the centre should be based on terminals already existing (container, the conventional packaged or universal solutions), turning on sea and land terminals into structures of the centre for providing with the comprehensiveness of operation (Kubicki & Kuriata 2000: 132).

Logistic distribution centres (LDC), in formulating the strategy of the development roles, functions and a spatial scope, should consider areas of the gravity of cargoes, services and the information (Salomon 2003: 210-212). In this regard, it should be preferred determined spatial structures of distribution and logistic processes which certain relations in solving logistic problems in global, regional and local arrangements. For these purposes the model of distribution and logistic structures of spatial processes, based on the conception of chain-radial arrangement, is very useful.

## 3. Local, regional and global logistic distribution centres (LDC)

Local logistic centres of distribution are localised in transport hubs (terminals) on areas about the biggest economic activity, usually on the deep hinterland. At the moment, the area of being a burden is being determined on the size of the ray 20-50 km, ultimately up to 300 km. The size and the scope of the infrastructure and superstructure require possessing the surface of 10-30 ha, with taking reserve surfaces into consideration to developmental destinations. Local logistic centres of distribution are tied together with logistic, creating the radial arrangement concentrated in the definite regional logistic centre channels.

Regional logistic centres of distribution are located near big economic activity zones (large urbanized areas, seaports). They usually serve as overall centres for cargoes coming from local logistic centres of distribution, swimming across with arrangement of the distribution network or of chain links realized on the principle multimodal transport. Area of the gravity is determining with ray up to 300 km, ultimately 500-800 km. The size and the scope of the required infrastructure and superstructure are determining the surface area of the centre on 20-50 ha, with taking into consideration the reserve surface allotted to developmental destinations. Regional logistic centres of distribution are tied together with logistic channels creating the radial arrangement concentrated in the definite global logistic centre of distribution (Szwankowski 2002: 104).

Global logistic centres of distribution are centres about the top stair of the organizational and functional expansion, enabling the cooperation in the continental and intercontinental range. They are usually located in areas about the highest economic and commercial activity about the more than regional reach (seaports, airports), making main cells in distribution-logistic channels. They usually serve as overall centres for coming from regional logistic distribution centres, swimming across goods with arrangement of the distribution network or of chain links realized on the principle multimodal transport. Area of the gravity global LDCs is diversified: the described hinterland is a ray 500-800 km, however outskirts have unspecified area. The size and the scope of the required infrastructure and superstructure require the surface of developing 100-500 km, with taking the reserve developmental surface into consideration. They are connected by global LDCs with logistic channels with different global LDCs or regional LDCs, creating the chain arrangement in the global scale. It is assuring the completion of comprehensive logistic services about diversified spatial and temporary structures of logistic chain.

Branch logistic centres are working for the defined business. The ray of the cooperation is depending on the business, however surface dependent on tasks. The standard of logistic services is profiled for the business.

The logistic-distribution centres should be carefully designed in terms of area, the infrastructure and superstructure, not taking the newest achievements into consideration in the scope of designing spatial structures, the technique and technology and operating needs. Possessing the surface is necessary for forming the centre at least 50 ha, essential for locating buildings and the building, an access roads, squares of components and with free surfaces for the future expansion of the centre. Moreover, centres should search for an optimal solutions from a point of view of the reduction in costs, integrated transport connections with taking into consideration the most appropriate technology of the transport-handling and stock, spacious information and the system should assure of control. We should widen the scope of services rendered by contractors together with the standardization of technological solutions applied in Europe and the organization of electronic data interchange (EDI) (Kondratowicz 1999: 19-20).

At forming the centres, we should take into consideration the possibility of the transfer railway-motorway-seaway-river, combining the local transport and the long-distance transport through the interaction with a computer system. We should also take into consideration the recycling of cargoes and improving economic regional attraction.

## 4. Location of logistic distribution centres (LDC)

As part of the conception of creating logistic centres, a few years ago, has been already worked out the project entitled "Location of logistic centres". Study carried out consists of 17 volumes, embracing the structure, directions and straining flows of service fall-ropes in Poland, together with the forecast of the change in directions, in the perspective of setting about of Poland to the European Union. It contains results of comparative studies, solutions to logistic networks in Europe, with special taking into consideration of Germany and the Netherlands. With the part of study, making up most spacious of ten volumes, there is a creative project of deploying logistic centres in Poland, embracing: Warsaw-Lodz, Poznan, Katowice-Gliwice, Szczecin, Gdansk and localised on the Polish-Byelorussian border.

Table 1 Chosen logistic objects ensuing in Poland in 1988-2000 years.

| Storage surface (square meters) | Location of the logistic object | Year of putting into operation |
|---|---|---|
| 23000 (option 35000) | Distribution centre of the Raben company: Centre of Distribution in Gadki near Poznan | 1994 |
| 12000 | Store-distribution Centre in Grodzisk Mazowiecki near Warsaw | 1997 |
| 60000 | Stock centres of the FM LOGISTICS company in Mszczonow, adapted for storing every kind of cargo | 1995-1997 |
| 34000 (option 100000) | Centre of Diamond distribution Business Park in Janki (Raszyn) near Warsaw, the distribution Centre of the English BOC Distribution Services company | 1998 |
| 16600 (option 52000) | Stock centre Logistics common land Park | 1999 |
| 10000 (option 260000) | Distribution centre - the largest Polish centre of distribution Europe Park in Mszczonow | 1998 |
| 12000 | Stock centre of the SPEDIMEX company in Lodz | 1999 |
| 8000 | Forwarding Centre Kuhne & Nagel in Gadki near Poznan | 1999 |
| 16760 | Logistic-stock centre Logistics Hays near Czestochowa | 1999 |
| Total over 30000 | Centre of the logistic service MULTISPEDYTOR state intercity bus service in Słubice, Blonie, Srem, Czechowice-Dziedzice, Trzebnica | 1988-1999 |
| 17000 | Stock-exhibition centre plane tree Park in Warsaw | 1998 |
| 18000 | Logistic-stock centre of the German concern Gruppe Schneider in Mosin near Poznan | 1999 |
| 15000 | Logistic centre of the German company Distribution Bertelsmann in Plewiski near Poznan | 1999 |

Kordel & Jezierski 2003: 201.

The project of construction of first six logistic centres is making the first stage of their arranging on the Poland, resulting from data connected with increasing loading rotations, like also with the development of the transport network of the country. All have the access to at least from two for six branches of the transport and are also located by designed motorways Al, A2, A3 and A4.

The planned logistic centre owns the right infrastructure, such as: roads, squares, car parks, magazines, computers and communication centres. It possesses the trained staff and the competent organization for services of logistic services in the scope of transports, handling, storing, distribution and collecting, carrying out supply and distribution posts in the framework of temporary orders or constants of agreements with individual companies.

Last setting of the draft the location of logistic centres in Poland was devoted to feasibility study school of the pilot logistic centre, localised in the Northern Port in Gdansk. We should emphasize that as a result of studies were chosen six logistic centres in Poland: the region of Warsaw, Poznan, Katowice-Gliwice, Szczecin, Gdansk and the Eastern areas of Poland, all directly are connected with four main transport corridors and connected with the program of construction of motorways Al, A2, A3 and A4. A principle adopted by the location of the logistic centre exists so that it is reunited, with at least two branches of the transport. The best example is the area of Tri-City (Gdansk-Sopot-Gdynia), where the logistic centre is localised in the Northern Port in Gdansk. Besides, the designed motorway Al has the access to six branches of the transport as well: road, sea and river, transmission, air and rail transport. The centre is localised in the proximity of the Gdansk, having Refinery transmission connection with the domestic net, like also with the pipeline of the base of handling of liquid fuels in the Northern Port in Gdansk. It is put also in the nearby proximity of an airport (Lech Walesa in Rebiechowo), supporting a transport different kind of cargoes. As part of investment on the Ostrow Grabowski in Szczecin were built the wharves (lengths of 440 m and depths 10.5 m), for two ship standings. An assumed handling ability is above the l000000 ton of the unitized and conventional cargo.

Functioning of centres considerably will influence over the organization of transports on road. The studies revealed a large stake of empty runs on the way back, after making the service. Functioning of centres will permit also for tying the domestic transport together with international, in order to increase the effectiveness of exploiting the transit ability.

## 5. Functions and tasks of the Tri-City Logistic Centre (TLC)

Coming into existence and the development of logistic centres are connected with the globalization of the economy, improving distribution processes and with the development of the logistics in the industry and the trade. Logistic centres are one of essential elements of the modern economy and the information society. Competitiveness is an also essential condition in the transport. Polish economy and its transport system must take aiming action for fast adapting oneself to requirements of the rival market, peculiarly in the context of the progressing process of integration with European structures (Salomon 1999: 168-170.).

In the framework of the Polish logistic system forming a few logistic centres is being expected. The Tri-City Logistic Centre is supposed to be one of them. It would be located on the immediate hinterland of Gdansk and Gdynia seaports. The uprising and the development of this Centre are one of basic conditions of the participation of cities and ports of the Gdansk urbanized area and in integrating Europe and Baltic region (Klimek 2002: 112).

The Tri-City Logistic Centre (TLC) will be accomplishing the logistic functions connected with the transport of goods transferred in international and domestic relations. TLC will also be rendering all different standard logistic services, like storing goods, collecting the documents, packing, repair services, securing the quality, processing of goods and different. In a TLC area are located two main terminals: land-marine Baltic Container Terminal in Gdynia about annual turnovers about 300000 TEU (about target possibilities about 500000 TEU) and land train-road multimodal terminal in Gdansk about turns of the class of a few thousands of ton of cargoes annually (forecast 2010 is 50-67 thousand tones).

Because of the very big area of the service and its structure, TLC is located in the port-urban zone. TLC will be accomplishing all purposes of the logistics tied: streamlining of costs, increasing the quality, extending the scope of rendered logistic services, according to with requirements of customers and rendering information services.

Basic connections will concern the logistic service of international transports going through TLC. Potential senders and recipients of loading mass are localised in the entire area of the domestic and international hinterland of Gdansk and Gdynia seaports. Sizes of this hinterland has the long-lasting character (Neider 2002: III).

## 6. Choice of the TLC location

The specific location of the TLC in the proximity of big seaports in Gdansk and Gdynia is causing that this centre will be connected with the land-marine transport. The centre won't be adjoining directly to the line of the sea edge, therefore directly it won't be operating the ships. However indirectly, thanks the logistic services of maritime cargoes, it will be connected with the sea-borne trade. The centre will also be cooperating with existing multimodal terminals: land-marine - BCT and BGT in the Gdynia and container terminal in the Northern Port in Gdansk, as well as with the land multimodal terminal in Gdansk. It should be underlined, that proximity of multimodal terminals or even situating them in logistic centres considers itself the main element of the logistic system (Miklinska 2002: 5).

The majority of TLC's transport services from the side of the economic hinterland, will be rendered for the road and the rail transport. The Lech Walesa Airport is putting on the edge of the Tri-City. Not only passenger movement, but also domestic and international freight traffic, are causing that in the centre rendered logistic services will be offered the air transport services. The influence and connections of the TLC with different regional functions and demands of the regional strategy, should be taken into consideration. In the analysis of potential locations, two groups of regional criteria were accepted: usefulness of the land and influences on the labour market (the absorbency, journeys). The usefulness of the land was being assessed according to a few detailed criteria:

- sizes of area and its development potential;
- the geodetic land surveying of the land;
- the environmental and urban planning limitations;
- possibilities of performing different regional functions.

## 7. Functions and objectives of the West-Pomeranian Logistic Centre (WLC)

The main factor deciding the uprising and the location centre in the West-Pomeranian province is its profitable geographical situation, judged in the following plains:

- coastal location and along the pivot of the lower reaches of the Oder,
- putting on crossing important transport trails on international meaning in the North-South arrangement: from the Scandinavia to Southern and South-east Europe and east-west: from Western Europe to states of Eastern Europe and Asia,
- border location with Western Europe (the length of land borders amounts the over 450 km).

Consequence of the geographical situation as well as the natural aptness, is a development of the sea economy, the industry, the farming, the tourism and the transport. Region possesses the well-developed transport, enveloping the land i.e. road and train, sea, river and air transport system.

The sea transport is based on shipowners's activity of operators. Passenger turnover by sea in the international communication are taking place mainly by ferries from the Ferries in Swinoujscie. Lines, being a permanent route of ferries, are linking the province and Poland with the Scandinavia (Ystad. Malmö, Copenhagen, Rönne), with inland aqueous navigation, through the Oder and channels Odra-Havela and Odra-Sprewa, region has the direct link with inland watercourses of Germany and Western Europe.

The International Air Port Szczecin-Goleniow is supporting regular international connections from Szczecin to Copenhagen and the domestic connection to Warsaw. Judging the economic potential of Szczecin region we should point at six particularly important defining its development potential and having the influence on creating of the West-Pomeranian Logistic Centre factors:

1) particularly profitable geographical putting on the intersection important communications trails;
2) multifunctional and multiple-branch industry;
3) favourable tendency in the restructuring of the economy, being characterized by a height of private enterprises and companies with the participation of foreign capital;

4) high potential of the agricultural production on account of the good quality of soils and the favourable agricultural structure;
5) reflecting considerable tourist potential connected with natural advantages oneself in the existing base and straining the tourist move.

In the Polish transport policy, being in effect for 1995, it's establishing getting used (till the year 2010) of new transport technologies and the chapter and storing goods outside urbanized areas together with the full service of senders and recipients. This assumption is resulting from directives of the European Union, centres realized by membership countries in the form or logistic platforms. An Italian model of organizations of logistic centres, which are being located in seaports, is meriting attention mainly.

Next localisation variants analysed in the process of examinations WLC was being subjected to the assessment in a few criteria. To basic criteria of the assessment an ecological criterion, technical-technological, information, economic-organizational, personnel gravity of the volume of goods, the transport availability and a criterion were recognised as bonds of equal partners between subjects operating in WLC area. On the basis of analysis behind the most justified WLC location in the port Szczecin was recognised. Seaport in Szczecin performing unique economic functions, like transport, industrial, logistic, commercial, town-creative and region-creative, is meeting conditions which can let it fight off competition from different ports.

There are a few benefits of the WLC localization: the great storage potential, performing the function mediating in the trade, wide abilities offering to customers, the coordination of action of enterprises of the port arrangement, the telecommunications and computer service.

Main WLC localisation advantages in the area of Szczecin port are:

1) convenient geographical situation in the row of the North-South transit corridor;
2) extensive undeveloped port areas;
3) being of the transport infrastructure linking the port with the transit back (train, road connections, the network of inland connections);
4) existing handling-storage potential about universal and assuring the operation of cargoes and means of transport character on rival level;
5) high profitability of handling-storage and different services;
6) experience in rendering port services;
7) long-standing tradition of the cooperation with carriers;
8) workers appropriately prepared having experience in the range of the service of cargoes and means of transport in the port and the coordination of service processes.

An essential advantage of the Szczecin is activity of Free Accurate Area (WOC) located on the Russian Wharf, filling 1.5 ha and offering 20000 square meters of the storage space. WOC is enabling the rotation of goods in foreign relations without customs duties, quotas and different loads, till the moment of staying of the good in its borders.

## 8. Conclusions

Seaports as the elements of the multimodal transport chain, as a result of expectations of customers, are forced to render services not only in the scope of handling of goods but also different services, of logistic services called the logistic service package. A transport, storing, distribution, handling, sorting, accurate, information, financial, insurance, service, guarantee and different services are recognised as it. The logistic presentation is written down into the being of the transport chain.

The statistics is showing, that only commercial, service and food-processing operations are bringing the biggest profits in made in the road between the sender and the recipient. On exactly those operations, a power of ports and transport trails laid on intersections originated. Nowadays, in the multimodal transport conditions, places of making these operations are being determined as logistic and distribution centres. In western Europe they began to develop over 40 years ago. Today we assume, that effective functioning of the transport requires the network of logistic centres, for which hubs would be distant from oneself about 300 km.

In the web of logistic centres on preferred North-South direction, Gdansk has the special stance Gdansk as the place of the joint of five kinds of the transport: sea, river, train, road and air, as well as the main trans-European keystone of transport corridor leading from Scandinavia to the south of Europe and farther - to Nearest East. In Poland situating functioning and planned centres already in neighbouring and nearby countries will have the meaning influence on the location of logistic centres, especially in Germany, the Netherlands, France and Austria.

Tri-City (Pomeranian) logistic centre in the area of the Gdansk and Gdynia port and West-Pomeranian centre in the area of the Szczecin port will be accomplishing the logistic posts connected with the transport service on all international and domestic relations.

The location of logistic centres in seaports is giving the possibility of offering the wide range of concerning cargoes, generating the value added services. Together with widening the offer of services a role of the port in the entire transport chain is changing. It is stopping being perceived as place already only as traditionally comprehended of handling, storing cargoes. The logistic centre created in the port is a chance of the inflow of the even bigger number of specialists from different branches. We should also notice that logistic centres are serving not only port wines but also the city extending his supply abilities.

Neither Pomeranian, nor West-Pomeranian provinces, have a single one logistic centre at the moment. A fall of the economic activity is one of the most important causes of this state of affairs in this area, caused with the stagnation and the slump of all business of the sea economy.

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# GAME THEORETIC APPROACH TO INVENTORY MANAGEMENT IN SUPPLY CHAIN- A LITERATURE REVIEW

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## Abstract

*Today's marketplace is becoming increasingly dynamic. As consumers become more sophisticated, they demand the right product at the right time, at the right price, and at the right place. Whereas quality was the competitive weapon of the 80s, customer responsiveness is the differentiator today.*

*With the trend towards greater synergy between suppliers and industrial customers, most manufacturing enterprises are organized as networks of manufacturing and distribution sites that purchase raw materials, transform those materials into intermediate and finished products, and distribute the finished goods to customers. Management of such networks; also referred to as "supply chains" has emerged as a major topic in operations research.*

*The purpose of the study is to review the literature about inventory management in centralized and decentralized supply chains with fluctuating demand.*

*Keywords: Centralized supply chain, Decentralized supply chain, Multi-echelon inventory systems, Game theory*

## 1. Introduction

The functions of procuring the raw materials, transforming these raw materials into intermediate and finished products, and finally distributing the finished products to the customers comprise the supply chain. Supply chain is a dynamic structure and involves the constant flow of information, product and funds between stages. Each stage of supply chain performs different processes and interacts with other stages of the chain. In reality, a manufacturer may receive material from several suppliers and then supply several distributors. Therefore most supply chains are actually networks, which are also called supply networks.

Inventory is a stock of items kept by an organization to meet internal or external customer demand. Virtually every type of organization maintains some form of inventory. Most people think of inventory as a final product waiting to be sold to a retail customer. This is one of its most important uses. However, especially in a manufacturing firm, inventory can take on forms besides finished goods, including raw materials, purchased parts and supplies, in-process products, tools, machinery and equipment, and also finished goods. The purpose of inventory management is to determine the amount of inventory to keep in stock-how much to order and when to replenish, or order. Inventory theory has found a place as multi-echelon inventory theory is studied in supply chain coordination.

There are two main managerial insights in managing a supply chain; centralized and decentralized decision structure. In decentralized decision structure, independent managers (or decision makers) in every inventory location, observes the activities in that location and make the decisions. A supply chain which consists of independent decision makers has lots of differences from a supply chain where there is a central decision-maker. Different from the traditional supply chain structure, the firms which are included in the chain may have different, even conflicting objectives. Moreover, each manager may have his own firm's cost structure and demand pattern, but have no idea about the whole chain.

When two or more decision-maker's objects are in conflict, there is a competitive world. If strategy determining measures of the decision-maker's is not certain and there is not any information about probabilities associated with these strategies, the problem is a special decision problem under uncertainty. In these cases, the decision-maker makes the best decision not according to the situations that he faced with, but according to the strategies which other decision-maker can apply oppose to himself. Each decision-maker wants to optimize his objective and this case can be called as "game".

The concepts and techniques that are related with finding the best strategy for the conflicting decision-makers are called "Game Theory". Besides applying the game theory to the events which are seen in real life, it is possible to understand game theory as a philosophy which gives a direction to the policies of decision-makers.

The firms that makes the supply chain, mostly have conflicting objectives because different decision-makers in different locations want to optimize different objectives. Game theory provides suitable methods and techniques for characterizing the behaviors of the firm which are independent decision-makers under competitiveness.

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In literature, firstly the optimal policies in centralized systems are considered; starting from 1960. Recently, optimal inventory policies found via game theory in decentralized structure are studied. There are lots of studies in literature which search how the behaviors of the decision makers affect the effectiveness of the supply chain. In the following section the survey methodology will be stated. In section three, literature review will be proposed related with supply chain. Finally in the last section we conclude with further research directions.

## 2. Survey Methodology

This paper is a review of published articles which have appeared in English language. The search was done on-line. The major focus of our paper is to review the articles which are concerning inventory management of a multi-echelon system with fluctuating demand. There is diversity of game theory applications in supply chains that concentrate on information flow. These papers are not included in this study since we only interested in inventory management in a supply chain. Besides on-line search, some papers which selected from the reference sections of certain articles are also included whereas proceeding papers and working papers are excluded.

## 3. Review of the Literature

Clark and Scarf (1960) provides a theoretical foundation for much of the research in the increasingly important area of supply chain management. The Clark and Scarf study was significant for several reasons. It was the first to depict the form of an optimal policy for a stochastic demand, multi-period, multi-echelon model. It also was important for introducing the concepts of echelon stock and implied shortage cost, which form the basis for the analysis of more complex systems. However, the assumptions of this model make it unlikely that it would be used to manage a real system.

### Fluctuating Demand in Single Location Setting

Karlin (1960) formulated a dynamic inventory model in which the demand distributions may change from period to period. In other words, the demand in each period is assumed to be independent but not necessarily identically distributed. Several costs are incurred during in each period such as purchase cost, holding cost and shortage cost which are assumed linear. There is no fixed cost of ordering. Both the cases where excess demand is lost and backlogged were considered. Most studies of dynamic inventory models are concerned with determining the characteristics of the optimal policy which means the policy that minimizes the total expected costs in the future periods are properly discounted. If the cost functions of the model are suitably convex, and if demands that arise in successive periods are independent and identically distributed random variables with known distribution functions, then it is clear that the optimal policy in each period is characterized by a single critical number or at most two such numbers. The main importance of Karlin's paper is that he developed qualitative results describing the variation of the critical number which describes the optimal policy over time as a function of the demand densities in all future periods. Cost functions are assumed to be the same in all periods.

Iglehart and Karlin (1962) considered again an inventory model with a stochastic demand process but this study is different from Karlin's paper in that this time the distributions of demand in successive periods are correlated. The relationship of demands in successive periods regarded as a generalized Markov process and the demand process is described by discrete time Markov chain. Iglehart and Karlin also consider the case in which costs are nonconvex.

Models have been developed for the situation where the warehouse holds no inventory. In these cases, retailers use the warehouse merely as a distribution point through which items flow. The first study of this type of system was from Eppen and Schrage (1981). Eppen and Schrage's model is essentially the warehouse/store system of two-echelon inventory system. The assumption that the warehouse does not hold stock does not mean that the warehouse serves no purpose. By ordering centrally, more advantageous quantity discounts can be sought. There are also "statistical economies of scale" as observed by Eppen (1979) in which savings are achieved by aggregating orders rather than operating N individual inventory systems. Eppen and Schrage show that unless the demand at the stores is perfectly correlated, the coefficient of variation of demand for the aggregate system is smaller than for the demand at the individual stores.

Eppen and Schrage (1981) assume deterministic lead times from both the supplier to the warehouse and from the warehouse to the stores. Demand originates only at the store level and is assumed to follow a normal distribution with parameters allowed to differ between stores. Eppen and Schrage call their ordering policy an (m,y), where every m periods, the inventory positions raised to a base stock of y. The warehouse must have enough stock to resupply the stores so that the probability of a stockout at each store is the same. This is shown likely to hold when the fixed cost of ordering from the warehouse is high and/or the coefficient of variation of demand at the stores is moderate.

Feregruen and Zipkin (1984a) consider the same problem approach the solution differently. This paper addresses the computational issues of the Clark and Scarf model. They showed that the optimal policy established by Clark and Scarf for the finite horizon problem, can be extended to the infinite horizon versions of the problem under the criterion of discounted cost and for long-term average cost. They also establish simpler computational formulas in the infinite horizon case.

Federgruen and Zipkin formulate the problem as a dynamic program with a state space of very large dimension. The dimension of the problem is at least N+L (the number of outlets+the supplier to warehouse lead time), which makes it impractical to solve except for small values of N and L. To avoid the "curse of dimensionality" they showed that the model can be systematically approximated by a single location inventory problem.

Federgruen and Zipkin (1984b) consider other approaches to the problem of approximating optimal policies where they assume that the penalty and holding costs are proportional. The results of this paper deal with the problem of unequal coefficients of variations of demand at the stores. The approximation techniques and results are similar those of Federgruen and Zipkin (1984a).

Zipkin (1989) considered an infinite-horizon problem with stochastic demands. This study is an extension of Karlin (1960) in that Zipkin developed an alternative and simpler approach. Zipkin proved the optimality of such policies for the average cost case.

Song and Zipkin's paper (1993) is similar to Iglehart and Karlin (1962). However, Song and Zipkin offer simpler computations. And also their demand model is specialized and simpler to specify than Iglehart and Karlin's model because for each state Song and Zipkin's model requires the demand rate whereas the others' requires the full demand density. Many randomly changing environmental factors, such as fluctuating economic conditions and uncertain market conditions can have a major effect on demand. Song and Zipkin called the variables representing the environment as the state of the world (demand state); and they modeled the world as a continuous time Markov chain. When the world is in state i, demand follows a Poisson process with rate. Then they called the demand process as Markov-modulated Poisson process. The demand state can affect other parameters of the inventory system such as the cost functions.

Sethi and Cheng (1997), gives a generalization of classical inventory models that exhibit (s,S) policies. In other words, this paper is a generalization of Song and Zipkin (1993). In the model in Sethi and Cheng (1997), the distribution of demands in successive periods is dependent on a Markov chain. The model includes the case of cyclic or seasonal demands. Sethi and Cheng considered the presence of various constraints on ordering decisions and inventory levels which can be seen easily in real life applications. For example periods such as weekends and holidays is considered. Furthermore they extended their model to the cases in which there is no ordering periods storage and service level constraints. In this study both finite and infinite nonstationary problems are considered. It is proved that (s,S) policies are optimal for their model.

### Fluctuating Demand in Multi-Location Setting

Chen and Song (2001) examine for the optimal policy with fluctuating demand in multi-period setting. In this study Chen and Song considered a multistage serial inventory system with Markov-modulated demand. Random demand arises at retailer stage. The demand distribution in each period is determined by the current state of an exogenous Markov chain. Backlogging is allowed. All costs incurred were assumed to be linear. They found a policy which minimizes the long-run average costs in the system. Chen and Song (2001) showed that the optimal policy is an echelon base-stock policy with state dependent order-up-to levels.

Gallego and Özer (2003) prove the optimality of state dependent, echelon base-stock policies for both finite and infinite horizon problems with advance demand information. The authors discuss in this paper that, how a Markov modulated demand process can be combined with advance demand information. They also show that the myopic policies are optimal for stationary demand case.

### Time Series Models in Single Location Models

The papers that will be mentioned in this part, examine the demand process which are related among time periods. In other words, the assumption of independence is not relevant any more. Then it is suitable to use time series models.

The first and one of the fundamental papers belong to Veinott. Veinott (1965) examine a multi-product, dynamic, nonstationary inventory problem. The demand process has no stationarity or independence assumptions. Unfilled demand can be backlogged. The costs are linear and also may vary over time. Veinott aimed in his study to determine an ordering policy that minimizes the expected discounted costs over an infinite time horizon. It is proven that the base-stock ordering policy is optimal and also that base stock levels in each period are easy to calculate. Veinott's paper is quite significant in that; it was the first study which attempt to develop sufficient conditions ensuring that the optimal policy takes a simple form and to compute the parameters of that policy easily. This approach was going to be called myopic policy. The paper derived the solutions under the assumption of independence of demand across periods. Also the case of dependent demands over time was examined. In this case, the distribution of demand in period i depends upon the past history of the system.

Johnson and Thompson (1975) examined the myopic replenishment rules for periodic inventory systems operating under certain dependent demand process. This paper shows that the myopic policies are optimal under certain demand processes even when demand is not stochastically increasing over time. The demand process was characterized by means of the models described and analyzed by Box and Jenkins.

Miller (1986) assumed in his study that, the expected value of demand is given by exponential smoothing formula and that uncertainty is multiplicative. Miller considered a finite horizon inventory model with linear holding, shortage, and ordering costs. The demand random variables are dependent, and average demand is described by an exponential smoothing formula. This model is formulated as a two-state variable (inventory level, weighted past demands) dynamic program. It is proven that two-state variable dynamic program can be reduced to one state. Also it is shown that dependent demand model orders less than or equal to the amount ordered by a comparable independent demand model.

Erkip, Hausmann and Nahmias (1990) extended the studies in which various time series models used for the demand process in multi location models. The authors consider an extension of the Eppen and Schrage (1981) model to the case of correlated demands over time. This work differs from a number of other studies in that it is allowed that item demands to be correlated both across warehouses and also in time. They observed both high correlations between successive monthly demands (around 0.70) and correlations between demands for an item at different locations (also about 0.70) in a given time period. They derive an explicit expression for the optimal safety stock as a function of the level of correlation through time. Erkip et.al's analysis requires two assumptions; the allocation assumption and the equal coefficient of variation assumption.

Lovejoy (1990) shows that a simple inventory policy based on a critical fractile can be optimal or near optimal in some inventory model with parameter adaptive demand processes. In these, some parameter of the demand distribution is not known with certainty, and estimates of the parameters are updated in a statistical fashion as demand is observed through time.

Lovejoy (1992) considers replenishment policies for single-item, periodic review inventory systems with linear costs and immediate delivery. The demand distribution in each period can depend on an information process that includes demand in previous periods as well as exogenous economic parameters. This paper evaluates the efficacy of restricting attention to the class of policies that behaves myopically in the near term.

### Decentralized Cost Structure

In multi-echelon inventory system environment, inventory control policies may take one of two approaches. One approach is local inventory control policy where each warehouse is responsible for their own stocking policies, independent of each other. This approach can be stated as decentralized control scheme. The second approach is echelon inventory control policy where inventory control parameters are determined simultaneously, taking into account the interrelationship between the depot and the warehouses. This approach can be called as centralized control scheme.

Hausmann and Erkip (1994) considered a multi-echelon inventory system which has a central depot and M warehouses. At each location, a continuous review inventory policy (S-1,S) is used. Hausman and Erkip examined the amount of suboptimization, which can occur if multi-echelon inventory systems are managed as independent single echelon systems or in other words, managed locally. They studied Muckstadt and Thomas's optimal multi-echelon policy and an improved version of the local inventory control model.

(2001) considered two-echelon inventory system consisting of a central warehouse and a number of retailers and gave a framework for decentralized control. The final demand occurs at the retailer level. In this paper a cost structure that can be used for decentralized control of a multi-echelon inventory system is provided. This cost structure means that the warehouse, in addition to its local costs, pays a penalty cost for a delay at the warehouse to the retailer facing the delay. By minimizing its local costs according to the suggested cost structure, an installation can reduce its costs. Then the total system costs are reduced by the same amount.

Lee and Whang (1999) mainly examined the incentive problems arising in the supply chain system when each decision maker maximizes his/her performance metric and discussed performance measures in decentralized supply chain. This paper also discussed the cost conservation, incentive compatibility, and informational decentralizability properties of the supply chain system. They concluded by giving a particular performance measurement scheme.

Chen (1999) considered a series system, which consists of N divisions. Customer demand is occur at the last stage, again. The demand is assumed to be independent in different periods and has the same probability distribution. Backlogging is allowed. The paper considers two models for the system. First the model for centralized control scheme is identified. Each installation manager has local information and there is a like minimize the total cost in the system. It is proved that for the centralized model, for each installation base-stock policy with a determined level is optimal. Secondly, each installation is considered as cost centers. Each manager makes his/her decision based on the costs incurred in his/her own installation. It was found that decentralized decision-making is very beneficial when the owner of the firm does not have perfect knowledge about the demand distribution or when the firm faces a fluctuating demand environment.

### Competition in Single-Period Multi-Location Setting

Eppen (1979) considered a multi-location newsboy problem with linear holding and penalty cost functions at each location with normal demand. He assumed N identical retail outlets that order independently according to a simple order-up-to point model obtained by minimizing one period holding and penalty costs, and derived an expression for the expected cost each facility. The model is used to demonstrate: the expected holding and penalty costs in a decentralized system; the magnitude of the savings depends on the correlation of demands, and if demands are identical and uncorrelated, the costs increase as the square root of the number of consolidated demands.

In many production/inventory related decision problems the presence of several decision makers with competing objectives can be observed. When more than one decision maker is involved in a decision situation, the classical optimization concepts may no longer applicable. Instead, game theoretic ideas may be suitable to analyze the possible decision making strategies of different players. Using game theory in inventory problems provides a better analysis when a decision maker's problem cannot be treated in isolation from the others' decisions and objectives.

Parlar's article is the first one which analyzes an inventory problem using game theory. Parlar (1988) developed a two-firm competitive newsboy problem where the firms face independent random demands. He examined the substitutable product problem using concepts from two person continuous games. The decision makers were called players who choose order quantities of the products. As the demands are random and substitution may exist, the objective function of each player depends on the decision variables chosen by the players. The players are assumed to have knowledge of the demand densities and all other information related with the game and each other. He proved the existence of a unique Nash equilibrium in inventory levels when demands are represented by strictly increasing and continuous cumulative distributions and showed that the expected profit when the firms cooperate exceeds the sum of the competitive profits.

Lippmann and McCardle (1997) considered a competitive version of classical newsboy problem in which a firm must choose an inventory or production level for a perishable good with random demand. They also investigate the effect of competition on inventory. Prior to realization of demand, firms (players) choose an inventory level of perishable good to be sold at a predetermined price. Each firm's strategy is its level of inventory. There is no price competition because each charges the preset price. Instead, competition among the firms emanates from the fact that they share the industry demand and that an increase in one firm's inventory stochastically reduces the other firm's sales. Aggregate industry demand was allocated among the firms and individual firm demands were considered to be correlated in each other. Lippmann and McCardle proved in their study that there is an equilibrium and showed that each firm's equilibrium inventory ordering strategy is represented as fractile of the effective demand distribution.

Among applications of stochastic games, one of the papers is written by Cachon and Zipkin (1999), which analyzed a two-echelon game with the wholesaler and the retailer making stocking decisions. Cachon and Zipkin investigate a two-stage serial supply chain with stationary stochastic demand in each period. Inventory holding costs are charged in each stage, and each stage may incur a consumer backorder penalty cost. It is considered two games such as local and echelon games. In both, the stages independently choose base stock policies to minimize their costs. The games differ in how the firms track their inventory levels. The policies chosen under this competitive regime is compared to those selected to minimize total supply chain costs. Cachon and Zipkin showed that the games have a unique Nash equilibrium, and it differs from the optimal solution.

Mahajan and Van Ryzin (2000), analyze a model of inventory competition among n firms that provide competing, substitutable goods. Each firm chooses initial inventory levels for their good in a single period (newsboy-like) inventory model. Customers choose dynamically based on current availability, so the inventory levels at one firm affect the demand of all competing firms. This creates a strategic interaction among the firms' inventory decisions. Their work extends earlier work on variations of this problem by Lippman and McCardle (1997) and Parlar (1988). Specifically, the authors model demand as a stochastic sequence of heterogeneous consumers who choose dynamically from among the available goods (or choose not to purchase) based on a utility maximization criterion. They characterize the Nash equilibrium of the resulting stocking game and prove it is unique in the symmetric case. Finally, they propose a stochastic gradient algorithm for computing equilibria and provide several numerical examples.

Rao et.al.(2003) examine a simulation-based application of non-zero sum stochastic game formulation on an N-retailer and W-warehouse inventory planning problem. The authors use reinforcement learning approach as a n optimization tool. The inventory system consists of N retail outlets belonging to independent agents. The agents deal with a single product, and are interested in maximizing their own profit. The retail agents may pool inventories at W central warehouses. Demands are independent in each of the N retail locations. The warehouses experience any demand, and the agents make inventory decisions for the warehouses.

Wang et.al. (2004) analyses non-cooperative behaviour in a two-echelon decentralized supply chain composed of one supplier and n retailers. They extend Cachon and Zipkin (1999) model to a one-supplier and n-retailers situation.

## 4. Conclusion

Supply chain is a flow of product, information and finance among suppliers, producers and retailers. Since the inventory is everywhere in a supply chain, exact inventory planning provides firms with important gains. According to traditional viewpoint, centralized inventory control is convenient and overall supply chain costs should be minimized. However, because each firm which makes the supply chain desire to optimize its own objective function decentralized systems have been considered. With this fact, game theoretic models have been using in multi-echelon systems, recently.

The purpose of the study is to review the literature about inventory management in centralized and decentralized supply chains with fluctuating demand, especially on game theory applications in supply chains. According to the literature, game theoretic applications in inventory management for supply chains are limited in number. This area has been becoming popular recently. Based on the review of the literature, fluctuating demand in multi-location setting, game theory applications to the supply chain; such as stochastic game, Stackelberg game in which the supplier is considered as a leader may be the topics that need to be considered in the future research. The papers proposed in the study will be summarized in Table 3.1 according to certain characteristics. The articles are listed on the table below according to order listed in this paper rather than the time sequence.

Table 1 Certain characteristics of some papers in literature related with system structure, demand pattern and solution method.

| Author(s) | System structure | Unit Costs | Number of Echelon/location | Demand across periods | Demand distribution |
|---|---|---|---|---|---|
| Karlin (1960) | Centralized | Linear | Single location | Independent, non-stationary | continuous rv |
| Iglehart & Karlin (1962) | Centralized | Linear | Single location | dependent, non-stationary | Random |
| Eppen & Schrage (1981) | Centralized | Fixed | 1 depot N warehouse | Independent, stationary | Normal |
| Fedregruen & Zipkin (1984a) | Centralized | Linear | 1 depot N warehouse | Independent, non-stationary | Normal |
| Fedregruen & Zipkin (1984b) | Centralized | Fixed +linear | Two echelon | Independent, stationary | Random |
| Zipkin (1989) | Centralized | Convex | Single location | Independent, non-stationary | Random |
| Song & Zipkin (1993) | Centralized | Linear | Single location | Dependent, non-stationary | Poisson process |
| Sethi & Cheng (1995) | Centralized | Convex | Single location | Dependent, non-stationary | Markov process |
| Chen & Song (2001) | Centralized | Linear | Single location | Dependent, non-stationary | Markov process |
| Gallego & Özer (2003) | Centralized | Linear | Single location | Dependent, nonstationary | Markov process |
| Veinott (1965) | Centralized | Linear | Single location | Independent, non-stationary | continuous rv |
| Johnson & Thompson (1975) | Centralized | Linear | Single location | Dependent, non-stationary | Stationary autoregressive process |
| Miller (1985) | Centralized | Linear | Single location | Dependent, non-stationary | Exponential smoothing formula |
| Nahmias et.al. (1990) | Centralized | - | 1 depot N warehouse | Dependent, non-stationary | continuous rv |
| Lovejoy (1990) | Centralized | Linear | Single location | Dependent, non-stationary | continuous rv |
| Lovejoy (1992) | Centralized | Linear | Single location | Dependent, non-stationary | continuous rv |
| Hausmann & Erkip (1994) | Centralized | Fixed | Multi echelon | Independent, stationary | Poisson distribution |
| (2001) | Decentralized | Fixed | Two echelon | Dependent, non-stationary | Poisson process |
| Lee & Wang (1999) | Decentralized | Fixed | Multi echelon | Independent, stationary | continuous rv |
| Chen (1999) | Decentralized | Fixed | Multi location | Independent, stationary | continuous rv |
| Eppen (1979) | Decentralized | Linear | 1 depot N warehouse | Independent, stationary | Normal distribution |
| Parlar (1988) | Decentralized | Linear | Multi location | Independent, stationary | continuous rv |
| Lippman & McCardle (1997) | Decentralized | Fixed | Multi location | Independent, stationary | continuous rv |
| Cachon & Zipkin (1999) | Decentralized | Linear | Two echelon | Independent, stationary | continuous rv |
| Mahajan & van Ryzin (2000) | Decentralized | Fixed | Multi location | Independent, stationary | continuous rv |
| Rao et.al.(2003) | Decentralized | - | Multi location | Independent, stationary | continuous rv |
| Wang et.al. (2004) | Decentralized | Linear | Two echelon | Independent, stationary | continuous rv |

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# ESTABLISHING AN EFFICIENT SUPPLIER NETWORK FOR A NATION-WIDE RETAIL COMPANY: DATA ENVELOPMENT ANALYSIS

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## Abstract

*The evaluation of the supplier performance has recently witnessed a considerable interest since their efficiency plays a key role on the productive efficiency of the supply-chains. Managers aim to determine the best practice supplier network to improve allocation of resources and firm performance. In literature, widely used traditional methods, based on accounting and financial systems has been gradually alienating the stage to multiple criteria decison making methods. The objective of this paper is to determine the performance of the suppliers of a nation-wide retail company in Turkey using Data Envelopment Analysis (DEA), a multiple criteria decision making method developed by Charnes et al (1978). In literature, there exist many applications of this method comprising various industries (Baby Food Manufacturing Industry, Weber (1996); Agricultural and Construction Equipment Industry, Liu et al. (2000), Telecommunications Industry, Narasimhan et al. (2001); etc.). However, to the author's best knowledge, this will be the first study evaluating the supplier performance of a retail company through DEA.. To this end, retail-specific input and output measures will be developed. Moreover, we expect to display the critical factors to design an efficient supplier network for the managerial units.*

*Keywords: Data Envelopment Analysis, Supplier Evaluation, Supply Chain, Efficiency, Retail*

## 1. Introduction

Today, the competition between corporations is growing fast. In this highly competitive environment, the corporations wich design and manage its supply chain best, will be more profitable and hence stronger. "Supplier" is one of the most important chain of the supply chain. The corporations which develop good relationships with its suppliers, gain cost advantages, on time and desired quality deliveries. Therefore, supplier evaluation has a strategic importance for the corporations. The results reached by using the right performance criteria and evaluation method would produce robust solutions towards improving the performance of suppliers. Dickson (1966) presented 23 supplier selection criteria, and assigned the rankings of these criteria. Some recent supplier evaluation and selection studies in various industries are, Baby Food Manufacturing Industry, Weber (1996); Wooden Furniture Industry, Yahya and .Kingsman (1999); Agricultural and Construction Equipment Industry, Liu et al. (2000), Telecommunications Industry, Narasimhan et al. (2001); Food Manufacturing Industry, Çebi and Bayraktar (2004). There are few studies, comprising performance evaluation in retail industry (Wagner et al. (1989).

Retail, in Turkey and worldwide, is a rapidly developing industry where competition is significantly high. Since the retail process does not involve any production phase the supplier relations have a dominant role. To this end, this study, first, aims to propose performance criteria for the suppliers in retail industry. Second objective of this study is to present a multiple criteria performance measurement methodology for supplier evaluation. The methodology used in this study is a mathematical programming technique, Data Envelopment Analysis (DEA). DEA is used to evaluate the performance of the suppliers of a national retailing firm in 2005 and the results are analyzed in detail.

This study is organized as follows. In second section, a short literature review about the supplier evaluation is given. The methodology used in supplier evaluation is briefly described in the third section. The data set and analytical results of the application are presented in the forth section. Finally, the conclusions are given in the last section.

## 2. Supplier Evaluation and Selection Approaches

The first step of supplier evaluation is, stating the performance criteria. In his study Dickson (1966) presented 23 performance criteria, with interviewing 273 purchasing responsibilities and managers in USA and Canada. The most important three criteria presented by his study, were, "quality", "delivery" and "price". Weber, Current and Benton (1991), stated that, in 74 supplier evaluation and selection studies since 1961, the "net price" used in 61 supplier papers, followed by "delivery" with 44 studies and "quality" with 40 studies.

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In literature there exist few studies, comprising performance evaluation in retail industry. In his study, Wagner et al. (1989) , presented “markup”, “delivery” and “selling history”, as “highly important” performance criteria for retail buyers.

Timmerman (1986), classified traditional supplier evaluation techniques in three category: Categorical methodology, cost-ratio methodology and simple linear weighted average methodology. The subjectivity and complexity of the traditional methodologies directed researchers to different performance measurement methodologies like mathematical programming techniques, Weber ve Current (1993), Ronen veTrietsch (1988), Weber (1996), Mandal (1993) , and multiple criteria decision methodologies, Narashiman (1983).

## 3. Methodology

The supplier evaluation methodology utilized in this study is DEA. Brief description of the methodology is given below.

DEA is a mathematical programming technique which developed by Charnes et al. (1978). DEA calculates the relative efficiencies of decision making units (DMU’s) based on multiple inputs and ouputs. The most efficient DMU’s, determine the efficiency frontier, than the efficencies of other DMU’s are being calculating relative to this frontier. The DEA model used in this study is the model which was developed by Charnes, Cooper and Rhodes (CCR) in 1978, based on the assumption of constant returns to scale. The model is given below;

$$\begin{aligned} & \min\ \theta \\ & s.t. \\ & \sum_{j=1}^{n} x_{ij}\lambda_{ij} \leq \theta x_{i0,} \qquad i = 1,....,m \\ & \sum_{j=1}^{n} y_{rj}\lambda_{j} \geq y_{r0,} \qquad r = 1,.....,s \\ & \lambda_j \geq 0 \qquad\qquad j = 1,.....,n \end{aligned} \tag{1}$$

## 4. Data Set and Empirical Results

The two methodologies presented above are applied to a nation-wide retail firm in Turkey. A strategic commodity group with 9 suppliers and 5 millions USD purchasing-selling volume for 2005 is chosen. The application is performed using the year 2005 data of the firm.

The supplier performance criteria are chosen based on Wagner et al. (1989) and with discussion with the firms purchasing managers. The criteria used are markup, delivery and selling history.

The input oriented CCR model is used in the application. The inputs and output are as follows:

Inputs:

Markup ($X_1$): The markup percent obtained by supplier for selected commodity group in 2005.Since markup was an input variable, the smaller the better, the difference of the markup from 100 was used in the model.

Delivery ($X_2$): The on-time delivery percent by supplier for selected commodity group in 2005. Since the delivery is also an input variable, the percent of the late deliveries is used in the model.

Selling History ($X_3$): The selling volume by supplier after returns for selected commodity group in 2005. Since selling history is an input variable, the reciprocal of selling history is taken and multiplicated with one milion and used in the model.

Output:

Purchased quantity (kilo’s) (Y): The single output of the model is the net purchasing quantities by supplier for selected commodity group in 2005.

The DEA results are given on the Table 1

Table 1: Supplier efficiency scores and slack values (DEA)

| Supplier | Efficiency Score | Slack Value ($X_1$) | Slack Value ($X_2$) | Slack Value ($X_3$) |
|---|---|---|---|---|
| $S_1$ | 1 | 0 | 0 | 0 |
| $S_5$ | 1 | 0 | 0 | 0 |
| $S_3$ | 0.792 | 1.805 | 0 | 0 |
| $S_2$ | 0.763 | 0 | 0.035 | 0.27 |
| $S_7$ | 0.526 | 0 | 0 | 2.78 |
| $S_6$ | 0.35 | 0 | 0 | 1.891 |
| $S_8$ | 0.173 | 0 | 0 | 4.901 |
| $S_9$ | 0.082 | 0 | 0 | 1.624 |
| $S_4$ | 0.027 | 0 | 0.301 | 2.099 |

$S_i$:Suppliers

Table 1 shows that, $S_1$ and $S_5$ are the best suppliers with efficiencies scores 1 and slack values 0. $S_4$ is the worst perfroming supplier with the efficiency score 0.027. Table 1 shows that, $S_1$ and S5 are efficient suppliers and $S_3$, $S_2$, $S_7$, $S_6$, $S_8$, $S_9$ ve $S_4$ are inefficient suppliers.

The reference supplier for inefficient suppliers and their reference weights is given on the Table 2.

Table 2: Supplier reference group and reference weights

| Supplier | 1. Reference | 1.Reference Weight | 2. Reference | 2. Reference Weight |
|---|---|---|---|---|
| $S_1$ | $S_1$ | 1 | | |
| $S_2$ | $S_1$ | 0.769 | | |
| $S_3$ | $S_5$ | 0.327 | $S_1$ | 0.432 |
| $S_4$ | $S_1$ | 0.026 | | |
| $S_5$ | $S_5$ | 1 | | |
| $S_6$ | $S_5$ | 0.247 | $S_1$ | 0.096 |
| $S_7$ | $S_5$ | 0.523 | | |
| $S_8$ | $S_5$ | 0.176 | | |
| $S_9$ | $S_5$ | 0.044 | $S_1$ | 0.035 |

$S_i$:Suppliers

Table 2 shows that, $S_1$ is the reference supplier for $S_2$ and $S_4$ . $S_5$ is the reference supplier for $S_7$ and $S_8$. A virtual supplier with combination of the suppliers $S_1$ and $S_5$ is the reference supplier for suppliers $S_3$, $S_6$, $S_9$. The reference weights in Table 2 are used to calculate the target inputs values for inefficient suppliers to be efficient.

From Table 3 to Table 11, original input values, the target values, radial movement values and slack movement values are presented for each supplier.

Table 3: DEA results for supplier $S_1$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 258287.000 | 0.000 | 0.000 | 258287.000 |
| $X_1$ | 94.710 | 0.000 | 0.000 | 94.710 |
| $X_2$ | 7.700 | 0.000 | 0.000 | 7.700 |
| $X_3$ | 2.515 | 0.000 | 0.000 | 2.515 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

Table 3 shows that, the original values and the target values of the efficient supplier $S_1$ are all same.

Table 4: DEA results for supplier $S_2$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 198588.000 | 0.000 | 0.000 | 198588.000 |
| $X_1$ | 95.380 | -22.561 | 0.000 | 72.819 |
| $X_2$ | 7.800 | -1.845 | -0.035 | 5.920 |
| $X_3$ | 2.886 | -0.683 | -0.270 | 1.934 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

$S_2$, is a supplier which is not on the efficiency frontier with 0.763 efficiency score. Table 4 shows improvement targets for all three performance criteria. $S_2$ , in order to move on to the efficiency frontier should reduce $X_1$ 22.561 point, $X_2$ 1.845 point and $X_3$ 0.952 point.

Tablo 5: DEA results for supplier $S_3$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 154789.000 | 0.000 | 0.000 | 154789.000 |
| $X_1$ | 93.330 | -19.411 | -1.805 | 72.115 |
| $X_2$ | 4.200 | -0.874 | 0.000 | 3.326 |
| $X_3$ | 3.271 | -0.680 | 0.000 | 2.591 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

$S_3$, is a supplier which is not on the efficiency frontier with 0.763 efficiency score. Table 5 shows improvement targets for three performance criteria.

Table 6: DEA results for supplier $S_4$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 6726 | 0 | 0 | 6726 |
| $X_1$ | 90.93 | -88.464 | 0 | 2.466 |
| $X_2$ | 18.5 | -17.998 | -0.301 | 0.201 |
| $X_3$ | 79.815 | -77.65 | -2.099 | 0.065 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

Table 6 shows the target values for supplier S4 which has the minimum efficiency score 0.027.

Table 7: DEA results for supplier $S_5$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 132103.000 | 0.000 | 0.000 | 132103.000 |
| $X_1$ | 95.390 | 0.000 | 0.000 | 95.390 |
| $X_2$ | 0.000 | 0.000 | 0.000 | 0.000 |
| $X_3$ | 4.599 | 0.000 | 0.000 | 4.599 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

$S_5$ is an efficient supplier like $S_1$, so the original values and the target values for inputs are the same.

Table 8: DEA results for supplier $S_6$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 57351.000 | 0.000 | 0.000 | 57351.000 |
| $X_1$ | 93.200 | -60.556 | 0.000 | 32.644 |
| $X_2$ | 2.100 | -1.364 | 0.000 | 0.736 |
| $X_3$ | 9.332 | -6.063 | -1.891 | 1.378 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

Table 8 presents improvement targets for supplier $S_6$ .

Table 9: DEA results for supplier $S_7$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 69114.000 | 0.000 | 0.000 | 69114.000 |
| $X_1$ | 94.850 | -44.944 | 0.000 | 49.906 |
| $X_2$ | 0.000 | 0.000 | 0.000 | 0.000 |
| $X_3$ | 9.856 | -4.670 | -2.780 | 2.406 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

Table 9 shows the improvement targets for supplier $S_{7.}$

Table 10: DEA results for supplier $S_8$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 23240.000 | 0.000 | 0.000 | 23240.000 |
| $X_1$ | 97.080 | -80.299 | 0.000 | 16.781 |
| $X_2$ | 0.000 | 0.000 | 0.000 | 0.000 |
| $X_3$ | 33.034 | -27.324 | -4.901 | 0.809 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

$S_8$ should reach 16.781 and 0.809 level, on the inputs $X_1$ and $X_3$ to move on to the efficiency frontier.

Table 11: DEA results for supplier $S_9$

| Variable | Original Value | Radial Movement | Slack Movement | Target Value |
|---|---|---|---|---|
| Y | 14916.000 | 0.000 | 0.000 | 14916.000 |
| $X_1$ | 91.670 | -84.134 | 0.000 | 7.536 |
| $X_2$ | 3.300 | -3.029 | 0.000 | 0.271 |
| $X_3$ | 23.298 | -21.383 | -1.624 | 0.291 |

Y: Purchased quantity (kilo's), $X_1$: Markup, $X_2$: Delivery, $X_3$: Selling History

Table 11 shows the improvement targets for supplier $S_9$.

DEA is a performance measurement methodology that offers many tools. The main advantages of DEA as a performance measurement tool for supplier evaluation is listed below:

1) Objectively: The results of the DEA obtained by the solution of the mathematical model without any subjectivity. The
2) Benchmarking : DEA presents the reference suppliers for inefficient suppliers.
3) Determining improvement targets: Based on the efficient suppliers DEA gives the improvement targets for inefficient suppliers.
4) Negotiation tools: DEA supplies negotiation tools and values for each performance criteric.

## 5. Conclusion

Increasing competition among the corporations in the global market is today leaving the stage to the competition among the network of corporations. Leading this competition requires increasing productivity, minimizing costs and customer response times. An efficient supply-chain and performance-based supply-chain management as well as other within-corporation processes are vital to reach these objectives. Suppliers are one of the most important chains of the supply-chain. The quality of products, total costs and customer satisfaction under these circumstances are directly affected by the supplier performance. Hence, supplier evaluation has a strategic importance for the corporations. The results reached by using the right performance criteria and evaluation method would produce robust solutions towards improving the performance of suppliers.

The first aim of this study is to develop suitable supplier performance criteria and criteria weights based on the performance criteria determined for the retail industry in the literature. Presenting DEA as a supplier evaluation methodology is the second aim of this study.

The performance criteria used for supplier evaluation are, markup, delivery and selling history. The best suppliers are $S_1$ and $S_5$ based on the DEA methodology. The objectively, benchmarking, determining improvement targets and negotiation tools proprieties make DEA a suitable supplier performance evaluation methodology.

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# PHYSICAL DISTRIBUTION STRATEGIES IN THE GLOBAL SUPPLY CHAIN

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## Abstract

*The last decades of the twentieth century witnessed a considerable expansion of globalization that is dramatically changing the main logistics pattern and the physical distribution strategies across the supply chain from raw material sourcing to end product delivery. The longer geographical distances from the point of origin and the point of consumption not only have increased transportation costs, but also complicated decisions due to inventory cost trade-off related to increased lead-time in the supply-chain. The present paper analyses physical distribution strategies in a global supply network, focusing on the sourcing strategies of European companies. A framework for the selection of transportation alternatives is proposed with respect to some key factors to be taken into account for designing a global physical distribution network. Impacts of different buying policies on selecting best logistics and transportation alternatives are also discussed.*

Keywords: Supply Chain Management; Transportation Management; Global Sourcing

## 1. Introduction

Technical progress, liberalization of markets and the diffusion of production systems on global scale are creating new opportunities and challenges for developed countries and for the global market economy. Trends of globalization are affecting organizations in the emerging economies as well as those operating in the more mature ones, which are aggressively trying to achieve growth by selling to the emerging countries, having high market potential. Simultaneously, companies in the emerging economies are targeting the large markets in mature countries in their efforts to grow beyond the boundaries of their local economies. As a result of this mix of economic systems, rapid organic and inorganic growth of organizations is driving a wave of consolidation across global markets. With organizations investing thoroughly in their growth plans, organically scaling, acquiring other companies, merging with like-sized companies and creating joint ventures, should as well manage this rapid change.

One of the most significant consequences of globalization is that supply chains become more international and global. The outcome of all of this is that the logistics patterns – related to production, warehousing, distribution and transportation - should also be changed. Above all globalization creates the need to efficiently plan inter-continental transportation of goods (Bhatnagar and Viswanathan, 2000; Pollit, 1998). As a matter of fact geographical distances in global situations not only increase transportation costs, but also make trade-off between inventory carrying and transportation cost more complicate to solve. Since little attention has been given by literature to the effects of globalization on transportation, we present a decision model in order

The term "global sourcing" gives a far different meaning to the mere international purchase, which can be defined as "the acquisition of raw materials, components and subassemblies from international sources for use in fabrication, assembly or for resale, regardless of whether the import source is internal or external to the company" (Kotabe and Omura, 1989). Indeed global sourcing has a more open meaning: "integration and coordination of procurement requirements across worldwide business units, looking at common items, processes, technologies and suppliers" (Trent and Monczka, 2003). This definition highlights as key factor the ability to schedule, coordinate and synchronize the goods and information flows, from multiple sources to multiple destinations. Transportation and logistics, conceived according to the new point of view, turn from being variable costs to keep under control into strategic levers for the reshaping of supply and value chains.

For instance, up till a few years ago in container shipping from Far East (particularly from China) to Europe, it used to be a significant unbalance between exports (increasingly higher) and imports flows. This unbalance forced European companies to schedule shipments remarkably in advance, with a high risk of delay and thus causing inefficiency to the global supply chain. To get out of this some companies, having a poor control on their supply chain, tried to obtain the goods much before the moment of use, with an increase of logistics costs (inventory carrying costs and storage cost in the warehouse and at the terminal container). Nowadays the need of "synchronizing" flows is still present, and companies are particularly looking for the best choice in managing physical distribution flows as well as information flows.

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In the following sections, moving from the literature review on global supply chain design, will be presented the main physical distribution alternatives to organize a supply chain network on a global scale. The paper focuses in particular on the most relevant aspect from the European point of view, namely the supplying from the Far East. A model to assess total logistics costs has been developed in order to draw a framework for the selection of transportation alternatives to support companies in their global sourcing strategies. Then, with respect to how the purchasing process is managed, we propose a general framework for the selection of transportation alternatives. Concluding remarks and further research areas are presented in the final section.

## 2. Literature review

The growth in globalization and the related management challenges has motivated both practitioner and academic interest in global supply chain management (Meixell and Gargeya, 2005). Taking into account the impact of globalization on a company's supply chain involves a deep analysis on several key issues: from the selection of production sites, to the level of outsourcing of both production and logistics activities, up till the suppliers selection. Recent studies can be grouped in four categories: the strategic alignment of the supply chain, the distribution strategies, the organization of the supply chain network and, finally, the, coordination of the players in the same global supply chain.

Studies on facility location and on the vertical integration level belong to the first group, i.e. whether materials, components and products may be produced by company-owned facilities or by external supplier (Kotabe, 2004), in either domestic or international locations (Chopra and Meindl, 2004, MacCormak et al., 1994). Depending on the choice, there can be different supply chain network configurations, as reported in table 1.

The location of the production facilities and the relative distance of the final markets involve a different degree of responsiveness and agility of the supply chain towards the market demands. The strategic alignment of the supply chain has also been studied through analytical models, seeking a missing technical feature in the existing model-based literature concerning the drawing up of the supply chain (e.g. Cohen and Mallik, 1997, Goetschalckx et al., 2002).

According to a recent work (Mattsson, 2003), key aspects are market entry strategies (by direct export, sales agent or sales subsidiary), distribution strategies in new markets (e.g. change from sales agent to own subsidiary) and physical distribution network design (direct shipment, one or more echelon distribution network, cross-docking). An important aspect recently introduced concerning the distribution network design, is the adoption of the merge-in-transit distribution technique, where carriers pick up separate shipments from two or more points of origin (e.g. factories or warehouses) and drive them to a place where shipments are consolidated and a single delivery is performed. Merge-in-transit could be especially useful to companies expanding into new geographical regions not properly covered by existing distribution networks. Companies that have been reported to be utilizing merge-in-transit distribution include Hewlett Packard, Dell and Ikea (Ala-Risku et al., 2003).

Table 1. Example of supply chain Network Configurations (from Hong, 2002)

| Network configuration | *Description* | *Locus of manufacturer* | *Locus of supplier* | *Locus of demand* |
|---|---|---|---|---|
| *Local manufacture* | *Products are made locally, with local parts, to meet local demand* | domestic | *domestic* | *domestic* |
| Traditional export | *Local products are exported to foreign markets* | *domestic* | *domestic* | *abroad* |
| International sourcing | *Products are made locally, with parts sourced from abroad with procurement based on specific needs, to satisfy local or foreign demand* | *domestic* | *abroad* | *domestic or abroad* |
| *Global sourcing* | *Products are made with parts sourced from abroad as parts of a global procurement strategy, to satisfy local and foreign demand* | *domestic* | *abroad* | *abroad* |
| *Off shoring* | *Products are made abroad, and then are re-imported to meet domestic demand* | *abroad* | *domestic or abroad* | *domestic* |
| *Global manufacturing* | *Products are made abroad to meet demand in the respective foreign market* | *abroad* | *domestic or abroad* | *abroad* |

The organization of the supply chain network involves the choice of the suppliers, the transport mode (sea, air, rail and road). Many studies do often consider the transport side without including inventory costs as part of the decision problem while others concentrating on transports at global level, do focus on the creation of the global network from the carrier's point of view, using models like hub&spoke or multi-port calling (e.g. Imai et al., 2006 for maritime transport; Lee et al., 2003 and Zhang, 2003 for air transport). As far as suppliers selection or, more generally, purchasing management on a global scale is concerned, there are several articles in literature, mainly focused on the level of centralization of the purchase capacity (Arnold, 1999) and on the assessment of the performances (Degraeve, 1999), while there is not a thorough analysis of the relationship between the purchase organization (direct, intermediate) and the supply chain network.

Global supply chains are more complex to manage than domestic or continental ones. Different local cultures, languages and practices decrease the effectiveness of business process such as demand forecasting and material/production planning. Some authors (Trent and Montzka, 2003) study the need and the value for integration between facilities in the global supply chain (i.e. Vendor Managed Inventory practices or implementation of Advanced Manufacturing Systems). On the other hand, Bozarth (1998) recommends providing accurate forecasts of requirements from purchasing manager to suppliers, in order to allow them to plan their available capacity more effectively. The more frequent this type of information is shared, the quicker the supplier can react.

In the following section will be presented the main physical distribution strategies to organize the supply of end-product from Far East.

## 3. Transportation strategies to organize a supply chain network at global level

Transport modes which can be used at intercontinental level are principally container shipping or air cargo, while as far as the link from the supplier to the port/airport of loading and from the port/airport of unloading to the final destination is concerned, the prevailing mode of transport is road and, in some cases, intermodal transport.

Air cargo, due to a cost 5 times higher than the container shipping one, is generally employed when the value density of goods is high (e.g. high tech products) or its implicit value, when there is a contractual duty for express deliveries, even at costs which are definitely higher (e.g. when shipping critical spare parts to recover a IT system crash). Container shipping, due to low freight rates, represents the most used way to import from Far East a large variety of both industrial product and consumer packaged goods, despite long lead times (on average it takes from 4 to 6 weeks from a South-Eastern Asia port to any UE destinations).

With a focus on the supply process of nonfoods consumer goods from Far East to Europe by means of container shipping, we identify three main transportation strategies (see figure 1):

1) *Full Container Load (FCL):* a single container (or a group of containers) is completely loaded by one supplier and it is destined to a single customer. If goods are sold FOB (Free On Board), the freight and insurance costs are charged to the consignee. It has to be noticed that this transportation service is provided both by freight forwarders (e.g. DHL) and shipping lines (e.g. Maersk).
2) *Less than Container Load (LCL):* goods coming from several suppliers are consolidated at the freight forwarder site in the country of origin, generally located near a port. After arriving at the port of destination, goods are deconsolidated and shipped to several consignees.
3) *FCL via consolidation hub:* goods are consolidated in a warehouse in the country of origin and shipped as FCL (although multi supplier) to a single customer. Differently from solution B, here there is a consolidation point, where the container is filled with goods coming from several suppliers for the same consignee.

For each of the aforementioned solutions there are many variables that increase the degrees of freedom, for instance the opportunity to choose the container capacity (20 or 40 feet, standard or high cube) or packing system (palletized unit load, slip-sheets, break-bulk). LCL solution involves higher transportation costs than FCL, due to the additional handling and to more expensive pick-up and delivery routes. In order to avoid such a problem, when offering LCL services for the Chinese market, freight forwarders often use specialized companies (also known as NVOCC, that is Non Vessel Operating Common Carrier), which consolidate single shipments in the same port of origin.

Solution C (FCL via consolidation hub) is similar to the LCL service, but employs a less expensive FCL technique. The main difference lies, besides the way of managing only the import flows of one company, in the opportunity to store goods temporarily in the consolidation point. This transportation service implicates a better level of service towards destination markets and the possibility of a better planning of activities. The improvement in planning results even from a better guarantee of the quality of the incoming products, because the quality control can be performed before shipment.

Nowadays the majority of the companies tend to use the first solution (FCL), mainly because of its great operational simplicity and lower transportation costs, although is not necessarily the most convenient one. In order to fully understand the convenience of the FCL solution, a model for evaluating logistics costs has been developed as described in the following section.

## 4. Evaluating the FCL solution

We developed a model to assess the effectiveness of the FCL solution, using the data from an anonymous Italian retailer, leader in the *bricolage* and home improvement products. The aim of the model is to deeply understand how costs vary in relation to the volume of goods for a single buyer-seller relationship.

The following assumptions have been taken into account:

- conditions of purchase: FOB (Free On Board);
- transport mode: container shipping with a 40 feet container;
- origin: Southern Asia;
- destination: Northern Italy;
- replenishment policy: fixed order interval and variable order quantity;
- packing system: unpalletized loading.

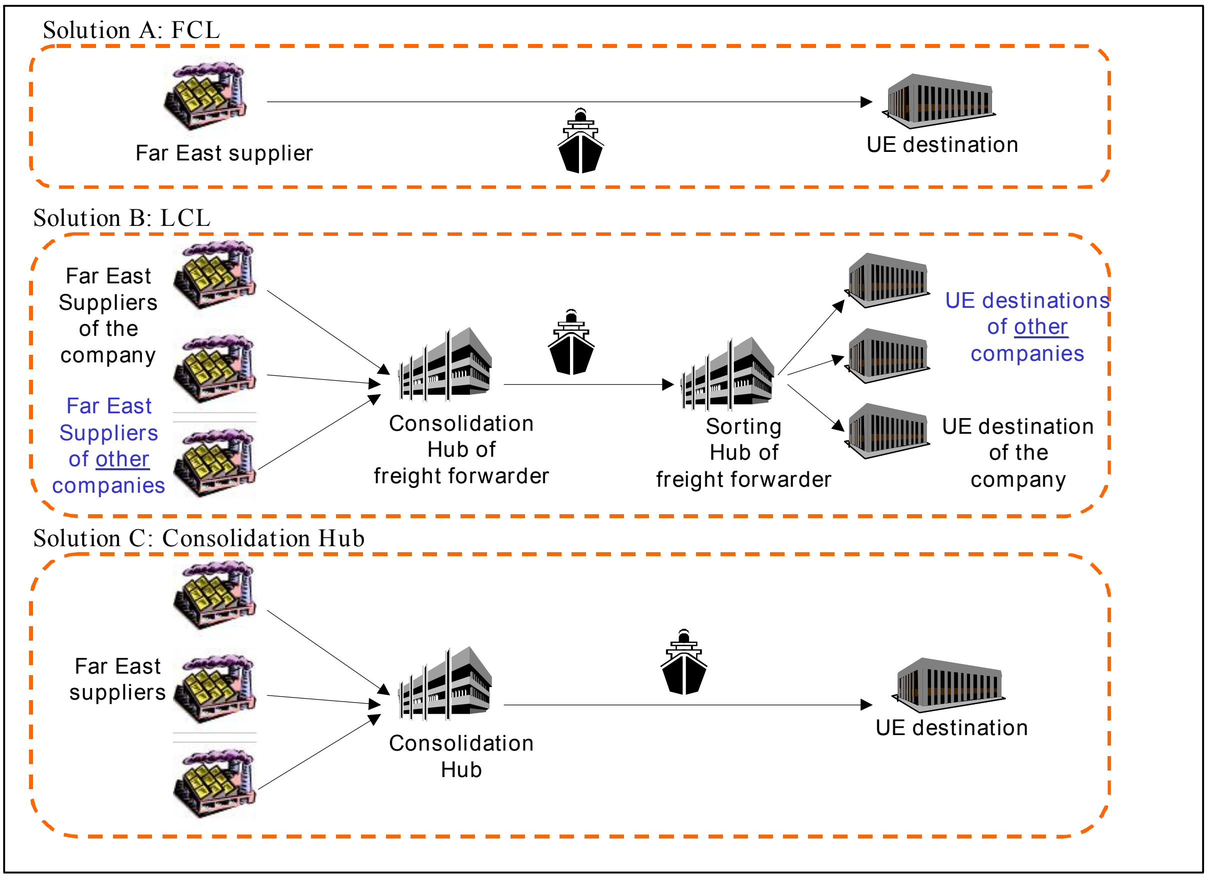


Figure 1. Logistic solutions for organizing the supply chain network at global level

Since we decided to focus on the optimization of the transport mode for a given annual volume of goods, we considered a constant unit price on annual basis. We classified logistic costs into three categories: transportation from supplier to Italian warehouse, inventory carrying costs in Italian warehouse, order processing costs. Transportation costs include freight rates, terminal handling charges (THC) and other costs such as agency fee, export documentation and insurance. Inventory carrying costs include storage costs, cost of capital, and other costs (insurance, taxes, theft, deterioration, damage, obsolescence). Inventory costs concern cycle and safety stocks in the Italian warehouse for each of the *n* supplied items, while in-transit inventories were not considered, because they mainly depend on transport lead time. Order processing costs are mainly related to salaries of employees responsible for purchasing and order processing system. We did not take material handling costs into account because they are not differential.

Cost evaluation was made for each of the above categories by identifying the main activities that is following Activity Based Costing approach (the cost of each activity is related to a cost driver, e.g. the number of annual orders). For instance order processing costs can be resumed into a model as a fixed amount per order plus a variable amount, depending on the number of lines per order.

For different annual volume of purchases, the optimum quantity for reordering and the correspondent logistic cost and the cost-to-value ratio (Zeng, 2003), has been calculated in the following way:

$$w = \frac{LC}{D \cdot P} \quad (1)$$

where:
w= cost-to-value ratio
LC =annual logistics cost [€/year]
D = annual demand [items/year]
P = average unit purchase price [€/item]

This model has been applied to a basic scenario (see table 2), which is typical for many UE retailers (e.g. nonfood consumer goods), calculating optimal logistic costs when the annual volume varies.

The results shown in table 3 underline a relevant fluctuation in logistic costs concerning the FCL solution, when the annual demand changes, and consequently the influence on the considered flows. The less the handled flow per single origin-destination relationship is, the more a company will concentrate annual volumes in few FCL shipments, in order not to increase transportation costs. With this solution total logistic costs grow due to higher inventory holding costs. Therefore the cost-to-value ratio mainly depends on the volume at stake and on the frequency of shipments, while nowadays companies, especially due to its operational simplicity, prefer always to adopt this solution, regardless the business environment they are in.

Table 2. Basic assumptions of analyzed scenario

| Parameters | *Value* |
|---|---|
| *Number of items* | *30* |
| Coefficient of variation (std deviation on average demand) | *0.4* |
| Average lead time [weeks] | *6* |
| *Standard deviation of lead time [weeks]* | *2* |
| *Inventory carrying rate [%]* | *25* |
| *Order processing cost* | *1 €/order + 10 €/order line* |
| *Transportation cost [€/container]* | *2,400* |
| *Unit volume [$m^3$/item]* | *0.12* |
| *Unit purchase value [€/item]* | *25* |

Table 3. Logistics costs as function of annual demand

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Procurement value [€/year] | 39,000 | 78,000 | 156,000 | 234,000 | 390,000 | 468,000 | 702,000 |
| Annual demand [$m^3$/year] | 187 | 374 | 748 | 1,123 | 1,872 | 2,246 | 3,369 |
| Optimal logistics cost [€/year] | 10,836 | 19,770 | 37,229 | 53,926 | 89,606 | 104,385 | 152,726 |
| Cost-to-value ratio | 27.7% | 25.3% | 23.8% | 23.0% | 22.9% | 22.3% | 21.7% |

## 5. A framework to evaluate the transportation strategy

As pointed out in the above example, FCL solution is potentially not convenient when logistic complexity is high, that is when flows are not remarkable (for instance below 400 $m^3$/year*)*. Thus for a company it is convenient to use solution A (FCL) when logistic complexity is low (see figure 2), e.g. when flows on origin-destination relationship are high. On the contrary solutions B (LCL) and C (FCL via consolidation hub) prove to be worthy when the logistic complexity is high. Choosing between these last 2 alternatives mainly depends on the importance of the supplying countries considered by the company. The greater the importance (and thus the number of suppliers/facilities and the annual volume) the bigger the need for a consolidation warehouse. Otherwise it is better to rely upon the logistic network of freight forwarders and shipping companies, using a FCL service.

The value of the flow on the origin-destination relationship (and thus the logistic complexity) depends not only on the supplier's production volume but also on the annual demand volume required by the European customer, which depends on the overall global supply chain organization. Indeed, in the case of a supply chain based on a single European distribution center where goods are shipped out to customers in every single country, the supplier's overall outbound flow equals the inbound flow at the central warehouse. On the contrary, when a network of domestic warehouses are used instead of a single European distribution center, there should be not enough volumes on each single routes from the supplier to every single domestic warehouse so to employ a FCL solution (without relevant changes in the frequency of replenishment), thus increasing the logistic complexity.

In order to fully understand the application fields of the transportation strategies we are examining, it is important to investigate as well the kind of suppliers dealing with the company on a global level and the impact on supply chain planning. Intermediaries for the supplying of finished goods could be divided into three categories:

- commercial intermediaries;
- complete traders;
- primary manufactures.

In the first case generally the company has a relationship with a commercial intermediary, who provides a connection with local manufactures. The customer-supplier relationship occurs without undertaking audit actions or anyway without developing a continuous contact with the aim of having a strong control on the process. Often the only contact between trading partners occurs at the beginning of the relationship, in order to agree the purchasing conditions (e.g. during trade fairs). A relationship of this kind fits in natural way to a not really complex process, where there's no need to develop an accurate control on quality and on the development of the supplied product.

In the second case, the company relies upon a complete trader offering many services, ranging from quality control to selection and assessment of suppliers, up to ensure, in many cases, the management of the logistic process and of sourcing activities (Lee, 2000). In this last case it is interesting to highlight that some "complete" traders have a consolidation warehouse on which the customer can rely on for the organization of the logistic process.

Finally, in the case the company directly deals with the manufactures, the complexity increases in terms of control of the relationship and the activity planning. In order to carry out these activities a trade unit (called also

IPO, International Purchasing Office) could be established. Trade unit makes easier to work directly with producers, carrying out many activities, such as performance measurement, in field quality control, planning plans sharing.

Using a classification scheme similar to the one proposed for transportation strategy selection, it is possible to classify the above described solutions according to the importance of the supplying countries and complexity of relationship with supplier (e.g. importance of planning activities management, physical flows control and products quality control). The greater the complexity of relationship with supplier, the bigger the need to strictly control and monitor the relationship. The responsibility of the management of supplying and planning activities will be in charge to the complete trader in case of low importance of supplying countries (see figure 3). Otherwise it is better to manage directly the relationship through an IPO.

In case of low complexity of relationship with supplier it will be more useful to work with commercial intermediary. In this case, growing the importance of supplying countries, it will be favorable for the company to introduce a trading company to bypass the intermediary and increase mark up.

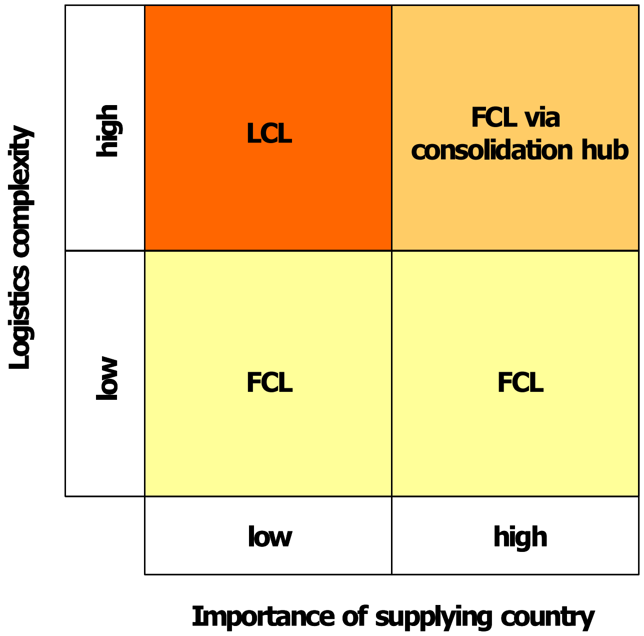


Figure 2. Transportation strategies in a global supply chain

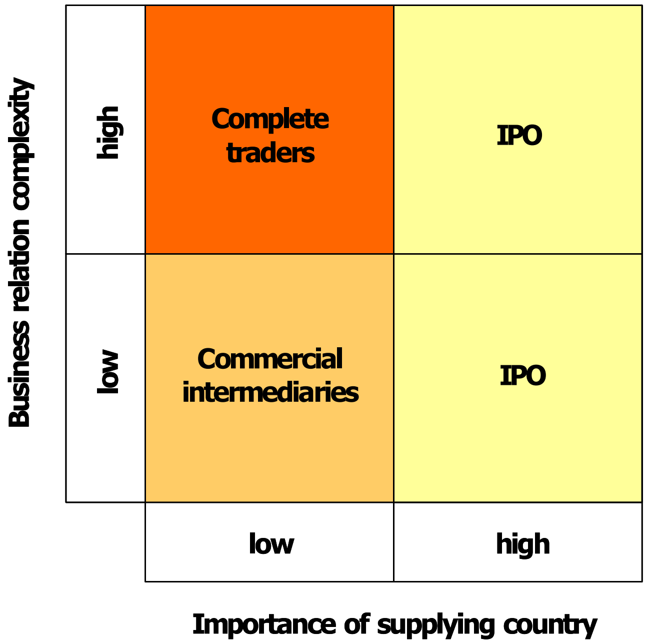


Figure 3. Solutions for the organization of the purchasing process at global level

## 6. General Framework and final remarks

On the basis of transportation strategy analysis (see figure 2) and implementing solutions in the organization of purchasing process (see figure 3), it is possible to identify some scenarios for logistics organization at global level (see table 4):

- if the importance of supplying countries and logistic complexity are low, it is worthy to use FCL solution both with commercial intermediaries and complete traders.
- if the importance of supplying countries is low and logistic complexity is high, LCL solution could be used with commercial intermediaries; otherwise, if possible, it should be preferable to use the FCL via the hub of consolidation managed by complete traders.
- if the importance of supplying countries is high, it will be necessary to introduce an IPO. The IPO should provide planning and management of relationship with low logistic complexity, while an increase in logistic complexity needs to introduce also one or more consolidation hubs.

It's very important to underline the strong relationship between the two kinds of complexity examined in this work (logistic complexity and relationship complexity). With a procurement strategy focused on minimizing procurement cost through multiple sourcing policy, the management of relationship will be less important (low complexity of relationship with supplier) while the values of the flow on the origin-destination relationship will be low and thus the logistic complexity will be high. Otherwise when a company has a strong relationship with a small number of suppliers relationship complexity increases, while decreases logistic complexity, because of the incidence of single supplier on physical flows is higher. So it is very important to assess benefits diminishing in importance in the use of multiple sourcing within a given class of products (quantity discounts, lead time reduction following from higher percentage of supplier capacity, reduction of logistics costs) with those obtainable through traditional bidding from multiple sources (above all low price).

Drawing a balance of the present study, which focuses on physical distribution strategies to be applied in a global supply chain, not only in relation to transportation cost but taking into account other logistics aspects such as inventory levels, ordering process and goods unit value, we found out that FCL solution is not necessarily the most convenient one.

We developed a decision matrix to support the choice of transportation strategy, where main aspects to be considered are logistic complexity (based on the annual volume shipped on the origin-destination route) and importance of the supplying countries.

Table 4. General framework to select logistics organization at global level

| Importance of the supplying countries | Logistic complexity | Relationship complexity | Proposed solutions |
|---|---|---|---|
| Low | Low | Low | FCL and commercial intermediary |
| Low | Low | High | FCL and complete trader |
| Low | High | Low | LCL and commercial intermediary |
| Low | High | High | Complete trader and use of trader's consolidation hub |
| High | Low | Low / High | FCL and IPO |
| High | High | Low / High | FCL via Consolidation hub and IPO |

Results open a number of other issues that call for in-depth studies and further investigations. For instance, a key issue to further evaluate the consolidation hub solution is the number of hubs, with respect to the number and localization of suppliers. Furthermore it could be very interesting to study the implementation of physical distribution strategies with reference to purchasing consortia of small and medium sized companies or industrial districts.

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# THE PRODUCTION OF STRATEGIC KNOWLEDGE WHILE PLANNING FOR THE FUTURE OF SUSTAINABLE COMPETETIVE POWER: THE ANALYSIS OF LIFE CYCLE COST

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## Abstract

*The change process having multiple variables and multi-facets, in the 21st century influenced the genetic codes of the enterprises (focusing on the customer, technology and product structure, production processes, human resources, cultural structure, etc.) so much that this process turned into a sustainable development in terms of ecological aspects. In this respect, the enterprises which are weak and which do not have the adaptation capability are continuously under the threat of the changes around and to be able to exist, they have to develop adaptable models and reactive behavior styles. (the enterprises having skills that will enable it to survive in the long term, using the new sources efficiently and effectively, developing the decision making and practice skills, etc.) This reactive behavior style that will be developed by the enterprises, in a way, means "strategic administration skills". The enterprises which cannot use the strategic administration skills effectively lose their competitive power it is not important that the enterprises have the competitive power for a temporary or limited period of time. The important thing is that this power is constant and permanent. It is because the superiority of the successful enterprises can be easily imitated and this superiority can be lost in a very short time. Sustainable competitive power is possible if the valuable and rare abilities and strategies of the enterprise do not allow any room for imitation and substitution by the chancing environmental conditions. Thanks to the environment-adaptable ability concept, there is more possibility of creating more value than the rival enterprises. Whether value is creating or not becomes clear with the customer perceiving the product & service that he bought. When the client thinks that he can buy a standard product or service with a lower cost or when he believes that he got more than he paid, a value for the client is created. All the activities related to producing a good that will have a value for the client or delivery cost some deal. The value added to the product by the enterprise activities is expected to be more than the cost of the activity. If the case is so, it means that value is created in that enterprise. On the other hand in the enterprises, each value added by the activities is not the same as one another. The value that some activities add to the products is lower than no value has been created. In this respect, the activities that create value in the enterprises and the value they add to the products is determined by "Value Chain Analysis" (VCA).*

*In VCA, in determining costs of basic and support activities, usage of "Life Cycle Cost Analysis" (LCCA) with Activity Based Costing will provide more efficiency to enterprises according to economical modeling.*

*Life Cycle Cost is a concept that covers all costs such as R&D, investment, actuation, maintenance and also taking the system out of service costs. But LCCA is a method and a chain of processes developed for estimation of costs that can come out in a period beginning from concept phase of a system, product, project or facility until taking the system out of service, including R&D and actuation costs.*

*LCCA made comes out as a result of usage of basic and support costs' system and products which are the main factors that form costs. In this context, it will be better to take into account not only owning costs but all life cycle costs that will be formed and endured throughout all life time while taking production or provision decisions.*

*The main purpose of this paper is to state that LCCA system can be used in enterprises as a decision making tool. In this paper, our principal aim is to put forward that Life Cycle Cost Analysis system can be used as a decision making medium in businesses.*

Keywords: Sustainable Competetive Power, Life Cycle Cost, LCCA, Strategic Knowledge

## 1. Introduction

The multi-dimensional process of change with multi-variables has increased its impact and pressure on the genetic codes of enterprises (such as customer-focus, technology, the shape of the product, production processes, human resources, cultural structure, etc.) so much that this process of change has turned into a sustainable development in ecological aspect (SDEA). In this context, weak and inadaptable enterprises are always under the threat of the change in their field, and thus, their sustained existence depends on their coming up with compatible adaptation models and maintaining reactive attitudes (finding new talents for the business to sustain longevity, using the new resources effectively, developing decision-making and implementing talents). This reactive attitude, in a sense, means "strategic management skills". The businesses which don't use their strategic management skills effectively will lose their competitiveness. It is not important for competitiveness

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to be momentary or for a certain period of time because the advantages of successful businesses can easily be copied by their competitors, and thus, the advantage might be lost soon. Sustainable competitive power is possible when the asset strategies of the companies and their uncopiable, rare skills become compatible with the changing environment. Thanks to the concept of compatible talent, it becomes possible to create more value than the competitors. Whether this value has been created will became clear when a customer perceives the good or service he/she has bought. When a customer thinks that he/she can buy a standard good or service for a lower price, or believes that he/she is getting more benefit from the product than that of the price he/she has paid, that product has been able to create a value for that customer. However, any activity of producing the goods that will create value for the customer and delivering this to him/her will cause a sort of cost. So, the value this activity adds to the products of the enterprise is expected to be higher than the cost of this activity. In this case, value can be said to have been created in this business. On the other hand, not all the values the activities provide for the businesses are the same. In some cases, the value might be smaller than its cost, which means that no value has been created. In this context, we determine the value-creating activities and the value they add to the products via "value-chain analysis".

In value-chain analysis, while determining the cost of basic and secondary activities, we can be more effective, with regard to economic modelling, by using "life cycle cost analysis" with costing based on activity. In this paper, our principal aim is to put forward that Life Cycle Cost Analysis system can be used as a decision making medium in businesses.

## 2. The Concept Of Life Cycle Cost, Its Reason, Relevant Concepts And Topics

In social life, the path to success in economical, social, political and cultural aspects requires obtaining necessary data in the fastest way, recording them, turning them into information and using them efficiently. This process, also defined as the management of information effectively and efficiently, is the most vital means of evidence of the organisation in global competition.( Von Krogh&Ichijo-Nonaka, 2002:18)

Management of information is not only composed of making the best use of the latest information technologies, but also requires a certain culture. Sharing information, transparency, combining the talents to create synergy all constitute the vital parts of this process. Information is a notion that increases when shared and gets enriched when fed from different perspectives. Hence, using information effectively and efficiently requires its transformation into not only technology but also institutional culture (Tiwana, 2003:18).

Competitiveness relies on information – the only production factor that increases when used and shared because information is the most important factor that directly affects productivity and cost-efficiency which are the components of competitiveness (Elmacı, 1990:28). Businesses have to push their core abilities and institutional identities across all geographical distances, language and cultural obstacles, and thus enriching its essence with innovations from various cultures. All this formula must be presented at the right time and at the right place as the right product and some abstract.

Concepts like the talents, image and prestige of the business must be added to this formula. The fact that these abstract concepts are used with the right timing and the right formula will lead the competitiveness of the businesses to rise.(Dervişoğlu,2004:16,Bröndenburger&Nalebuff,1998:36) While defining intellectual capital, the difference between the book value and the market value of a business is gaining importance, especially with globalisation also called as new technologies ( Stewart,1997:152). Intellectual capital has three sub-components: human capital, customer buildup and structural capital. Human capital is equal to the information accumulation of human resources and its cost is equal to its ability to create this information again. Customer buildup is the affection a business has with its customer, and it stresses a kind of customer loyalty. Structural capital is the reflection of human capital and customer buildup to the product, and the faster a business achieves it, the faster its competitiveness increases (Hammer&Champy, 1994:76).

### 2.1. The Similarities and Differences between Life Cycle and the Longevity of a Product

Enterprises have to adapt to its environment – as in the evolution theory of biological species; otherwise, they may face extinction (Ülgen&Mirze, 2004:29). In this sense, a product of a business is exposed to mutation with environmental impacts as a biological species is. Therefore, the mutant product can survive by adapting the environment. The life cycle of the product involves being born, growing up and death. While analysing this cycle, not mistaking the product life cycle with the life cycle of a product means a critical point (Atçı,1992:46,Özkil,2002:23).

The product life cycle means the process starting with the necessity of the product and going on with all kinds of preparation, system development, trial and mass production, stocking, launching to the market, running and developing and taking it out of inventory. The life cycle of a product, on the other hand, means the process in which the strategies and determined and applied so as to get maximum profit from the product from the time it has been launched to the market (Atçı, 1992:47).

The concept of life cycle theory, by referring to "the evolution theory of biological species", argues that businesses, products alike, have to adapt themselves to the environment, and that whichever cannot won't survive. This notion argues that the a creature in development exists in a secret form, logic, program or code which organises its evolution processes, and moves it from the starting point to the next coded point (Ülgen& Mirze,2004:29).

The source of this notion is biological. The notion means a living organism which can be affected by the environment and whose development is governed by rules that explain how it grows up and develops.

2.2.The Cost and Analytical Structure of Life Cycle

The cost of life cycle ( LCC) involves all total costs of the planned system and its secondary activities. It also involves the current and future costs of research and development, production/purchasing, operation, backup and selling activities (Genel Kurmay Başkanlığı (GB), 2004:220). We can formulate this as follows: (Ostwald, 1992:6, Fabrycky&Blanchard, 1990:513, Fabrycky&Blanchard, 1991:29, Özkil, 2002:30).

$(LCC) = C_R + C_I + C_O + C_D$

$C_R$ : Research –Development Costs

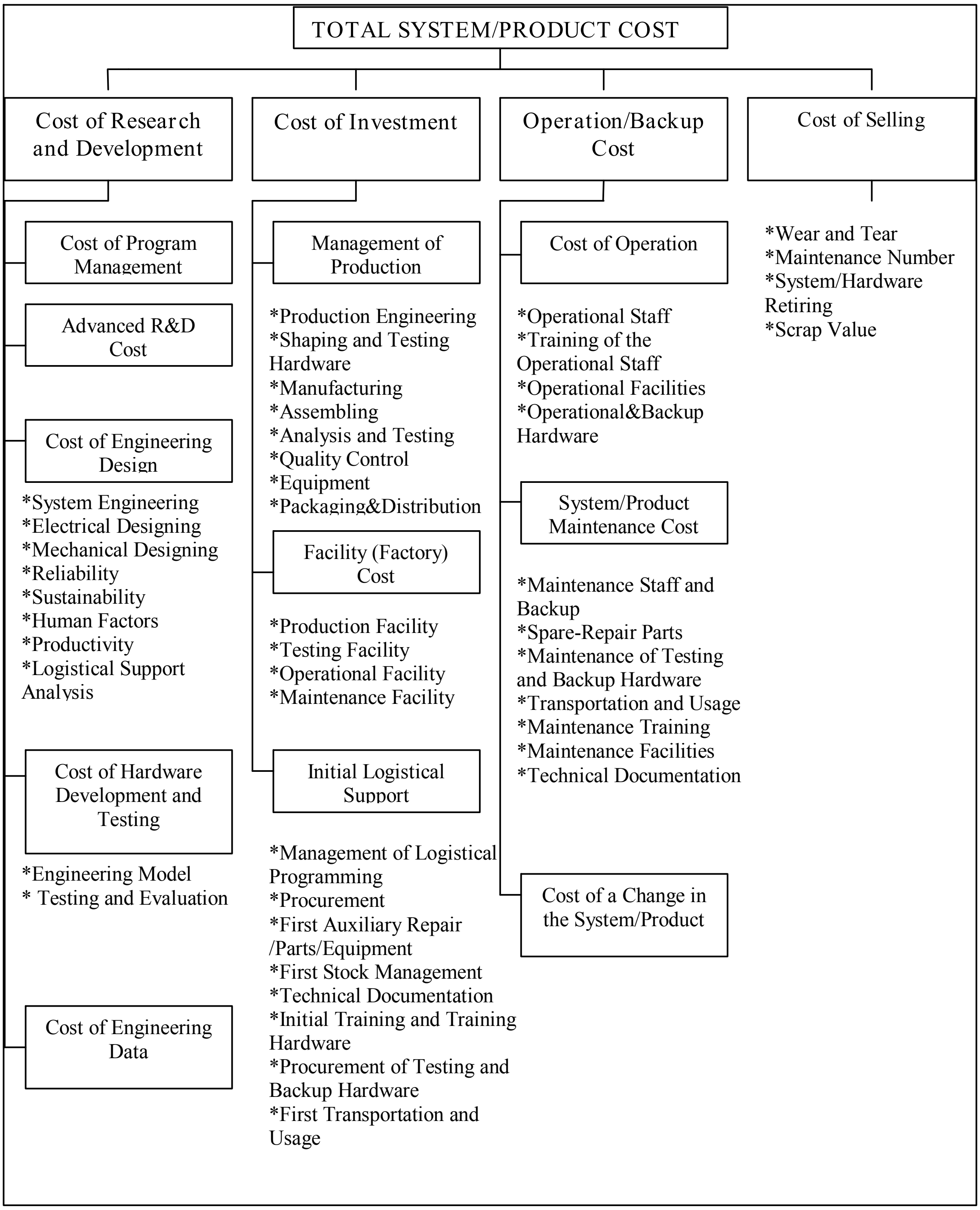
$C_I$ : Investment costs (Production and System Costs)

$C_O$ : Operation/Backup Costs

$C_D$ : Costs of taking out of inventory (Selling)

The Analytical Structure of The Cost of Life Cycle is shown at Table 1.1. (Fabrycky&.Blanchard,1990:513,Fabrycky&Blanchard,1991:29).

Table 1.1. The Analitical Structure of The Cost of Life Cycle



2.3. The Cost Analysis of Life Cycle

When we say "Cost Analysis of Life Cycle", we understand the dynamical analysis of the relations of the factors, which cause all life cycle costs, between each other and with other factors. We are interested in how costs have occurred at different times throughout the life cycle between what is in hand and other abandoned alternatives. It is possible to list the factors affecting the life cycle costs as follows: (Şimşek, 1999:51).

- Inflation,
- Budget limitations,
- The increase in the use of Cost-Activity analysis,
- Competition,
- Products with high costs (commercial planes, military systems etc),
- Increasing maintenance costs.

The analysis of LCC especially in businesses which use order cost system not only plays a vital role in determining, decreasing and keeping the costs under control, but, depending on the production, model has various other applications as well (Genel Kurmay Başkanlığı (GB),2004:224).

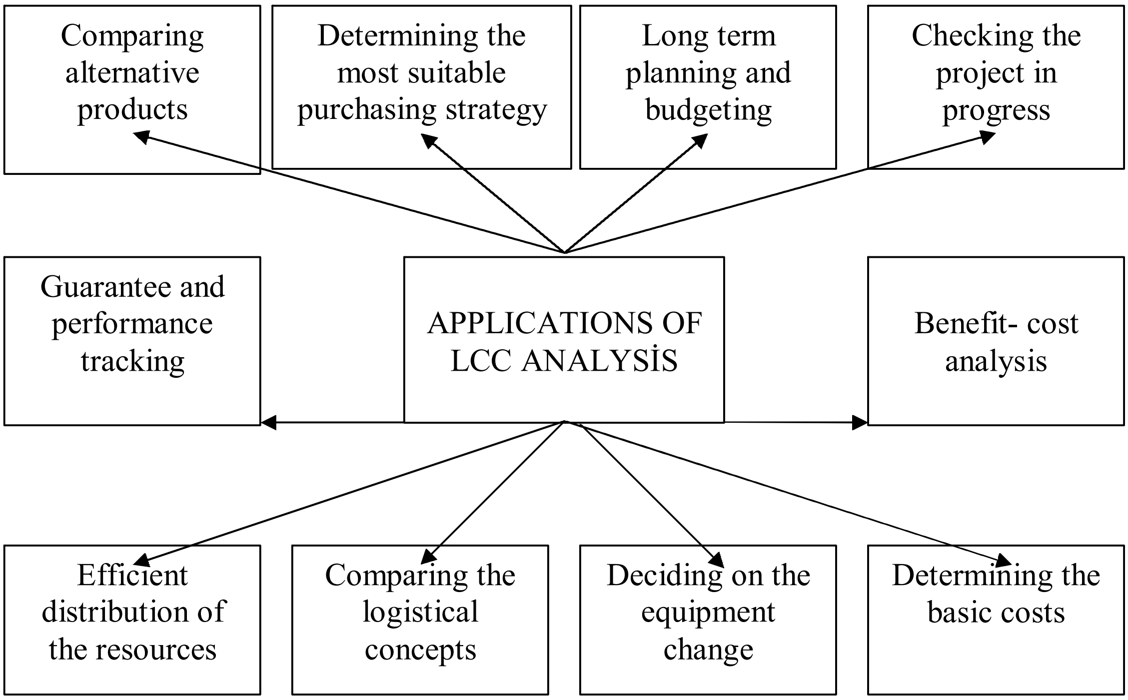



Figure 1. Applications of Life Cycle Cost Analysis (Genelkurmay Başkanlığı, 2004:224).

## 3. LCCA Business Formulation

A systematically and effective LCCA study is comprised of consecutive four stages. Furthermore; these four stages must be formulated so as to involve relevant sub-stages within itself. The mentioned five stages are (Şimşek, 1999:37);

Preliminary research for LCCA,
Preliminary design for LCCA,
Detailed design for LCCA,
Testing the accuracy of LCCA,
Implementing LCCA.

*Preliminary Research For LCCA;*

At this stage, the primary activity is to determine the aim of the analysis (choosing the most suitable among alternative products, making the total possession cost of the product minimum or tracking the cost of the purchased product) under management support. The next step will be compiling the necessary logistical information for alternative operation / maintenance, alternative design structuring, alternative purchasing charts and alternative logistical support policies (Şimşek, 1999:37).

*Preliminary Design For LCCA*

At this stage, the limitations of LCCA are determined and eliminated. As in all mathematical and graphical models, what are tried to be predicted are the stages and events the product goes through all its life such as purchasing, maintenance, repair, etc., and the costs of all these. The more extensive the model is, the more possible it will be to involve the processes the product has undergone into the model and the more accurate our predictions will be. However, our limitations might hamper enlarging the scope of the model. What we mean as limitations here are such things as time, the infrastructure of the system, personnel background, data in hand (Genel Kurmay Başkanlığı, 2004:39). After determining the aim and the extent of the model, we must determine the necessary data required for model calculations. At this stage, we must also determine when and at what time intervals we will do LCCA and what the prediction procedure will be. It will also be logical to determine the most suitable assumptions in order to overcome the concurrent uncertainties in the prediction procedure (Altaylı, 1995:14).

*Detailed Design For LCCA;*

The more extensive the cost refraction structure in LCCA is and the wider the formulas are composed, the close the calculated cost will be to the real cost. When we say "extensive", we mean that there are two ways to calculate a cost item; we can either directly assign a formula for that item or create sub-items and assign a formula for each. In the first way, there is more chance to make a mistake while predicting a big cost item. Therefore, as long as we have adequate data, creating sub-cost refraction structures will enable us to make better predictions (Başaran1998: 22).

*Testing The Accuracy Of LCCA;*

After making up a LCC model, we must determine how to test the accuracy of the model; if needed, we must create testing scenarios from past experiences. We can start designing a model only after we have had a certain opinion about the above mentioned points for the cost analysis of a product or a system (Dhillon, 1989:38).

*Implementing LCCA(Sensitivity and Risk Analysis);*

As mentioned above, a fraction of the data used for cost estimation may not be equal to the real figure all the time. Unfortunately, this case can be understood only after we have purchased the product and have started to collect the real data. Hence, prior to the purchasing, in order to cope with this uncertainty, we can apply sensitivity and risk analysis. Sensitivity analysis enables us to evaluate the effect of the key parameters of LCC on LCC, while risk analysis lets us assess the effect of the change in the behaviours of these parameters on LCC. Here, "behaviour" means whether the mentioned parameter has constant or certain dispersion (normal, uniform, etc.). In risk analysis, by changing the defined behaviour of a parameter in LCC analysis, we can observe the relevant changes in LCC(Fabrycky&Blanchard,1991:135).

The concept of LCC may mean different things according to where and why it is used. Generally, LCCAs are carried out prior to purchase or manufacturing of a product so as to compare and contrast the alternatives with respect to their cost. The procedure here is choosing the most cost-effective product by creating a model that will reflect the product life-span according to product type and usage aim in order to compare the alternative on a common platform, and by evaluating the results when this model is calculated for each alternative. While calculating the cost model for alternative products, most of the required data can be obtained from a contractor. In addition, the organisations that will use the product will also its own data. The aim in this analysis is to predict the cost of the life cycle cost of the product with the data in hand prior to using the product (Earles, 1991:1-10).

In another type of analysing called "actual life cycle cost", the cost analysis of an already bought, in-use product is done throughout its life cycle. In this type, the parameter values of the cost model are updated frequently and LCC parameters of the product are calculated on the basis of the latest figures. As a result of doing the analysis with up-to-date parameters, LCC of the product will be more realistic especially for recent years. This, in return, provides reliable data transfer to the budgeting studies of the product, and thus cutting down budgeting errors (Stewart, 1991:43). It is possible to gather LCCA process under four main titles as shown in Table 2.1;(Fabrycky&Blanchard,1991:135,Fabrycky&Blanchard,1990:17,Jang, 20.09.2002, http:// www.tsm.ksp.or.jp) namely, i. Determining an aim, ii. Cost prediction, iii. Preliminary cost analysis, iv. Decision.

## 4. APPROACHES FOR LCCA

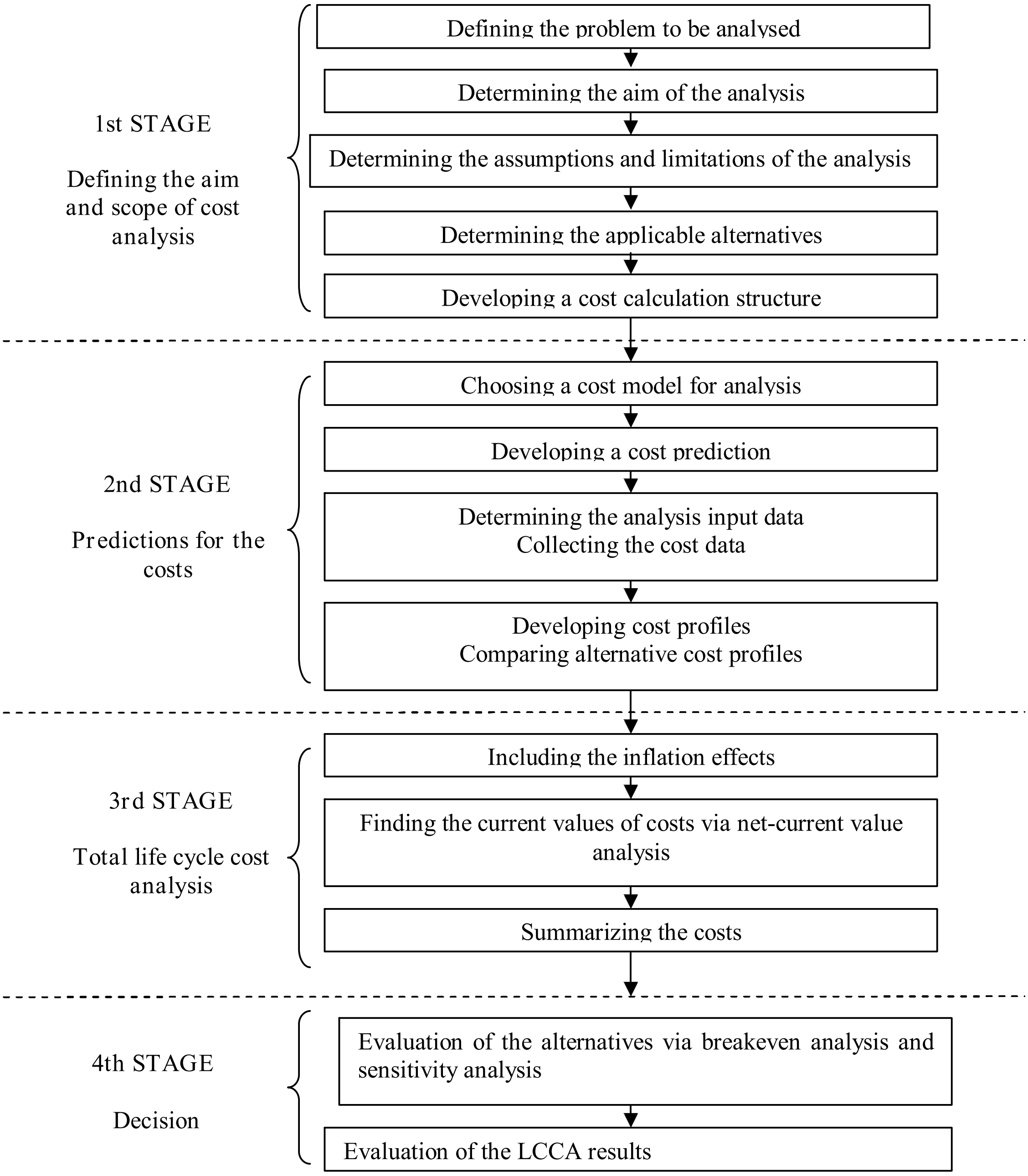
In the process of LCCA, especially at the second stage, "the expected value / scheduled value" are found via cost prediction methods. Cost prediction methods might involve a formulation ranging from one term to multi term equation according to the formation of these data and the way we obtain them. It is possible to list them under three main titles (Özkil, 2002:33, Candan, 2003:21,Aytok, 2006:31):

Analogy ( Simulation) Method
Parametric Methods
Engineering methods

### 4.2.1 Cost Estimation Relations (CER)

In its simplest definition, CER is either the cost itself or function of the multiple cost variables that create the cost. As can be understood from this definition, while it is possible to define cost relation simply as the ratio of two values, it is also possible to complicate it by defining it as a formulation that involves multiple variables. As it gets more complicated, it will be defined by an analyst as a cost model (Özkil,2002:37).

Table 2.1. LCC Process




4.2.2 Parametric Prediction Models

It is possible to list these models in two groups: one designed for commercial use and the other for other private reasons by businesses. Organisations and businesses want to develop their own parametric prediction methods for various reasons the most important of which is that the current available models aren't enough for the businesses to provide for their estimated necessities. Another reason for the businesses to act like this way is that they have the opportunity to develop their own models parallel to the experiences they have built up about cost prediction. There are no models in the commercial concept as parametric models (Özkil,2002:38).

4.2.3 Expert's Decisions

This technique involves comparing expert opinions and experiences for projects or systems designed by one or more expert personnel. The most common techniques of this sort are DELPHI and Analytic Hierarchy Process-AHP. This method is based on making an assessment between the only developing sample systems and the past / future systems especially if there are no available data for the past. However, bias of the experts and lack of information about the past and current systems might distress the experts. Therefore, it is impossible to use these kinds of techniques to determine, for instance, the cost of newly-written software program. As a result, this technique is generally used at the stage when we are composing input for other type of models (Özkil,2002:38).

### 4.2.4 Bottom-up

Being a sophisticated and time consuming technique, bottom-up prediction technique analyses every unit about cost in detail. Afterwards, combining the analysis results, total cost is predicted. Generally, it is used at design stage and is more sensitive than other methods. With this kind of prediction model, cost check-ups can be done easily. In spite of these advantages, it also has some shortcomings. Especially, the need for detailed information requires time and extra cost. In some cases, it might be probable to miss some costs during bottom-up compilation of the cost pieces (Özkil,2002:41).

### 4.2.5 Parametric Models

Parametric models base the predictions on statistical relations. In parametric model, dependent variables (cost/program etc) are predicted via one or more independent variables (parameters). In general, all the costs are considered. It gives accurate results as other techniques, but requires sound verification and confirmation. Thanks to these advantages, this prediction model has been used by procurement agencies of many countries who procure basic weapon systems. Some commercially developed models of this type are Constructive Cost Model (COCOMO) designed for predicting the costs of the software for parametric models, PRICE, Software Evaluation and Estimation of Resources Software Estimating Model- SEER SEM and so on (Özkil,2002:41).

### 4.3 Engineering Method

This method needs the most amount of and most detailed data. In order to determine cost predictions detailed analysis has to be carried out on equipment, labour, and general production costs. The basic assumption is that we can obtain the total project or system cost by consolidating all the cost predictions from the bottom line. In other words, the cost analyst starts with analysis of the bottom level, and calculates and defines the workload, production processes, equipment type and amount in order to complete the system. General manufacturing costs are loaded on the basis of direct labour and equipment. Calculating the cost at every level in this way, we can obtain the total system or project cost by adding them to one another (Özkil,2002:41).

In this method, there is no need to develop just one methodology for all the sub-systems; we can use any of the cost prediction methods for each sub-system cost prediction. For example in a developing system, while calculating the cost of a sub-system with similar characteristics with the currently-used ones, analogy method can be used whereas CER might be used for the complex cost relations of another sun-system (Özkil,2002:42).

### 4.4 LCCA Models

It is possible to see the models, which are developed by using the above cost prediction methods for LCCA, grouped under different titles. It is also possible to group them in the below categories as model groups (Özkil, 2002:44):

Cost factor models
Accountancy models
Prediction models related to cost
Economical analysis models
Logistical support, cost simulation models
Reliability development cost models
Models of repair analysis levels
Models of maintenance, manpower planning
Stock management models
Guarantee and in-place maintenance models
Risk analysis models

## 5. Result

Competitiveness depends on information that increases when used and shared. That information provides competitiveness is an undeniable fact. Therefore, senior management needs to have a practical perspective to make the most use of their strategic information. In this paper, we are in the opinion that all the activities regarding the production of strategic information provide a business with profitability above the sector average both in the short and long run. The biggest handicap is that senior managements rarely focus on the strategic role of information or on the attempts to produce information. The key to overcome this handicap is the change in the way how senior managers and enterprise strategists see information; namely, their perspectives must be changed. Information must not be seen as quantity that has a vague relation with creativity, that needs to be but is impossible to objectify, but as an entity related to certain activities and business results. In this paper, we aimed to state the role of information produced via life cycle cost analysis and related information processes.

There are two main strategies in businesses: strategy to survive and strategy to progress. The strategies to survive enable the business to sustain the available profitability levels. This type, while stressing on the strength of the resource and information base of the business, suppresses the weaknesses. The aim is to catch the opportunities and to keep away from risks. The strategies to survive aim to take the most advantage of the available business environment. These strategies look for ways to decrease the power of the suppliers and customers to bargain, to be in a better position than competitors regarding product-market position, to meet the expectations of various major groups like the nation, society, employees and the government.

The strategies to survive, by making use of the business's experiences and the advantages of economies of scale, tries to discourage new rivals from entering the market and to make the business ready for any rival products that will replace its own.

The strategies to progress cover the future profitability of the business. These strategies focus on the strengths of the business and try to suppress weaknesses in the information base as much as possible with its own resources. The aim is to catch the future opportunities and to keep away from risks. In the process of developing progress strategies, the information and experience of the management is of little use. Instead, the management needs to put forward creative approaches for strategy establishing and come up with new ideas about the business and the business environment. They are typical strategies for developing sectors like IT (information technologies), finance services and telecommunication. In these sectors, the roles, bargain power and product-market positions of various players are in constant change.

While developing progress strategies, the experience of senior managers might have less importance than lower level managers' creativity, intuitive and different point of view. These strategies might enable the business to advance by seizing the new, different faces of business environment. They also show the business how they will increase their bargaining power against potential suppliers and customers by affecting the development of the sector. This sort of effective power can be gained by employing rare research experts, collaborating strategically with research centres, by developing technology standards or by having strong relations with the strong suppliers and customers of the future. These strategies also show potential competitors and how they will react to the business's ventures. They also stress on the new product and service concepts and state how the products can be launched to the market better than the rivals. Moreover, they explain how the business will meet the future expectations of various major groups.

Providing the right balance between the strategies to survive and to progress will enable the enterprise to overcome the sector limits, to be ready for any rapid change in the sector, to cope with any dilution of existing information and competence and to be prepared for any of its products or services being out of date. However, since managers, for example, tend to be biased to go for "information for action" that will enable them to drive a powerful competitor out of business, the strategies to survive stand out in strategy studies.

There is always a limitation on the financial resources to provide various recurrent needs of the businesses. Every business has to make optimum use of its own resources, and for this aim, in the decision, process, costs for alternatives must be determined, the uncertainties must be eliminated, maximum benefit and efficiency must be obtained from the limited resources in hand. In front of these limited financial resources, we can use the resources allocated for production or purchasing effectively if we, keeping LCC in mind, use the LCC analysis in the business and thus provide and run a cost-effective system/hardware/facility. Whether we will be able to use the resources effectively depends on the accuracy and efficiency of the decisions we have made. In such decision problems as investing the right project, producing/purchasing the right system, determining the most suitable purchasing strategy, planning and budgeting, etc., we can use LCCAs as an effective decision making tool.

With regard to the assets that business resources must be used to purchase, the decision maker has to determine the most suitable alternative. With this respect, this man has to compare the costs of alternative systems so as to decide upon the best choice keeping such criteria in mind as how compatible the new system will be to the existing systems and sub-systems, and for how long it will meet the necessity. LCC - which means all constant and variable costs that can arise from the use of a hardware, tool, project or system from the time it was an idea to the time it has been discharged after use – make it possible to compare systems according to certain parameters.

Life cycle cost analysis is a technical process that compares the utility of two or more choices. It is used to compare the alternatives of a system prior to its purchasing or production regarding its cost. Thus, this analysis is carried out to classify a system/hardware/facility's research and development costs, investment/production/purchase costs, and operation/backup costs and discharge costs; and to associate these costs with one another; and finally to obtain the system's life cycle cost.

After theoretical researches and applications, it is observed that most of LCC is composed of operation and backup costs. Although most of the costs result from the activities carried out while the system is being used, it is observed that the best time to decrease costs happen to be in the initial stages since these costs occur due to the decisions taken in the first stages during when the system has been developed. Therefore, in order to determine LCC most cost-effectively and most accurately, it is vital we give importance to cost matter especially in the first stages of system development. From this perspective, in order to minimize the LCC of the systems to be produced, it is vital that the approach that can be called "design regarding the cost" be used in the businesses.

In life cycle costs analysis, in order to decrease the costs and to make optimum use of the available resources, it is aimed to handle cost as an essential condition, to take only cost-efficient requirements into account, to draw up realistic cost predictions, to have sustainable resource requirements, to determine hard bur obtainable cost targets, to balance cost and performance, and to reward and share cost savings.

The results of life cycle cost analysis, although they can be used in many different decision making problems, will provide efficiency in the process of choosing the best alternative regarding cost especially while giving purchasing or production decisions. Moreover, because the expected operation and backup costs of businesses throughout the years the system has been used will put a burden on the budget, the results of life cycle cost analysis can also be used in budgeting studies as an important input.

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# SUPPLIER PARK SYSTEMS TO REACH LEAN LOGISTICS GOALS

Funda Ahmetoğlu[1], Engin Kurtcan[2], Şenim Özgürler[3], Mesut Özgürler[4]

## Abstract

*Increasing competition force has become the most important factor as a result of the increasing international competition and globalization in these days. Variation and achievement in lean manufacturing created important changes in multinational firms and made lean manufacturing more important.*

*Technological developments, especially the developments in advanced production technologies have made joint production and production development possible through influencing relations between main and side industries to a great extent. After the utilization of advanced production technologies in enterprises, competition has increased and market shares have narrowed. Thus, the enterprises of world automotive industry, firms have utilized advanced production technologies to surpass their rivals.*

*In this study, the manufacturing methods that have developed until lean manufacturing period are examined and advantages and techniques of lean manufacturing system are determined. It is emphasized that side industries have to adopt lean manufacturing philosophy in order to make main industry- side industry relations beneficial for companies. The Supplier park system which is formed by both main industry and the side industries are examined. Europe automotive industry based Supplier park structure has presented by the observation in factory.*

*Key Words: Lean Thinking, Lean Manufacturing, Logistics Management, Supplier Park System.*

## 1. Introduction

The supplier park concept is one of the new concepts in procurement logistics, evolved in the last years. The dynamic and complex environment of today's markets force companies to concentrate on their core competences and to transform fix into variable costs. Thus, the decision of outsourcing is growing in importance at the strategic management level. With the increasing importance of the consequences that procurement has on the financial performance of a company's procurement process, new concepts in procurement logistics have evolved over time. Supplier Park is such a concept, becoming more and more popular. To understanding the spreading of supplier parks it is necessary to look at new requirements for concepts in procurement logistics.

Build-to-order (BTO) has been hailed as a production strategy that fits the demands of the 21st century, fulfilling customer orders in short lead times through responsive manufacturing and information exchange. Yet a considerable challenge is how to achieve flexibility from extended supply chains that retain elements of the destructive cycle of make-to-forecast. Today automotive supply chains hold weeks of component stocks, driven by a combination of vehicle manufacturer (VM) forecasts and supplier concerns over 'stock-out' arising from quality or delivery issues. (Howard, Miemczyk, & Graves, 2006)

## 2. The Concept of Lean Thinking and Lean Manufacturing

In 1990 James Womack and Daniel Roos coined the term 'Lean Production' in their book *The Machine That Changed the World* (Tapping, & Shuker, 2003:1). Since then, it has become common to use the word *lean* as short land for lean production. The underlying principle of Lean Thinking is the elimination of all non-value-adding activities and waste from the business.(Levinson, & Rerick, 2002). Lean production (or lean manufacturing) refers to a manufacturing paradigm based on the fundamental goal of the Toyota Production System-continuously minimizing waste to maximize flow. Being lean therefore implies a continuous effort to achieve a state characterized by minimal waste and maximal flow. To become lean requires to change mindset(Tapping, & Shuker, 2003:1).

The starting point in the lean approach is that value needs to be created in the eyes of the final consumer, who is, after all, paying for the product or service they consume. This focus on value is therefore translated across functional and company boundaries in both the design and delivery of the appropriate product-service bundle. In order to do this, the lean message suggests that the focus of attention should not be on the company or functional department but instead on the complete value stream. The value stream is those set of tasks and activities required to design and make a family of products or services that are undertaken with a group of linked functions or companies from the

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point of customer specification right back to the raw material source. Any company may focus its attention on a variety of value streams depending on which market segments or categories they are seeking to work within.

It is common to find that in a factory less than 5 per cent of activities actually add value, 35 per cent are necessary non-value-adding activities and 60 per cent add no value at all(Jones, Hines & Rich, N. 1997:154).

In order to maximize the value of products and services as they are delivered throughout the value stream it is necessary to concentrate attention on a rapid and uninterrupted flow. This allows for a minimum of wasteful activities. By wasteful activities, it means anything other than the minimum amount of equipment, materials, parts and workers (working time) that is absolutely essential to production. Storage and banking must be minimized. If it cannot be used now, it is not made now because it would be waste(Black, 1991:5).

The ultimate lean target is the total elimination of waste. *Waste* or *Muda* is anything that adds cost or time without adding value. Over the years, seven deadly wastes have been identified. These are; waste of overproducing, waste of waiting, waste of transport, waste of processing, waste of inventory, waste of motion, waste of defects and spoilage(Tapping & Shuker, 2002:41)

Lean manufacturing contains some techniques to improving tool and worker efficiencies and eliminating wastes. These techniques can be listed as;

- Just In Time (JIT)
- Efficient Use Of Materials
- Standardization
- Product Design Principles
- 5S
- Visual Controls
- Cycle Time Reduction
- Single Minute Exchange Of Die
- Poka-Yoke
- Team Oriented Problem Solving
- Six Sigma
- Kaizen
- One Piece Flow
- Autonomation

## 3. The Gains of Becoming Lean

The importance of becoming lean can be explained as fallows (Tapping & Shuker, 2003:15);

- Lean systems can make a business more competitive and more likely to survive. A lean system can translate into greater market share. There is no guarantee of job security but chances are certainly better in lean enterprise.
- There is a potential for tremendous improvement in the office setting. While lean has gradually become an accepted part of production models, both in Japan and America, very little attention has been devoted to implementing lean in the administrative area.
- Lean seeks to eliminate waste and employees function better in waste-free environments. Waste in the workplace causes fatigue, frustration and burn-out.
- Lean systems encourage employees to become more actively involved with how the work is done. That involvement produces positive results.
- Events and activities that occur in lean systems are controlled by the workers-not the other way around.

## 4. Logistics and Lean Logistics Concepts

The universal definition of logistics is; distributing correct material in correct quantity, in correct conditions, at correct place, in correct time, to the correct consumer with correct price.

Logistics is comprised of all the operations needed to deliver goods or services, except making the goods or performing the services. In manufacturing, it covers the material flows between plants and between production lines within a plant. It also includes the information flows generated by the processing of transactions associated with the material flows, the analysis of past activity, forecasting and the planning and scheduling of future activity, as well as the funds flows triggered by the movements of goods and information(Baudin, 2004: 9).

Lean logistics is the logistics dimension of lean manufacturing. Its first objective is to deliver the right materials to the right locations, in the right quantities and in the right presentation; its second, to do all of it efficiently. Lean logistics tailors approaches to the demand structures of different items, as opposed to one-size-fits-all. It is a pull system: materials move when destination signals that is ready for them. Moving small quantities of many items between and within plants with short, predictable lead times requires pickups and deliveries at fixed times along fixed rotes called ‘milk runs’. In turn, this supports the use of returnable containers (Baudin, 2004: 27).

## 5. Supplier Park System and Drivers Towards Supplier Parks

A supplier park can be defined as a concentration of dedicated production, assembly, sequencing or warehousing facilities run by suppliers or a third party in close proximity (i.e. within 3 km) to the OEM plant. The numbers of automotive supplier parks have grown over the past decade especially in Europe and currently total 23 sites. Most OEMs have implemented some kind of Supplier Park including Ford, GM, Fiat, Peugeot, Renault, BMW and Volkswagen. One of the key trends in the automotive sector is the increase in variant numbers of individual models of car. This trend has led to an increase in the part numbers required by assembly plants and thus had an impact on the inventory policies of vehicle manufacturer (VM) and the general need to maintain mix flexibility to remain competitive. In this case assembly plants either hold a greater amount of inventory to ensure of supply of the correct parts or install more responsive supply chain processes such as sequenced in-line supply (SILS)(Howard, Miemczyk, & Graves, 2006).

One important aspect of just in time (JIT) deliveries, especially in the automotive industry, is the use of synchronized production. This arrangement sets extremely tight boundaries regarding delivery reliability since the entire production process is dependent upon the timely delivery of components. The need for extreme reliability comes from the fact that sequential JIT production requires suppliers to deliver unique components in the same sequence and synchronized with the assembly process of the customer. This means that once a component is ordered from the supplier it is destined for one particular car on the assembly line. Any errors in delivery or product quality cannot be solved by taking any new finished product since each component is destined for one specific car(Larsson, 2002: 769-770).

Where SILS has been implemented the time between a car starting final assembly and the fit point of the particular part (such as a seat) is given to a supplier to deliver the part exactly as specified. Where this short order cycle time is only a matter of minutes, the supplier is often located to the OEM plant. Another trend related to increasing product variety in the automotive industry is the move towards simplifying production by introducing modules(Howard, Miemczyk, & Graves, A. 2006).

The most recent issue being discussed in relation in automotive supplier relationships is the process of modularization. Modular production is often put forward as one of the major explanations behind the organizational locational logic of supplier parks. The basic definition of a module can be made by distinguishing between the car as a totality or as a product built up of modules(Larsson, A., 2002: 771).

Arguments for modular supply include cost reduction through lower supplier wages and overheads, and inventory reduction, increased space and simpler transactions. Firms can mitigate the negative impact of product variety on operational performance by using modularity in the design of product family architectures. Taking modular supply to the extreme leads to the idea of 'modular consortia' where each module supplier locates next to the OEM plant, and has responsibility for all suppliers into the module, investing in the facility with the OEM and even assembling the module directly into the vehicle in some places. Yet current practice shows that supplier parks are also represented by suppliers of commodity components (e.g. nuts and bolts), parts which are bulky, and high variety parts which can be late-configured just before delivery to the vehicle assembly line. Volume flexibility is seen as a further key to obtaining competitive advantage and there are a number methods by which manufacturing firms can achieve this. The decision to co-locate a supplier facility near the OEM assembly plant can also be driven by a need for volume flexibility, for example where capacity is taken by an additional assembly line. The cost to hold this inventory may be shifted to the supplier instead of making use of an OEM-controlled warehouse(Howard, Miemczyk, & Graves, 2006).

Apart from delivery requirements, other factors may benefit from a location in direct proximity to the main customer, such as organizational and technical integration and the advantage of 'being there' in order to facilitate social linkages and communication(Larsson, 2002: 769).

## 6. Automotive Supplier Relationship in Europe

The European automobile supply industry has developed within a framework of national automobile industries. This structure has been challenged in the last decade by two main factors; the influx of Japanese investments and the introduction of the single European market.

The most important factor for the 'rebirth' of the United Kingdom auto-industry was the Japanese investments in the late 1980s and early 1990s. Japanese supplier practices, including 'Just in time' delivery and single-sourcing, changed the conditions for suppliers. In 1993, out of a total of 180 Nissan suppliers, 25 were located in the northest of England, compared to a higher proportion in more distant locations in the Midlands. One important aspect of new purchasing models in the Europe automotive industry is the increasing use of sequential JIT deliveries. This has led to a growing use of dedicated logistics warehouses or final assembly points in close proximity to the customer. The Spanish automotive has adopted flexible production methods including JIT production, a process that has been triggered by foreign investments in new assembly plants during the late 1980s and early 1990s.

These new establishment have been situated outside the traditional automotive-producing region. The decentralization process cannot be identified to the same extent among suppliers. This is explained by the widespread use of local warehouses for the coordination of deliveries from distant suppliers. Similar solutions to transport and delivery requirements are used by Renault. Besides the importance of Japanese investments and the opening up of the European market, transportation and infrastructure conditions are important factors for just in time production and the locational strategies(Larsson, 2002: 768-769).

## 7. Application

### 7.1. Supplier Dispatching in Old System

Before applying supplier park system, firms were learning their programs from 'Supplier Network' screen and according to these programs products that were wanted from the factory were being sent. After the supplier park had been established, the firms in the park started to use sequential material flow system. The firms out of the park are still using old system.

### 7.2. Foundation Process of the New System

For the purpose of providing a competitive superiority to its European competitors in quality and cost fields, a Supplier Park has been established within the Firm's Turkey Plant, making use of the examples in Europe and USA. The buildings and facilities located at the manufacturing site were constructed by firm considering lean manufacturing philosophy and rented to manufacturers.

The Supplier Parks, with the European automotive industry origin, is gathering of limited number of manufacturers whose manufacturing park are at a limited number in an area near the site and make a lean production practice in field, quality, transportation, packing, equipment, tables or personnel etc. In the global examples, manufacturers gather at 1 to 2 km distance from the main industry and form an organized industry zone.

### 7.3. History of the Project

After making the decision for the Supplier Park project investment, the firm carried out discussions with manufacturers. The manufacturers chosen for discussions are the ones complying with the quality requirements specified by firm. At the end of the discussions, the suppliers gave bids for production and the companies giving the best bids advised firm the power; air, natural gas, water etc. requirements in relation with their activities. For all manufacturers, infrastructure works and plant settlement plans were completed with priority and then building constructions were commenced by firm.

The construction works for the manufacturer buildings were continued simultaneously with the firm's Turkey Plant Construction. The Supplier Buildings were completed in October 2001, and the suppliers began settling at the areas allocated to them. The forms peculiar to the processes of manufacturers were provided by firm, and 6 manufacturers settled in their areas in January 2001.

In the Supplier Park area, the dining room, showers, toilets and resting areas are available to manufacturer personnel and guests. Such services are provided by firm, against an amount. In addition to those services, the electricity, pressurized air, process water, drinking water or other phone services employed by the Suppliers in their own building are provided for value to be paid by manufacturers.

### 7.4. System Structure

Within this system founded by making use of the global examples, targets functioning of the process providing the sequential transportation of the parts between firm and Supplier Park. By means of sequential transportation, depending on the number of vehicles in the line as well as the order of the vehicles, the suitable parts are brought to line just in time, and the line edge stocks are eliminated. In order to keep a pace for the material flow with the increasing supply rate, the parts supplied by manufacturers should be of high quality, with lower fault rates. For that purpose, the parts are transported in small quantities, frequently and at a suitable sequence.

In the former functioning, customer orders are taken daily, and the part requirements to which corresponds by the material management system were determined. According to these requirements, manufacturers were sent a delivery schedule. The delivery schedule so sent stipulated that how many parts are to be manufactured by the Supplier within 14 days, and realize the delivery. These plans transmitted the daily alterations to the manufacturers, but the daily changes were not reflected on the deliveries. Yet the suppliers followed the daily alterations, they did not own a delivery schedule. The materials from Supplier come firstly to the material acceptance pointy, after being approved there, they were entered to the warehouse. The materials positioned at the suitable storehouse, were sequenced there. The sequenced materials were called from the warehouse to line using Kanban system and the ordered materials were transported to the line edge by firm employees. Unloading of the large volume parts particularly, their positioning at the suitable warehouse address, ordering, and delivery from the warehouse to the line required extra man power and cost for firm (Figure 1).

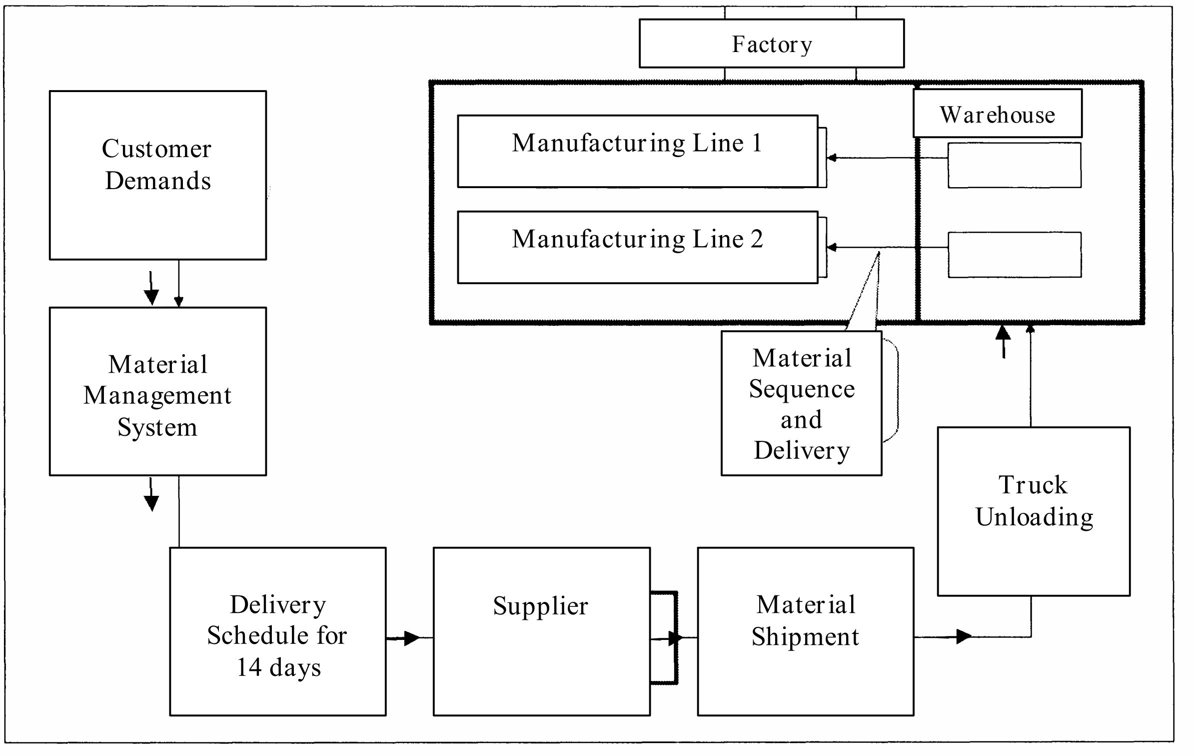


Figure 1. Part Calling Through Delivery Plans

Thank to the Sequenced Manufacturing and Sequenced Delivery System which removed the negative factors in the former functioning, the parts taken from the suppliers within the Supplier Park are delivered to the installation line edge, at the point where the part is installed onto the vehicle just in time, instead of being transported to the warehouse. The parts brought by the manufacturer to the line edge, belong to the manufacturer until they are installed onto the vehicle and the vehicle leaves the line. At the time the vehicle leaves the line, its ownership is transmitted to firm. This is also an indicator that firm does not keep an inventory for any part provided by the manufacturers within the Supplier Park. In addition to not keeping an inventory, the parts are received in accordance with the sequence of the vehicle. Operator's wasting time other than the installation will be prevented. Zero stocks in the installation line brings both inventory area and cost gains.

In order to realize the sequenced material flow, signal points were determined on the line that will plan the part manufacturing of the supplier. In the process of determining the signal points, the manufacturing processes and times of the entire parts supplied by firm were taken into account. While the vehicles are proceeding on the manufacturing tube, they send automatic signals. The signals so produced notifies the supplier as to the point on which the vehicle is located and which parts are to be used in installation. The VIN (Vehicle Identity Number) where the entire properties of the vehicle are defined is a significant part of the signaling system.

Beginning at the welding line inlet, the signals are transmitted to the supplier from the signal points at the painting and installation lines. The Supplier may start line follow up at any signal point on the condition to complete part manufacturing. In line with the signals received, he carries out the manufacturing and sends the parts to the installation line in an sequenced form. In order to realize the sequencing correctly, it the part sequencing should be carried out based on a signal from a point in the installation line. The reason for this is the possibility of the changing of the vehicles in the welding and dying. The vehicles entering to the source in the sequence of A-A-C-B may leave the source in the sequence of A-C-B-A. This is also valid for painting house. But the sequencing of the vehicles entering to the installation line does not change through the line. The installation line is stopped only if no part is received in the line in time, this does not cause a change in vehicle sequence. If deficient installation is allowed on the condition to be completed later, the workmanship values of the missing works completed later are invoiced to companies. The target here is making the detailed part and the body on the installation line just in time, and installing it on the line. (Figure 2.)

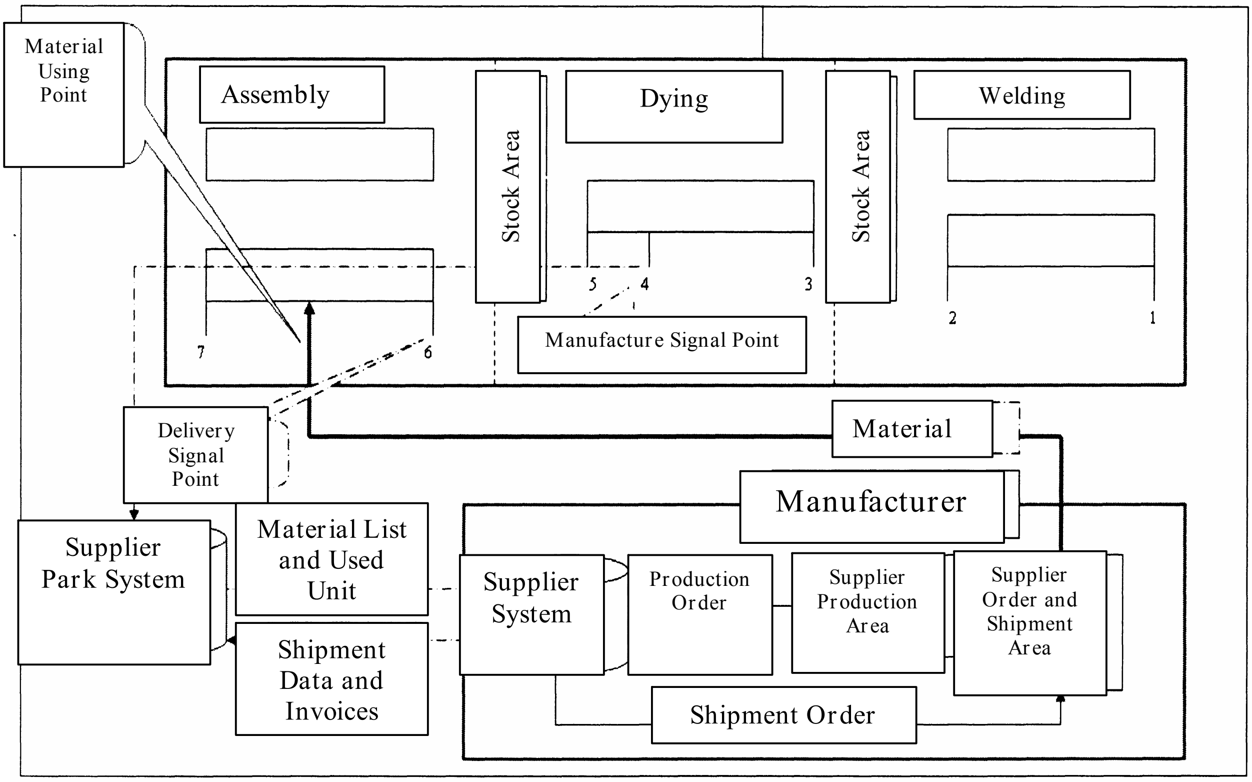


Figure 2. Sequenced Material Flow and Signal Points

## 7.5 Earnings of Manufacturer

### 7.5.1 System Design Earnings

The System was designed and developed by firm Information Technologies Department. This provided elimination of the costs that would otherwise be incurred in case the system design was outsourced.

### 7.5.2 Field Earning

Instead of employment of the available fields within the plant as sequencing and stock areas, they were hired to supplier, which created an annual rental income.

### 7.5.3 Inventory Earning

Firm calculates the number of parts in the vehicles that has left the line, and make payments to supplier s for those parts, while the parts from supplier becomes property of firm when the vehicle leaves the line, rather than when they were installed onto the vehicle. This shows that there is no inventory kept for the parts purchased by firm from the suppliers who are located within the Supplier Park.

### 7.5.4 Transportation and Packing Revenues

The transportation charges payable to forwarding companies for transportation of the materials from the side industry companies to firm, damage costs caused by the motor vehicles used for transportation due to road conditions and long distance travels as well as the cost of the materials which would be damaged in the process of transportation have been eliminated.

### 7.5.5 Personnel Savings

Receipt of materials, internal material flows and carrying out of the sequencing by the supplier s so that the materials arrive line in an sequenced manner all in turn reduced the number of operators.

### 7.5.6 Equipment Savings

By means of arranging the equipment necessary in the process of material receipt and the materials from the supplier according to their urgency, the number of materials such as forklift, and the investment costs and maintenance expenses have been reduced.

### 7.5.7 Investment Earnings in the Installation Line

Firm's installation line station cycle speed and the manufacturing speed is accordingly high. The detailed actions on the side of the installation line according to customer requirements which would otherwise take a long time are carried out by the supplier and brought to the line so that high manufacturing rate is preserved and the operations take place with lower number of stations.

#### 7.5.8 Sequenced Delivery on the Basis of Motor Vehicles

Thanks to arranged delivery and following up the installation line using signals, the period of harmonization to the changes in the manufacturing process has been shortened. As the parts are received at the edge of the line timely, depending on the alteration, the line edge stock quantity and stock fields have been minimized.

#### 7.5.9 Controlling the Supplier General Expenditures

Firm provides profit free services to companies in the Supplier Park, so that the overhead of the companies are minimized, and also there is no first time investment cost for such services. All general expenditures of Companies are controlled by firm.

#### 7.5.10 Increase in Supplier Quality Performances

The suppliers within the firm Supplier Park can interrupt any failures which may arise in the process of using the parts shipped by them, in the installation line. If the parts received in the line are defective, this is advised to the supplier, who finds the opportunity to check the quality problem in site.

#### 7.5.11 Development of Detailed and Accurate Planning Skills of Companies

Thanks to the supplier park, the suppliers in the site can continuously monitor the firm manufacturing tube by means of the transmitted signals. With these observations, any change in the line is closely followed up and the manufacturing plans are renewed according to changes.

#### 7.5.12 Increasing the Manufacturing Flexibility of Firm

The parts with required specifications are shipped just in time according to the sequence of the vehicles on the installation line. Thereby, firm provides flexibility both in model and manufacturing speed.

#### 7.5.13 Part Cost Advantage

The companies in the Supplier Park also save through this system, while reducing their manufacturing costs. As a result of that, various discounts are available to firm on the unit costs of parts.

### 7.6 Earnings of Suppliers

- Delivering time of the orders has been decreased.
- Total Manufacturing time has been decreased.
- Suppliers had opportunity to manufacture simultaneously with the main factory and their supplier.
- The same work has been done in the less area.
- After manufacturing delivery has been done rapidly so stocks have been done decreased.
- Manufacturing and order viewing has been done with less worker.
- Sources have been used in other working points.
- The control of the costs has been easer and costs have been decreased.
- Supplier item number has been increased.
- The defects that happened in manufacturing process could be solved in less time.
- The defects can be viewed carefully so manufacturing has been done more effectively.

## 8. Conclusions

In 1990, the book called *The Machine that Changed the World* that was written by Womack and Jones provided the dissemination of the concept of lean production. The basis of lean thinking and lean manufacturing is the elimination of all non-value added operations, materials and labours in order to increase the performance of the system. Today's market is determined by consumers and producers they must seek and produce what potential consumers require so lean thinking and lean applications have been more important in the competitive environment.

Lean logistics is a dimension of the lean manufacturing is developed perfection that is designed to control the settlings and the movements of stocks in process and finished products and is used to form the directed systems. The ultimate goal of lean logistics is to reduce material storage and logistics costs by delivering the right part, in the right packaging, in the right place, in the right quantity and quality, at the right time.

Supplier park system provide to applicant to have volume flexibility, organizational and technical integration, simplifying production by introducing modules, increasing in the part numbers required by assembly plants. Supplier park system eliminates non-value added operations and reduces material storage and logistics costs. So it can be said that supplier park system can provide applicant a big advantage to reach the lean logistics goals.

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# THE IMPACT OF SUPPLY CHAIN MANAGEMENT PRACTICES ON PERFORMANCE OF SMES

Erkan Bayraktar[1], Ekrem Tatoglu[2], and Selim Zaim[3]

## Abstract

The purpose of this study is to identify the underlying dimensions of SCM practices and to empirically test a framework identifying the relationships among SCM practices, operational performance (OPER) and SCM-related organizational performance (ORG) with special emphasis on small and medium size enterprises (SMEs) in Turkey. Data for the study were collected from 203 SMEs and the relationships proposed in the research framework were tested using structural equation modeling. Based on exploratory factor analysis (EFA), SCM practices were grouped in two factors: Outsourcing and multi-suppliers (OMS), and strategic collaboration and lean practices (SCLP). The results indicate that both factors of SCLP and OMS have direct positive and significant impact on operational performance. In contrast, both SCLP and OMS do not have a significant and direct impact on SCM-related organizational performance. Also, as the direct relationship between the two performance-constructs was found significant, both factors of SCM practices have an indirect and significant positive effect on ORG through OPER..

*Keywords: Supply chain management, Turkish SMEs, survey*

## 1. Introduction

In today's highly competitive and interrelated manufacturing environment, materials represent a substantial part of the value of products. In view of the high percentage of the material cost, the key objective of the purchasing department ought to be purchasing the right quality of a product in the right quantity from the right source at the right time. The right source can provide the right quality of material on time at a reasonable price (Jay and Barry, 2001). In different industrial sectors of Turkey, material costs have a share of 56 (lowest on equipment manufacturing) to 87 (highest at automotive) percent on the manufacturing costs (Ulusoy, 2003).

Supply chain management (SCM) and related strategies are very important to the success of a manufacturing firm. This is because the cost and quality of goods and services sold are directly related to the cost and quality of goods and services purchased. Therefore, supply policies such as procurement and supplier selection have an important role in the supply chain management (Hartley and Choi, 1996; Degraeve et al., 2000).

Traditionally, vendors are selected from among many suppliers on their ability to meet the quality requirements, delivery schedule and the price offered. In this approach, suppliers aggressively compete with each other. The relationship between buyer and seller is usually adversarial. This traditional purchasing approach places special emphasis on the commercial transaction between supplier and customer. The main purchasing objective in this approach is to obtain the lowest possible price by creating strong competition between suppliers, and negotiating with them. However, in contemporary business, many firms prefer a strategy of few suppliers (Chandra and Kumar, 2000). Few supplier strategies imply that a buyer wants to have a long-term relationship and the cooperation of a few dedicated suppliers. Using few suppliers can create value to the buyer and yield both lower transaction and production costs. Cooperation between buyer and supplier is the starting point to establish a successful supply chain management and a necessary, but insufficient condition. The next level requires coordination and collaboration between buyer and suppliers. This includes specified work-flow, sharing information through electronic data interchange and the Internet, and joint planning and other mechanisms that permit to carry out the just in time (JIT) system and total quality management in the company (Spekman et al., 1998). JIT is an integrated set of activities designed to achieve high volume production using minimal inventories of raw materials, work in process and finished goods. Therefore, JIT purchasing requires the suppliers to produce and deliver to the manufacturer the right quantity at the right time with the objective of continuous and consistent conformance to performance specifications (Canel et al., 2000).

Ulusoy (2002, 2003) provides an excellent overview of manufacturing industry in Turkey with special emphasis on machinery and equipment industry. Main strategy for Turkish manufacturing industry on supply is low cost strategy (Ulusoy, 2003). The most important supplier selection criterion in machinery and equipment industry is also identified as low cost (Ulusoy, 2002). High share of material costs within the manufacturing costs may explain the popularity of low cost. Quality appears to be order qualifier where the price is order-winner from the suppliers' perspective (Ulusoy, 2003). In general, effectiveness of global sourcing, material management and warehousing are

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far from being satisfactory. Other than cement industry, JIT delivery is a bare practice among Turkish manufacturers. There is a trend to reduce the number of suppliers among Turkish firms which are increasingly being more in favor of system suppliers rather than individual component suppliers.

The purpose of this study is to determine the underlying dimensions of SCM practices and to empirically test a framework identifying the relationships among SCM practices, operational performance and SCM-related organizational performance with special emphasis on small and medium size enterprises (SMEs) in Turkey. There is a dearth of literature regarding the use of SCM practices and its effect on performance of SMEs in emerging market economies such as Turkey. SMEs play a very crucial role to the economies of most emerging nations from the viewpoint of generating employment and economic growth. They account for more than half of the employment and added value in most countries (UNCTAD, 1993). Similar trend is also observed in Turkey where SMEs constitute 99.5 per cent of all business establishments and employ 61.1 per cent of the workforce (Yilmaz, 2004). In view of the fact that the success of small business has a direct impact on the national economy, this paper seeks to add to the body of knowledge by providing new data and empirical insights into the relationship between SCM practices and performance of SMEs operating in Turkey.

The remainder of this paper is organized as follows. The next section presents the research framework and sets out the study's hypotheses. The research methodology is presented in the third section. Results and discussion are in section four followed by conclusion.

## 2. Research Framework

SCM practices involve a set of activities undertaken in an organization to promote effective management of its supply chain. The literature is replete on the dimensions of SCM practices from variety of perspectives. A list of these dimensions regarding the SCM practices is summarized in Table 1. In a recent study, Li et al. (2005) attempted to develop and validate a measurement instrument for SCM practices. Their instrument has six empirically validated and reliable dimensions which include strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices and postponement. Strategic supplier partnership represents the long term relationship between the organization and suppliers. Customer relationship covers the practices on complaint handling, customer satisfaction, and long-term relationship establishment. Information sharing means the information communicated between partners where the accuracy, adequacy, and timeliness refer to the quality of information. Lean practices are represented by the elimination of waste, low inventory, small lot sizes and JIT delivery. Postponement is the delayed differentiation of products on the supply chain.

In a later study, Li et al. (2006) applied this instrument to measure the impact of SCM practices on competitive advantage and organizational performance within a sample of 196 organizations in the USA. Their findings indicate that the higher level of SCM practices lead to the higher level of competitive advantage and organizational performance. They also found that competitive advantage had a direct and positive impact on organizational performance.

Anderson and Rask (2003) identified the impact of SCM on the organization of procurement. Based on their observation on 15 Danish companies, they acknowledge the new organizational practices such as key supply management, team-based management and changing skill requirements of purchasing personnel as a result of SCM practices.

Measurement of SCM performance is another fruitful area of research in the SCM literature. Recently Gunasekaran et al. (2004) developed a framework for SCM performance measures and metrics. They listed the metrics on two dimensions: supply chain process (plan, source, make and deliver) and level of management (strategic, tactical and operational levels).

Figure 1 presents the SCM framework developed in this study. The framework is based on the relationship between SCM practices, operational performance and SCM-related organizational performance of SMEs. The SCM framework developed in this study proposes that SCM practices have a direct positive impact on both operational and SCM-related performance of SMEs. SCM practices are expected to increase an SME's operational performance and improve its SCM-related organizational performance. Also, a positive relationship is expected between operational and SCM-related performance of SMEs.

Table 1. Dimensions of SCM Practices in the Literature

| Donlon (1996) | Tan *et al.* (1998) | Alvarado and Kotzab (2001) | Tan *et al.* (2001) |
|---|---|---|---|
| Supplier partnership<br>Outsourcing<br>Cycle time compression<br>Continuous process flow<br>Information technology sharing | Purchasing<br>Quality<br>Customer relations | Concentration on core competencies<br>Use of inter-organizational systems (e.g. EDI)<br>Elimination of excess inventory levels | Supply chain integration<br>Information sharing<br>Supply chain characteristics<br>Customer service management<br>Geographical proximity<br>JIT capability |

| Ulusoy (2003) | Chen and Paulraj (2004) | Min and Mentzer (2004) | Li *et al.* (2005) |
|---|---|---|---|
| Logistics<br>Supplier relations<br>Customer relations<br>Production | Supplier base reduction<br>Long-term relationship<br>Communication<br>Cross-functional teams<br>Supplier involvement | Agreed vision and goals<br>Information sharing<br>Risk and award sharing<br>Cooperation<br>Process integration<br>Long term relationship<br>Agreed supply chain leadership | Strategic supplier partnership<br>Customer relationship<br>Information sharing<br>Information quality<br>Internal lean practices<br>Postponement |

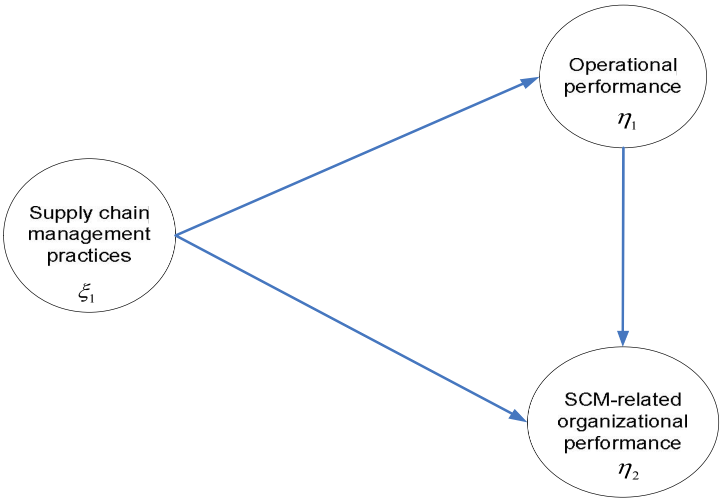


Figure 1. Path Model

## 3. Research Methodology

### 3.1 Sample and Data Collection

A survey instrument was developed to investigate the impact of supply chain management practices on the performance of SMEs. The questionnaire was pre-tested several times to ensure that the wording, format, and sequencing of questions were appropriate. Occasional missing data on variables was handled by replacing them with the mean value. The percentage of missing data across all data was calculated to be relatively small.

There is no consensus on the definition of SME, as variations exist between countries, sectors and even different governmental agencies within the same country (Yusof and Aspinwall, 2000). In line with small business research, this study adopted the number of employees as the base for the definition of SME. An SME is identified as one that employs fewer than 250 staff. The minimum of at least 10 employees was also chosen in order to exclude micro firms that would not be suitable for the purposes of this study. This range is consistent with the definition of an SME adopted by both the Turkish State Institute of Statistics (SIS) and Turkish Small Business Administration and also by a number of European countries such as Norway and Northern Ireland (Sun and Cheng, 2002; McAdam and McKeown, 1999).

Data for this study was collected using a self-administered questionnaire that was distributed to 800 SMEs operating in the manufacture of fabricated metal products and general purpose machinery (NACE codes 28 and 29) within the city of Istanbul in Turkey. For centuries as being the largest city of Turkey, Istanbul has been undisputedly the main industrial and trade centre. The city of Istanbul accounts for nearly 75 per cent of total capital investment generating nearly 23 per cent of Turkish GNP (Berkoz and Eyuboglu, 2005). The sample was selected randomly from the database of Turkish Small Business Administration (KOSGEB). The KOSGEB database includes a total of 12,270 SMEs in Istanbul, which accounts for nearly 28% of all SMEs registered throughout Turkey. The sampling frame consists of 1,917 SMEs operating in both industries in Istanbul.

It was requested that the questionnaire be completed by a senior officer/executive in charge of SCM practices. The responses indicated that a majority of the respondents completing the questionnaire were in fact members of the top management. Of the 800 questionnaires posted, a total of 229 questionnaires were returned after one follow-up. Twenty-six questionnaires were eliminated due to largely missing values. The overall response rate was thus 25.4% (203/800), which was considered satisfactory for subsequent analysis. A comparison of the annual sales volume, number of employees and sub-industry variation revealed no significant differences between the responding and non-responding firms (p>0.1). Thus, the responses adequately represented the total sample group.

### 3.2. Measurement of Variables

Based on the extant literature, a set of twelve SCM practices that are applicable to SME context were identified. These practices included 'close partnership with suppliers', 'close partnership with customers', 'just in time supply', 'e-procurement', 'outsourcing', 'subcontracting', '3PL', 'strategic planning', 'supply chain benchmarking', 'few suppliers', 'many suppliers' and 'holding safety stock'. Respondents were asked to what extent the following SCM practices were implemented in their organizations relying on five-point scales ranging from 1= 'not at all implemented' to 5= 'fully implemented'.

It is generally recognized that it is difficult to select a single measure of firm performance. The extant literature lists several quantitative objectives that can be set to guide performance over a period of time, as well as qualitative objectives (Hunger and Wheelen, 1993; Thompson, 1993). It has been argued that as there are obvious difficulties in obtaining quantitative measures, there is a strong a priori case that qualitative measures should be included in assessments of performance (Chakravarthy, 1986). Therefore, the subjective approach has been used extensively in empirical studies, based on executives' perceptions of performance, having been justified by several writers.

SME performance in this study was measured at two levels. A list of six operational (OPER) and five SCM-related organizational performance (ORG) measures were identified. The former group of performance indicators includes 'reduced lead time in production', 'cost saving', 'forecasting', 'resource planning', 'reduced inventory level' and 'flexibility', while the latter group includes 'increase in sales', 'more accurate costing', 'increase in coordination between departments', 'increase in coordination with suppliers' and 'increase in coordination with customers'. Respondents were asked to indicate on a 5-point scale, ranging from 'definitely better' through 'about the same' to 'definitely worse' or 'don't know', how their business had performed over the last 3 years relative to their major competitors on each of the operational and SCM-related organizational performance criteria.

The items used to measure SCM practices, operational and SCM-related organizational performance of SMEs are reproduced in the Appendix.

## 4. Results and Discussion

The frequency distribution of the sample firms with respect to the use of SCM practices is shown in Table 2. The SCM practices with the highest level of use by the sample firms included "JIT supply", "many suppliers" and "holding safety stock". The finding that both "JIT supply" and "holding safety stock" were the two most cited SCM practices in terms of the level of use appears to be somewhat surprising. This might be explained largely by the market conditions facing SMEs. Especially financial difficulties push them to follow principles of JIT supply while unstable economic conditions and unreliable suppliers as well as dominant suppliers operating in highly concentrated industries such as steel and aluminum mandate SMEs to hold inventory. Ironically, the same conditions may also dictate to deal with several suppliers to respond to the customers properly.

It is however, surprising to note that some popular SCM practices such as "outsourcing", "3PL" and "e-procurement" were cited as relatively less used in SMEs. In his survey of e-business strategies in Turkish machinery and equipment industry Ulusoy (2002) observed a relatively widespread use of electronic business practices. Our findings, however, did not corroborate this trend within the context of SMEs.

Table 2. Frequency Distribution of SCM Practices

| Supply Chain Management Practices | N | % |
|---|---|---|
| JIT supply | 103 | 50.74 |
| Many suppliers | 91 | 44.83 |
| Holding safety stock | 87 | 42.86 |
| Subcontracting | 76 | 37.44 |
| Few suppliers | 72 | 35.47 |
| Close partnership with suppliers | 66 | 32.51 |
| Strategic planning | 66 | 32.51 |
| Outsourcing | 56 | 27.59 |
| 3PL | 55 | 27.09 |
| Close partnership with customers | 53 | 26.11 |
| E-procurement | 45 | 22.17 |
| Supply chain benchmarking | 39 | 19.21 |

The data analysis testing the proposed relationships illustrated in Figure 1 was conducted at three stages:

1) Perform an exploratory factor analysis (EFA) with varimax rotation to produce a parsimonious set of supply chain management practices from a large set of SCM practices.
2) Measure internal consistency of constructs in the path model.
3) Measure the effect of SCM factors on both operational and SCM-related organizational performance.

These stages are discussed in more detail in the following subsections.

### 4.1. Exploratory Factor Analysis

Exploratory factor analysis with varimax rotation was performed on the SCM practices in order to extract the dimensions underlying each construct. The EFA of the 12 variables has yielded 2 factors explaining 44.5% of the total variance. Twelve items were loaded on two factors. Based on the item loadings on each factor, the first factor was labeled as strategic collaboration and lean practices (SCLP), while the second factor was labeled as outsourcing and multi-suppliers (OMS). Table 3 shows the results of EFA.

Table 3. EFA of the SCM Practices

| Factors | *Factor loads* | *Eigen-value* | *% Variance explained* | *Cum. per cent* | *Cronbach alpha* |
|---|---|---|---|---|---|
| *Factor 1: Strategic collaboration and lean practices* | | 4.07 | 33.94 | 33.94 | 0.80 |
| Close partnership with suppliers | 0.781 | | | | |
| Close partnership with customers | 0.775 | | | | |
| JIT supply | 0.640 | | | | |
| Supply chain benchmarking | 0.629 | | | | |
| Strategic planning | 0.574 | | | | |
| Holding safety stock | 0.560 | | | | |
| Few suppliers | 0.468 | | | | |
| *Factor 2: Outsourcing and multi-suppliers* | | 1.26 | 10.53 | 44.47 | 0.63 |
| Outsourcing | 0.780 | | | | |
| E-procurement | 0.640 | | | | |
| 3PL | 0.622 | | | | |
| Subcontracting | 0.526 | | | | |
| Many suppliers | 0.410 | | | | |

K-M-O Measure of Sampling Adequacy = 0.836; Bartlett Test of Sphericity = 582.650; $p$<.000.

The Cronbach's alpha measures of reliability for SCLP and OMS were 0.80 and 0.63, respectively. Although an alpha value of 0.70 and higher is often considered the criterion for internally consistent established factors (Hair et al., 1998), Nunnally (1978) suggests that the alpha value of 0.50 and 0.60 is acceptable in the early stages of research. Since Cronbach's alpha value for each factor is above 0.50, both factors are accepted as being reliable for the research.

### 4.2. Unidimensionality Tests

The validity and reliability of path constructs can be assessed by checking unidimensionality of each construct using three tools: Principal component analysis, Cronbach's alpha and Dillon-Goldstein's ρ. As shown in Table 4, all of the Cronbach's alpha values meet the threshold alpha value of 0.50 (Hair et al., 1998). According to the principal component analysis, since the first eigenvalue score of the correlation matrix of the manifest variables of each construct is larger than one, and the second one is smaller than one, each construct was considered as unidimensional. Similarly, ρ value in Dillon-Goldstein's ρ analysis is also above 0.70 for each construct. All three tests support unidimensionality.

Table 4. Unidimensionality Tests

| Constructs | Number of Indicators | Cronbach Alpha | Dillon-Goldstein's ρ | First Eigenvalue | Second Eigenvalue |
|---|---|---|---|---|---|
| *Strategic collaboration and lean practices* | 7 | 0.80 | 0.85 | 3.22 | 0.83 |
| *Outsourcing and multi-suppliers* | 5 | 0.63 | 0.77 | 2.02 | 0.99 |
| *Operational performance* | 6 | 0.77 | 0.84 | 2.82 | 0.91 |
| *SCM-related organizational performance* | 5 | 0.87 | 0.90 | 3.33 | 0.57 |

## 4.3. Path Model

### 4.3.1. Structural Equation Modeling

In order to avoid the multi-collinearity and measurement errors, while addressing the cause-effect relationships among the research constructs, we utilized partial least squares (PLS) method, which is a variance-based structural equation modeling approach. The PLS procedure, developed by Wold (1985), uses two stage estimation algorithms to obtain weights, loadings and path estimates. In the first stage, an iterative scheme of simple and/or multiple regressions contingent on the particular model was performed until a solution converges on a set of weights used for estimating the latent variables scores. The second stage involves the non-iterative application of PLS regression for obtaining loadings, path coefficients, mean scores and location parameters for the latent and manifest variables. For calculating the PLS procedure Spad Decisia V56 statistical data analysis software was employed (Fornell and Cha, 1994; Tenenhaus et al., 2005).

4.3.2. Outer and Inner Model Estimations

The relationships between the path constructs as shown in Figure 1 were tested. The estimation results for both outer and inner models were shown in Table 5 and Figure 2. Following the parameter estimation, bootstrapping was also undertaken to confirm the robustness of the findings. To do this, 1000 Bootstrap samples were built by re-sampling with replacement from the original sample. The summary results for bootstrapping were provided in the last column of Table 5. The bootstrap estimated coefficients of inner model were very close to those estimated by PLS.

Table 5. Inner and Outer Regression Weights for the Path Model

| Constructs | Standardized Regression Weights | Bootstrapping |
|---|---|---|
| SCLP1 – SCLP | 0.184** | 0.187 |
| SCLP2 – SCLP | 0.191** | 0.194 |
| SCLP3 – SCLP | 0.111** | 0.114 |
| SCLP4 – SCLP | 0.189** | 0.187 |
| SCLP5 – SCLP | 0.166** | 0.165 |
| SCLP6 – SCLP | 0.126** | 0.133 |
| SCLP7 – SCLP | 0.239** | 0.238 |
| OMS1 – OMS | 0.251** | 0.257 |
| OMS2 – OMS | 0.273** | 0.283 |
| OMS3 – OMS | 0.106** | 0.115 |
| OMS4 – OMS | 0.293** | 0.300 |
| OMS5 – OMS | 0.363** | 0.373 |
| OPER1 – OPER | 0.182** | 0.181 |
| OPER2 – OPER | 0.244** | 0.243 |
| OPER3 – OPER | 0.299** | 0.298 |
| OPER4 – OPER | 0.209** | 0.209 |
| OPER5 – OPER | 0.225** | 0.224 |
| OPER6 – OPER | 0.151** | 0.153 |
| ORG1 – ORG | 0.254** | 0.254 |
| ORG2 – ORG | 0.251** | 0.251 |
| ORG3 – ORG | 0.259** | 0.256 |
| ORG4 – ORG | 0.228** | 0.228 |
| ORG5 – ORG | 0.191** | 0.189 |
| OPER – SCLP | 0.156** | 0.144 |
| OPER – OMS | 0.169** | 0.158 |
| ORG – SCLP | 0.041* | 0.041 |
| ORG – OMS | 0.081* | 0.081 |
| ORG – OPER | 0.689** | 0.689 |

*p<0.1; **p<0.01

Outer model, also known as measurement model, links the manifest variables to their latent variables. The regression weights between the manifest variables and their related latent variables were found to be significant at p<0.01 level, as shown in Figure 2 and Table 5.

Of the individual SCM practices constituting strategic collaboration and lean practices (SCLP) factor, 'holding safety stock' (β=0.24; p<0.001), 'close partnership with customers' (β=0.19; p<0.001) and 'strategic planning' (β=0.19; p<0.001) featured as the most important SCM practices, while 'just in time supply' (β=0.11; p<0.01) and 'few suppliers' (β=0.12; p<0.01) were relatively less important SCM practices constituting SCLP.

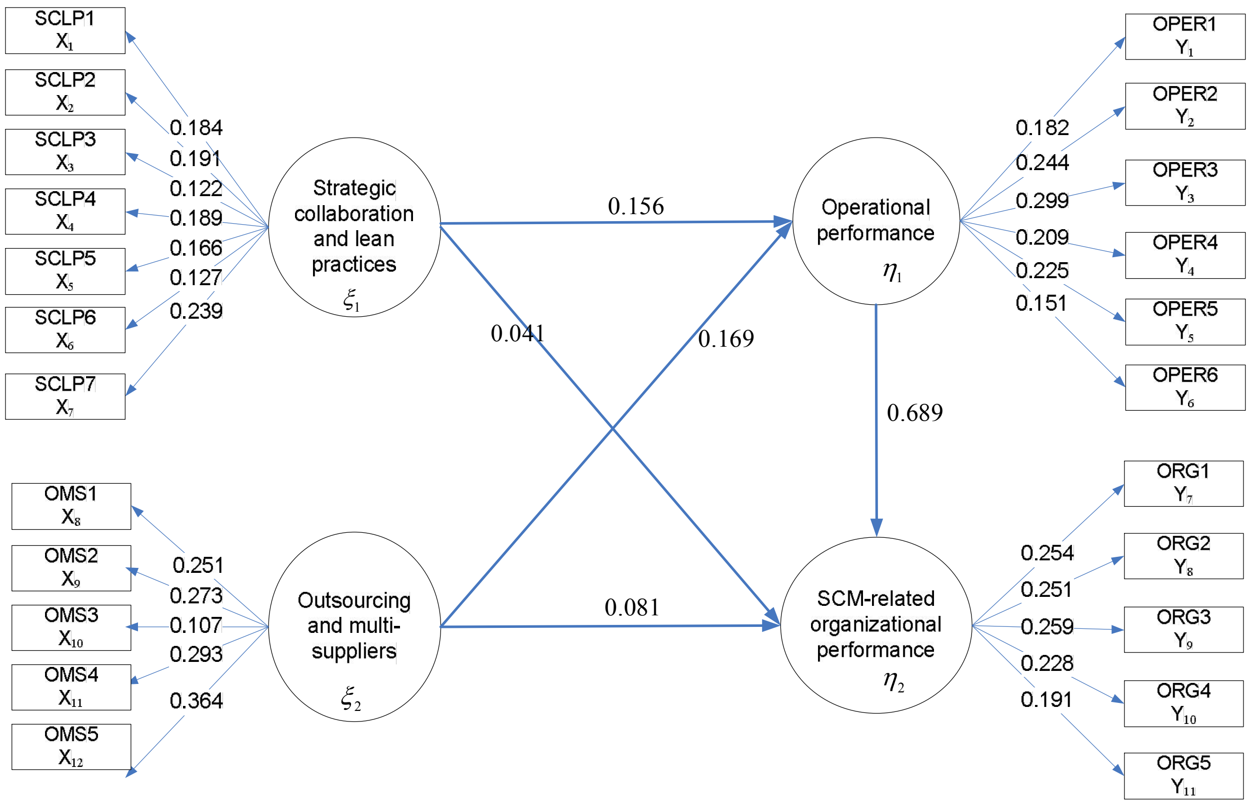


*Figure 2. Results of the Path Model*

This finding is not particularly surprising in an environment characterized by a relatively high degree of turbulence and instability. As compared to large size companies, SMEs are more susceptible to severe economic and financial crises due to lack of physical and financial resources. While Turkish Government's decisive implementation of macroeconomic stabilization program since November 2002, especially with regard to the reform of foreign exchange policy, capital markets and the privatization of state-owned enterprises have contributed to the economic growth and macroeconomic stability, the economic situation has still been marked by erratic economic growth and serious imbalances. This situation enforces Turkish SMEs to become more prudent and risk averse which obviously has an impact on their SCM strategies. Within the machinery and equipment industry, material and production management is poor (Ulusoy, 2002: 43). Safety stock is unavoidable in order to guarantee the availability of raw materials which have long lead times and unstable custom regulations for imported materials. The number of suppliers for main raw materials such as steel and aluminum is few and they dictate the market conditions (e.g., prices, minimum order quantity and delivery conditions). Some of the stock keeping units in the industry are heavily procured (Ulusoy, 2002: 39). This also explains why the individual SCM practice 'JIT supply' was found to have relatively less weight within the SCLP factor. Unreliable performance of the suppliers leads to SMEs to deal with a large pool of suppliers rather than a few. Without having a clear sense of customers, it is highly difficult to survive in the local market for manufacturing SMEs. Therefore, forging close relationships with customers is a natural consequence of doing business in seemingly turbulent Turkish market.

As for outsourcing and multi-suppliers (OMS) factor, 'many suppliers' ($\beta=0.36$; $p<0.001$) appeared to be the leading SCM practice. Similarly, '3PL' ($\beta=0.29$; $p<0.001$) was found to be the second most critical SCM practice comprising the OMS factor, whereas 'subcontracting' ($\beta=0.10$; $p<0.01$) was noted as the least important SCM practice constituting OMS. The finding that the use of 'many suppliers' was found to be the most critical SCM practice is not particularly surprising in that it has been a very common classical approach for procurement. If the share of commodity-type materials within the materials procured is high as in machinery and equipment industry, it is not unreasonable to argue why this classical approach has been widely implemented. This also tends to confirm the finding of Ulusoy (2002) that the most important criterion for the supplier selection in the machinery and equipment industry is low cost, thus the SCM practice of using 'many suppliers' is a practice to get lower prices. Given the fact that the nature of the industry makes the SMEs sensitive to their "know-how", the size of the companies is rather small, and many of them are subcontractor to the bigger companies, it is also understandable why subcontracting may not be too important for SMEs in machining industry.

The first two most important performance measures comprising operational performance (OPER) factor were found to be 'cost saving' ($\beta=0.29$; $p<0.001$) and 'reduced lead time in production' ($\beta=0.24$; $p<0.001$), while 'reduced inventory level' ($\beta=0.15$; $p<0.01$) had relatively less impact on OPER. On the contrary, there is much less variation between the SCM-related organizational performance (ORG) factor and its constituent variables in terms of the impact of each measure on ORG. Most SMEs in manufacturing industry needs to improve their production and material management systems (Ulusoy, 2002). In addition, dominant few suppliers of raw materials and long procurement lead times for imported materials are some other barriers to keep SMEs away from concentrating on their inventory levels.

Figure 2 presents the results of the inner model. The first equation in the path model has one endogenous variable (dependent variable), which is operational performance (OPER) and two exogenous variables (independent variables), which are SCLP and OMS. This model evaluates the impact of SCLP and OMS on OPER. Both factors of SCLP and OMS were found to have direct positive and significant impact on operational performance ($p<0.01$).

The second equation in the path model has one endogenous variable, which is SCM-related organizational performance (ORG) and three exogenous variables, which include SCLP, OMS and OPER. This model examines the impact of SCLP, OMS and OPER on ORG. In contrast to the causal relationship in the first equation, both SCLP and OMS did not have a significant and direct impact on ORG ($p>0.1$), though the sign on the coefficient was positive. As the direct relationship between the two performance constructs were found significant ($p<0.000$), both factors of SCM practices have an indirect and significant positive effect ($p<0.01$) on ORG through OPER.

## 5. Conclusion

This paper has provided empirical justification for a framework that identifies two groups of SCM practices and describes the relationship among SCM practices, operational performance and SCM-related organizational performance within the context of manufacturing SMEs. It sought answers to three main research questions: (1) do SMEs with high level of SCM practices have a high level of operational performance; (2) do SMEs with high level of SCM practices have high level of SCM-related organizational performance; (3) do SMEs with high level of operational performance have a high level of SCM-related organizational performance? Data for the study were collected from a sample of 203 manufacturing SMEs in Turkey and the research framework was tested using partial least squares method, which is a variance-based structural equation modeling approach. Based on exploratory factor analysis (EFA), SCM practices were grouped in two factors: Outsourcing and multi-suppliers (OMS), and strategic collaboration and lean practices (SCLP). The results indicate that both factors of SCLP and OMS have direct positive and significant impact on operational performance. In contrast, both SCLP and OMS do not have a significant and direct impact on SCM-related organizational performance. Also, as the direct relationship between the two performance-constructs was found significant, both factors of SCM practices have an indirect and significant positive effect on ORG through OPER.

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APPENDIX

SCM Practices

*To what extent the following SCM practices were implemented in your organization? (Five-point scales ranging from 1= 'not at all implemented' to 5= 'fully implemented')*

| Q# | Variables | Measurement |
|---|---|---|
| SCLP1 | Close partnership with suppliers | 1 to 5 |
| SCLP2 | Close partnership with customers | 1 to 5 |
| SCLP3 | Just in time supply | 1 to 5 |
| SCLP4 | Strategic planning | 1 to 5 |
| SCLP5 | Supply chain benchmarking | 1 to 5 |
| SCLP6 | Few suppliers | 1 to 5 |
| SCLP7 | Holding safety stock | 1 to 5 |
| OMS1 | E-procurement | 1 to 5 |
| OMS2 | Outsourcing | 1 to 5 |
| OMS3 | Subcontracting | 1 to 5 |
| OMS4 | 3PL | 1 to 5 |
| OMS5 | Many suppliers | 1 to 5 |

Operational Performance (OPER)

*How did your business perform over the last 3 years relative to their major competitors on each of the operational performance criteria? (Five-point scales ranging from 'definitely better' to 'definitely worse')*

| Q# | Variables | Measurement |
|---|---|---|
| OPER1 | Flexibility | 1 to 5 |
| OPER2 | Reduced lead time in production | 1 to 5 |
| OPER3 | Cost saving | 1 to 5 |
| OPER4 | Forecasting | 1 to 5 |
| OPER5 | Resource planning | 1 to 5 |
| OPER6 | Reduced inventory level | 1 to 5 |

SCM-Related Organizational Performance (ORG)

*How did your business perform over the last 3 years relative to their major competitors on each of the SCM-related organizational performance criteria? (Five-point scales ranging from 'definitely better' to 'definitely worse')*

| Q# | Variables | Measurement |
|---|---|---|
| ORG1 | More accurate costing | 1 to 5 |
| ORG2 | Increase in coordination between departments | 1 to 5 |
| ORG3 | Increase in coordination with suppliers | 1 to 5 |
| ORG4 | Increase in coordination with customers | 1 to 5 |
| ORG5 | Increase in sales | 1 to 5 |

MATHEMATICAL DESCRIPTION OF QUALITY ASSURANCE LOGISTICS

Béla Illés[1]

Abstract

*Handling of logistical quality parameters on the ground of requirements and possibilities of customers with insurance of quality parameters. Optimization of assurance logistical parameters with reduction of costs. Search of optimal assurance logistical parameters on the ground of cost functions in the light of possibilities and requirements of customers. Possibilities and requirements of customers satisfactory(with minimum cost) definition of quality assurance logistical parameters. Accentuated role of quality assurance logistics in the contact of supplier-user. Framing of quality assurance logistical activities series in accordance with reality on the ground of possibilities a requirement of customers.*

*Keywords: Quality requirements of customers, possibilities of customer, logistical quality requirements of customers, logistical elements of possibilities of customer, quality properties of given product structure, evaluations system of quality assurance logistics, quality assurance logistical net of product*

## 1. Introduction

In practice, if we talk about quality then we have to take a complex, but from the point of the consumer a subjective idea have to be taken into regard. The consumer might have expectations, like fast transportation time, avoid of mixture of different products automatic product identity process etc. The execution of the different consumer expectations can be proceeded on given conditions, for example payment of service fee, given special logistical background. One part of the conditions should be fulfilled by the consumer and this part is dependent on his/her possibilities. For example if the consumer would like to carry out a container goods transportation but the container handling system is missing then there is no possibility. In such a case the investment possibilities should be investigated for the containment goods transportation, what kind of benefit can be obtained after the introduction of such a system. If the consumer's possibilities give the possibilities then this quality demand will be kept, if not then this demand should be changed. So, from the point of quality the consumers demands and possibilities belong to the real market, that is the general consumers expectations and possibilities determine the real quality parameters for a given consumers cycle.

## 2. Complexity of Quality Assurance Logistics

Let us suppose that the prescribed quality of a given product or service is a complex thought in which the logistics has got a determinable feature.The story of prescribed quality of a given product or service can be seen in Figure 1.

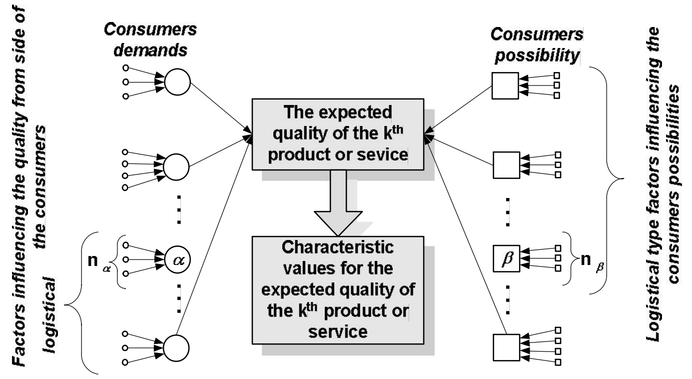


*Figure 1. Evolution of the process for the expected quality*

On base of Figure 1. it can be concluded

- the real expectation $\alpha$ are formed by $n_\alpha$ pieces of influencing factors

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- the $\beta$ real consumer's satisfaction are influenced by $n_\beta$ factors
- the expected quality of the $k^{th}$ product or service can be defined by concrete characteristic values from which some of them are clearly connected with logistical activities.
- Let us investigate, that in case of given product or service how the parameters describing the expected quality are varying. It is shown in Figure 2.
- On base of the Figure 2, it can be stated, that
- the quality of the product k can be described $n_k$ pieces of $E_{k_a}$ quality values,
- to a given value of $E_{k_a}$ on object function $F_{k_a}$ can be determined which $k$ could be have maximum or minimum character.

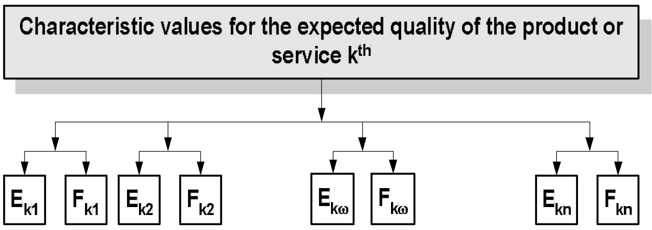

*Figure 2. Characteristic values for the expected quality of the product or service* k$^{th}$

By using the Figure 2. for each of the products or services quality characteristic values can be given. The structure can be seen in Figure 3.

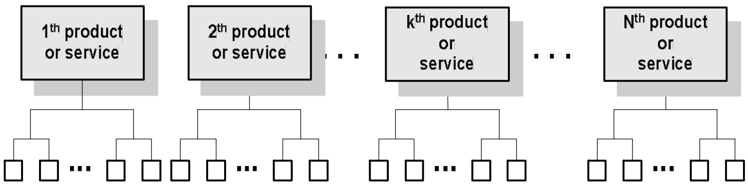

*Figure 3. Quality characteristics of a given product structure*

In case of product or service $k^{th}$ $n_{k,\alpha}$ pieces of logistical characteristic values $\left(E_{k,\alpha}\right)$ and $\left(F_{k,\alpha}\right)$ logistical characteristic objects functions can be given.

Creation of the values $E_{k,\alpha}$ are based on the consumer's expectations and possibilities and the belonging object function $F_{k,\alpha}$ shows whether the optimisation can be grained either by its increase or decrease.

Investigation the process how the value of $E_{k,\alpha}$ is obtained the following statements can be said:

- the logistical quality value $\alpha$ of the product or service $k^{th}$ are influenced by $n_{k,\alpha,\gamma}$ pieces of influencing factors $\left(T_{k,\alpha,\gamma}\right)$,
- the $\alpha$ factor influencing the logistical value of $\gamma.$ for the product or service of $k$ is dependent on $n_{k,\alpha,\gamma,\omega}$ pieces of parameters $\left(P_{k,\alpha,\gamma,\omega}\right)$,
- considering the product or service $k^{th}$ $\alpha$ the change of parameters $\omega$ which influence the logistical value $\gamma.$ and depend on $\gamma.$, there are $n_{k,\alpha,\gamma,\omega,\eta}$ possibilities $\left(V_{k,\alpha,\gamma,\omega,\eta}\right)$
- On base of the Figure 4 it cam also be concluded, that
- the change of the logistical type values for the product or service $k^{th}$ are going through a logistical chain of influence that is a net,
- this chain of influence is hierarchive, is can be seen in the figure it contains 4 levels: $E_{k,\alpha} \rightarrow T_{k,\alpha,\gamma} \rightarrow P_{k,\alpha,\gamma,\omega} \rightarrow V_{k,\alpha,\gamma,\omega,\eta}$,
- or the change of the $\alpha$ logistical type quality value $\left(E_{k,\alpha}\right)$ of an arbitrary product or service $k^{th}$ number of influencing factors $\left(T_{k,\alpha,\gamma}\right)$, are contributing,
- the change or one arbitrary influencing factor $\left(P_{k,\alpha,\gamma,\omega}\right)$ is function of more parameters $\left(P_{k,\alpha,\gamma,\omega}\right)$,
- for the variation of any arbitrary parameter $\left(P_{k,\alpha,\gamma,\omega}\right)$ there are more possibilities $\left(V_{k,\alpha,\gamma,\omega,\eta}\right)$,

- one given influencing parameter make changes for one or more logistical type quality values,
- one parameter can be fitted to one or more influencing factors.

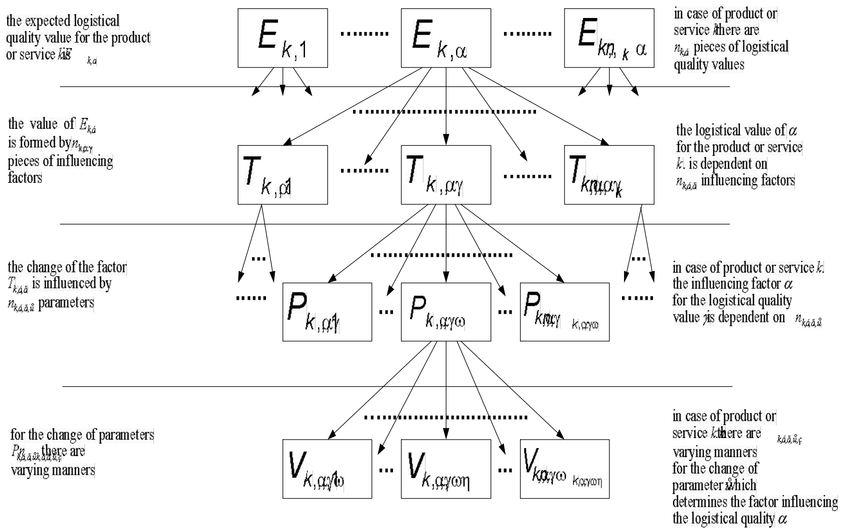


*Figure 4. The evolution system for the logistics of the quality assurance procedure*

The connecting net for the logistical evolution system of the quality assurance given in Figure 4. can be transformed by introduction of the new denotation system into the net given in Figure 5. The explanation of denotations of Figure 5.:

| | |
|---|---|
| $P_i$ | the $i^{th}$ parameter which influence the logistical type quality value of the investigated product or service $\left(i = 1,2,\ldots n\right)$ |
| $V_{i,\beta}$, | the $\beta^{th}$ possibility for the change of the $i^{th}$ parameter $\left(\beta = 1,2,\ldots p_i\right)$ |
| $T_j$, | the $j^{th}$ influencing parameter $\left(j = 1,2,\ldots m\right)$ |
| $E_k$, | a the $k^{th}$ logistical nature quality value $\left(k = 1,2,\ldots r\right)$ |

The practical forming of the structure given in Figure 5. will be shown by an example. Let us suppose for example the for the logistical type quality value

the transit time from the send of the purchase up to the arrival at the user is $E_k = prescribed.$

## 3. Analysis of Parameters

Let us examine what kind of factors influence the above given value.

Such kind of factor are:

- the applied traffic sub branch $\left(T_i\right)$
- the applied type ERKE $T_{(i+1)}$
- the applied product identity manner $T_{(i+2)}$ etc.

The factors are dependent on more parameters, for example

- the applied traffic sub branch can be
    - public high way,
    - train,
    - combination etc.

One parameter can be started in more variations, for example in case of public roads

- truck,
- van
- etc.

On foundation of the above the logistical net or effectiveness can be constructed. Of course, for given problems the actual logistical net of effectiveness should be determined all the time.

The evolution of the expected logistical type quality values $E_1, E_2, \ldots E_k \ldots E_r$, of the given product or service van be influenced by the variation of the parameters $P_1, P_2, \ldots P_i \ldots P_n$.

The total number of the variation possibilities can be determined on the base, that any variation could be combined by any from the others. For the change of given $P_i$ parameters there are $n_{p_i}$ pieces of variations. Any parameter variation can be combined by any other parameter variation, so forming a given parameter series. The number of possible parameter series can be determined on base of (1).

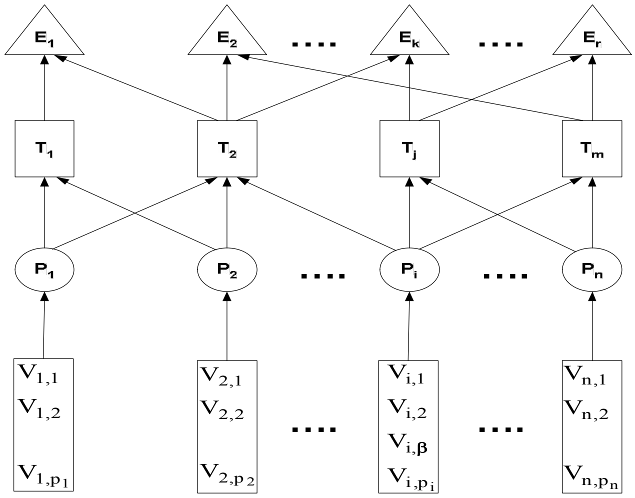


*Figure 5. Logistical quality assurance net of a given product*

$$PS = \prod_{i=1}^{n} n_{p_i} = n_1 \cdot n_2 \cdots n_i \cdots n_{p_i} \qquad (1)$$

where:

| | |
|---|---|
| $PS$ | is the maximum number of the parameter series, |
| $n_{p_i}$ | is the number of the possible variation of the changes of the parameter i., |
| $i$ | is the running index of the parameters, |
| $n$ | maximum number of the parameters. |

One given parameter series scan be characterized by the actual values of $n$ pieces of parameters.
In this way the possible parameter series variations can be given by a matrix $P(n,PS)$:

$$P = \begin{matrix} & 1 \quad 2 \cdots \lambda \cdots PS \\ \begin{matrix} 1 \\ 2 \\ \vdots \\ i \\ \vdots \\ n \end{matrix} & \begin{bmatrix} & & \\ & P_{i,\lambda} & \\ & & \end{bmatrix} \end{matrix} \qquad (2)$$

On base of (2) the followings can be given:

| | |
|---|---|
| $P$ | the matrix of the possible parameter series variations, |
| $i$ | the running index of the parameters, |
| $n$ | the maximum number of the parameters, |
| $\lambda$ | the running index of the parameter series variations, |
| $PS$ | maximum number of the parameter series variations, |
| $P_{i,\lambda}$ | the value of parameter i. in case of a $\lambda$. parameter series. |

On base of the parameter series variations and by using the quality assurance logistical net seen in Figure 5. it can be concluded, that both in cases of influencing factors on logistical type values and of logistical nature quality values suitable constructed T and E matrixes can be defined established by the matrix P. Structure of matrix T:

$$T = \begin{array}{c} \\ 1 \\ 2 \\ \vdots \\ j \\ \vdots \\ m \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & 2 & \cdots & \lambda & \cdots & PS \end{array} \\ \left[ \begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array} \right] \end{array} \qquad (3)$$

On base of (3) the followings can be given:

| | |
|---|---|
| $T$ | matrix involving the factors which influence the expected logistical type quality values of the given product, |
| $T_{j,\lambda}$ | value of the $j^{th}$ influencing factor in case of $\lambda^{th}$ parameter series, |
| $\lambda$ | running index of the parameter series variation, |
| $PS$ | maximum number of the parameter series variations, |
| $j$ | running index of the factors which influence the logistical type quality values, |
| $m$ | maximum number of the influencing factors. |

Structure of the matrix E:

$$E = \begin{array}{c} \\ 1 \\ 2 \\ \vdots \\ k \\ \vdots \\ r \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & 2 & \cdots & \lambda & \cdots & PS \end{array} \\ \left[ \begin{array}{c} \\ \\ E_{k,\lambda} \\ \\ \\ \\ \end{array} \right] \end{array} \qquad (4)$$

On base of (4) the followings can be given:

| | |
|---|---|
| $E$ | matrix of the possible, logistical type quality values, |
| $E_{k,\lambda}$ | the $k^{th}$ logistical type quality characteristic value in case of the $\lambda^{th}$ parameter series, |
| $k$ | running index of the logistical type quality characteristic, |
| $r$ | maximum number of the logistical type quality characteristic, |
| $\lambda$. | a running index of the parameter series variation, |
| $PS$ | maximum number of the parameter series-variations. |

On base of Figure 1. i. e. the consumers' expectations and possibilities for a given product or service the necessary values of the logistical type quality characteristics can be defined. Let the denoted by the vector ES.

$$ES = \{ES_1, ES_2, \cdots ES_k, \cdots ES_r\} \qquad (5)$$

On base of (5) the following can be given:

| | |
|---|---|
| $ES$ | vector of the necessary values for the logistical type quality characteristics, |
| $ES_k$ | the necessary value of the $k^{th}$ logistical type quality characteristic, |
| $k$ | running index of the logistical type quality characteristic, |
| $r$ | maximum number of the logistical type quality characteristic. |

The question is, which from the possible logistical type quality characteristics, belonging to the parameter series variations are fitted to the consumer expectations and possibilities. The text type description of the searching algorithm to get it, can be seen in Figure 6. By using the algorithm given by the Figure 6. the matrix of the logistical type quality values given originally by (4) has been modified in the following way:

$$EM = \begin{matrix} & 1 & 2 & \cdots & \nu & \cdots & NM \\ 1 & \left[ \right. & & & & & \\ 2 & & & & & & \\ \vdots & & & EM_{k,\nu} & & & \\ k & & & & & & \\ \vdots & & & & & & \\ r & & & & & & \left. \right] \end{matrix} \qquad (6)$$

## 4. Examination of Customer Satisfaction by Usage of Parameters

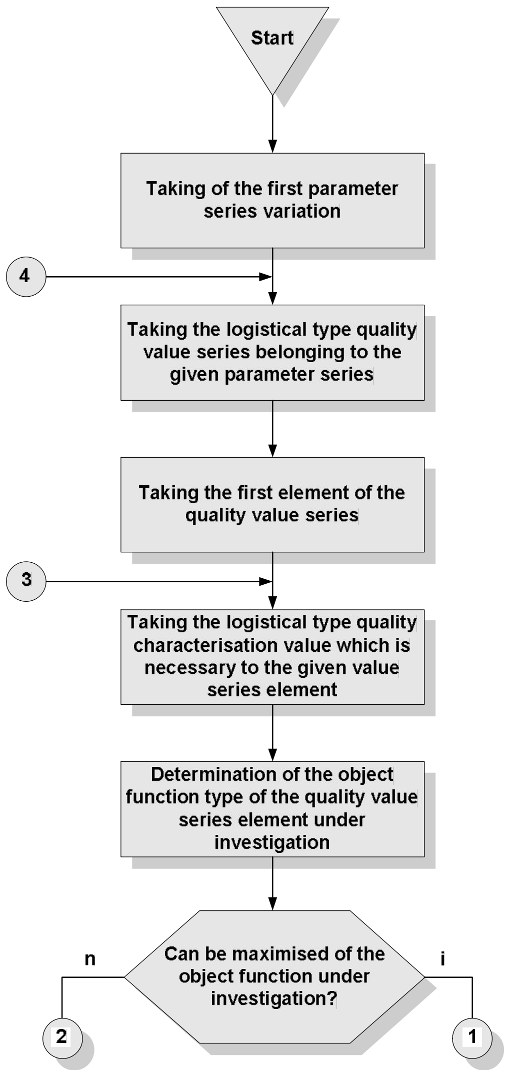


*Figure 6. Text type flow chart for searching of suitable solutions on base of the possible variations*

On base of (6) the followings can be given:

| | |
|---|---|
| $EM$ | matrix of the logistical type quality assurance characteristics in case of executable parameter series variation which serve the suitable values, |
| $EM_{k,\nu}$ | the $k^{th}$ logistical type quality characteristic in case of $\nu^{th}$ suitable parameter series variation, |
| $k$ | running index of the logistical type quality characteristic, |

| | |
|---|---|
| $r$ | the maximum number of the logistical type quality characteristics, |
| $v$ | running index of the suitable parameter series variations, |
| $NM$ | the maximum number of the suitable parameter series variation. |

In all of the cases it is true, that

$$NM \leq PS \qquad (7)$$

that is the suitable number of the parameter series variations should not be greater then the number of the totally constructable parameter series variations.

The following questions of the investigation:

$$NM = 0 \qquad (8)$$

If (8) is s valid, then the logistical type quality values, determined on base of the consumers expectations and possibilities can not be gained totally by the variation possibilities of the parameter series in hand. It means that the technical and informatics background to be involved should be improved and in addition one part of the logistical type quality values are not fitted to the consumers' demands.

If (8) is not valid, then the assurance of the logistical type quality parameters can be done as requested by consumers expectations and possibilities.

If the equation

$$NM = 1 \qquad (9)$$

is valid, then any further investigation can be neglected due to the executable variation. The values of the logistical type quality parameters can be realized only by one parameter series variation.

If the equation

$$NM > 1 \qquad (10)$$

is valid then the desire values of the logistical type quality parameters can be gained by any one of NM pieces of parameter series variation.

In such a situation from the more possible solutions it is expedient to determine the optimal parameter series variation by using a suitable object function.

## 5. Conclusions

*In practice basically the following two deterministic conditions should be satisfied:*

1) all of the logistical type quality characteristics determined on base of the consumers expectations and possibilities should be assured,
2) from the suitable parameter series variations the cheapest one should be applied.

*For this purpose cost functions have to be constructed in function of the parameter variations. The details of it can be the topic of an other paper.*

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# A HEURISTIC APPROACH FOR A THREE-DIMENSIONAL WAREHOUSE LAYOUT DESIGN PROBLEM: AN APPLICATION

Semih Önüt [1] and Umut R. Tuzkaya [2], Bilgehan Doğaç [3]

## Abstract

*The design and operation of a warehouse entails many challenging problems. The warehousing strategies can be classified as distribution-type, production-type and contract-type warehouse strategies. In this study, a distribution-type warehouse considered that various type products are collected from different suppliers for storing in the warehouse for a determined period and for delivery to different customers. The aim of the study is to design a three-dimensional warehouse shelf configuration which minimizes the annual carrying costs by using a mathematical model. The turnover rates of the products are classified and they are considered while putting/picking them to/from shelves regarding the distances between the shelves and docks. Considering that the problem is non-linear, the particle swarm optimization algorithm as a novel heuristic was developed for determining the near optimal warehouse layout design.*

Keywords: Warehouse Design, Order-Picking, Heuristics, Particle Swarm Optimization

## 1. Introduction

The efficiency and effectiveness in any supply network in turn is highly determined by the operation of the nodes in such a network, like the warehouses. Warehouses provide an important connection among suppliers, manufacturers, distributors and customers in the supply network. Planning, design and control of warehousing systems are complex issues. It includes a large number of interrelated decisions from a functional description through a technical specification, to equipment selection and layout determination. Essentially warehousing strategies are classified as distribution-type, production-type and contract-type warehouses (Vanden Berg & Zijm, 1999). Distribution-type warehouses collect different type products from different suppliers for delivering to different customers. Production-type warehouses are used for storage of the products having different kinds of characteristics in a production facility. Contract-type warehouse executes warehousing activities for different customers. In this study, a distribution-type warehouse is considered as the convenient warehousing strategy. Warehousing processes may be divided into receiving, storage, order picking and shipping phases (Rouwenhorst, Reuter, Stockrahm, Van Houtum, Mantel & Zijm, 2000; Vanden Berg & Zijm, 1999). In the receiving phase as the first process, goods are delivered generally by trucks, unloaded at the receiving area, checked and prepared for transportation to the storage area. The goods are transported to a storage location in the storage area as the storage phase. As the third phase, order picking refers to the retrieval of goods from their storage locations whenever a good is requested. These operations executed by the order pickers. At the shipping area, orders are checked, sorted, packed and loaded in trucks as the last phase.

There are a number of studies related with the design and integration of the different warehousing processes. A genetic algorithm with a special crossover operator was proposed by Poulos, Rigatos, Tzafestas, & Koukos (2001), who find the Pareto-optimal solutions in the warehouse replenishment problem. Lee & Elsayed (2005) considered the storage sizing problem for generic warehouses under a dedicated storage policy. Since the problem was formulated as a nonlinear optimization model, an iterative search procedure was developed to solve the model optimally. There are also some studies classified as the single or multiple-level warehouse layout design models mentioned below. Lai, Xue, & Zhang (2002) considered a paper reel layout problem formulating by integer programming, which is shown to be NP-hard. Following a natural decomposition of the problem, they proposed a two-stage heuristic procedure including an optimal method and a simulated annealing heuristic. Zhang, Xue, & Lai (2002) investigated a multiple-level warehouse layout problem considering multiple storage areas in different levels of a warehouse. An integer programming model was proposed and due to the similarity of the Lai et al. (2002)'s NP-hard problem, a class of genetic algorithm based heuristic was developed. Zhang, & Lai (2004) considered a multiple-level warehouse layout problem again and proposed a class of new heuristics by combining a genetic algorithm and path linking strategy to solve the problem. Heragu, Du, Mantel & Schuur (2005) presented a mathematical model and a heuristic algorithm that jointly determine product allocation to the functional areas in the warehouse.

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Various methods have been evaluated for order picking processes in the literature (De Koster, Van der Poort, & Wolters, 1999; Hsu, Chen, & Chen, 2005; Chen, & Wu, 2005). De Koster, & Van der Poort (1998) studied the problem of finding efficient order picking routes for both conventional and modern warehouses. They used an extended polynomial algorithm to find order picking routes with a minimal length and then compared the performance of this new algorithm with the well-known S-shape heuristic solution. In another work (Chew, & Tang, 1999) a travel time model with general item location assignment in a warehouse system was developed to analyze order batching and storage allocation strategies in an order picking system. Roodbergen, & De Koster (2001a) presented a dynamic programming based routing algorithm to determine the shortest order picking tours for a warehouse where aisle changing is possible at the front, the rear and in the middle of the warehouse. The same authors also described a number of extended heuristics to evaluate order picking routes in a warehouse with two or more cross aisles and they presented a new routing heuristic, called the combined heuristic, based on dynamic programming again. To analyze the performance of the heuristics, a branch-and-bound algorithm that generates shortest order picking routes was used (Roodbergen, & De Koster, 2001b). Kim, Graves, Heragu, & Onge (2002) solved an industrial warehouse order picking problem using an intelligent agent-based model. In the problem, goods are stored at multiple locations and the pick location of goods can be selected dynamically. Same authors presented a hybrid intelligent agent-based scheduling and control system architecture for the same problem mentioned above in another survey. They also developed a mathematical model and a genetic algorithm based heuristic for the resource assignment problem (Kim, Heragu, Graves, & Onge, 2003). Jewkes, Lee, & Vickson (2004) considered a multiple-picker order picking line which stores nk types of products in n bins, each with k shelves and determined optimal policy for the problem of product location, picker home base location and allocating products to each picker for minimizing expected order cycle time using a dynamic programming algorithm. Another survey (Hsieh, & Tsai, 2006) presented the effects on the order picking system performance for factors, such as quantity and layout type of cross aisles in a warehouse system, storage assignment policy, picking route, average picking density inside an aisle, order combination type, etc. using a simulation and analysis tool.

In this paper we present a mathematical model for determining a three-dimensional warehouse layout. Essentially a distribution type warehouse considered that various type products are collected from different suppliers for storing in the warehouse for a determined period and for delivery to different customers. The turnover rates of the products are classified and they are also considered while putting/picking them to/from shelves regarding the distances between the shelves and docks. Due to the problem is non-linear, the particle swarm optimization (PSO) algorithm as a novel heuristic was developed for determining the near optimal warehouse layout design. The rest of the study is constituted from the literature review for particle swarm optimization, explanations for steps of the PSO algorithm, three dimensional warehouse design model details and application of the PSO to the warehouse design model.

## 2. The Algorithm of Particle Swarm Optimization

PSO is a stochastic optimization technique and also a population based search algorithm first proposed by Eberhart, & Kennedy (1995) and Kennedy, & Eberhard (1995), inspired by social behavior of bird flocking or fish schooling. PSO is a meta-heuristic approach used for solving hard global optimization problems. Commonly used meta-heuristics can be briefly summarized as ant colony optimization, genetic algorithms, artificial neural networks, evolutionary algorithms and simulated annealing (Eusuff, Lansey, & Pasha, 2006). PSO is one of the modern meta-heuristic algorithms under the evolutionary algorithms. Evolutionary algorithms, like genetic algorithm, and evolutionary programming strategies are search algorithms based on the simulated evolutionary process of natural selection, variation and genetics. PSO has been defined as an evolutionary computation algorithm and has typical features of both genetic algorithms and evolution programming strategies. Evolutionary algorithms can also provide a near global solution (Kennedy, & Eberhart, 1995; Arumugam, & Rao, 2005). PSO combines local search and global search and ensures high efficiency. It has a more global searching ability at the beginning of the run and a local search near the end of the run. Therefore, while solving problems with more local optima, there are more possibilities for the PSO to explore local optima at the end of the run (Naka, Genji, Yura, & Fukuyama, 2003; Shi, & Eberhart, 1999). PSO has some common characteristics with genetic algorithm, such as starting with a group of randomly generated population, having fitness values to evaluate the population, updating the population and searching for the optimum with random techniques. But PSO doesn't have genetic operators. Particles update themselves and they also have own memory (Haq, Sivakumar, Saravanan, & Karthikeyan, 2006). PSO algorithm has been applied to a wide range of engineering problems in the literature. Recently some attention has been focused on hybrid applications and some comparisons with the different heuristics, especially in electrical, mechanical and industrial engineering. Huang, & Mohan (2005) proposed a simple hybrid boundary condition that could be used to obtain a robust and consistent PSO performance for high dimensional optimization problems regardless of where the global optimum is located in the search space. In another study, a solution model for the unit commitment problem was obtained using fuzzy logic to address uncertainties in the problem (Victoire, & Jeyakumar, 2006). In order to schedule the generating units based on the fuzzy logic decisions, hybrid tabu search, PSO and sequential quadratic programming was used. (Jeyakumar, Jayabarathi, & Raghunathan, 2006) described an adaptation of the PSO algorithm to solve various types of economic dispatch problems in power systems and solved these problems using both the PSO method and the classical evolutionary programming approach. The following examples are related with the manufacturing systems specifically. (Arumugam, & Rao, 2005) presented several novel approaches of PSO algorithm with new particle velocity equations and inertia weights to solve the optimal control problems of a class of hybrid manufacturing systems. (Xia, & Wu, 2005) proposed a hierarchical solution approach to solve multi objective flexible job-shop scheduling problem by using PSO algorithm to assign operations on machines and simulated annealing algorithm to schedule operations on each machine. Another work focused on the different scheduling mechanisms which are designed to generate optimum scheduling. These non-traditional optimization procedures, such as genetic algorithm, simulated annealing, memetic algorithm and PSO algorithm were then implemented for solving the scheduling optimization problem of flexible manufacturing systems and results were compared by Jerald, Asokan, Prabaharan,& Saravanan (2005). An activity network based multi-objective partner selection model in a supply chain was developed by Zhao, Zhang, Yu, Chen, & Yang (2005). They proposed a hybrid heuristic algorithm based on PSO and simulated annealing to solve this multi-objective problem. Although the PSO algorithm has been applied to the different industrial areas and the different engineering problems, only a few applications are known in the supply chain management, especially in the layout design, network design or warehouse design in a supply network. There is only one study encountered in the literature recently. In this work, Paul, Asokan, & Prabhakar (2006) proposed the PSO algorithm to derive better solutions for unequal-area facility layouts having inner walls and passages.

## 2.1 The Basic Algorithm

In PSO, each particle included by social structure, keeps in mind its best position and uses this as a factor affecting its speed. A particle gains speed toward its individual best position considering with how far away from,that point. It also shows the same behaviour for the global best position. In other words, while it is scanning the surface, it is affected by the global best position and adjusts its own speed. In the situation of it is far from the global best position, there will be a bigger change in its speed and direction. Individuals of a swarm show inclination to change their movements by using the information below;

- Current position (x, y)
- Current speed vx, vy
- Individual's best position (local best) (pbestx, pbesty)
- Global best position (gbestx, gbesty)

Each individual's speed change according to the formula in Eq. (1);

$$V_i^{k+1} = X( w^* V_i^k + C_1 * (Rnd) * ( pBest_i - x_i) + C_2 * (Rnd) * (gBest_i - x_i)) \quad (1)$$

$V_i^k$ : i. individual's speed on k. iteration
$X_i$ : i. individual's position
W : inertia function
$C_i$ : inertia factor
Rnd : random number
$Pbest_i$: individual's best position
Gbest: global best position
X : Constriction factor

Inertia value of the equation changes on each iteration. This change is based on the logic of decreasing from the value determined according to inertia function to minimum value. The objective is to converge the created speed by diminishing on further iterations, so more similar results can be obtained.

Inertia function is obtained as in Eq. (2):

$$w = w_{max} - \frac{w_{max} - w_{min}}{iter_{min}} \quad (2)$$

$W_{max}$ : First inertia force
$W_{min}$ :Minimum inertia force
$iter_{max}$: Maximum iteration number

Positions of particles change by speeds as shown in Eq. (3)

$$x_i^k = x_i + vx_i^k \quad (3)$$

Same procedure is reiterated for each dimension.

## 2.2 Difficulties of Using PSO on Constricted Models

PSO determines minimum or maximum value of any function easily between specific bounds. However, it has some difficulties when it is necessary to ensure some constriction equations. According to PSO, the difference between a constricted model and a function is based on high contradiction probability of any chosen point and constriction equation.

Another effect of this problem is no points ensuring the constrictions on the first iteration, so no global best can be found. If a global best can be found on the first iteration, then algorithm can reach to better results around this point. But if global and local bests can not be determined on the first iteration, then PSO is useless.

Considering all this cases, keeping sensibility low on the first iteration and redounding step by step of the procedure will grow up the efficiency of PSO. On the first iteration, the best integer will be chosen then other points will be investigated on decimal degree and this process will reach to the desirable sensibility about the last iterations. Therefore the probability of finding the best points on the first iteration arises and no need to redound particle number too much so no need to extend solving time.

2.3 Funnel Effect

When solution set is small, enlarging the solution set to cover some of neighbour points is another method to use. However this wideness must shrink by the iteration number grows up, so deviation from the constrictions can be diminished.

Stretching the constrictions including the points on a specific approximation to the solution set is useful to overcome this problem. But this elasticity should not be permanent; it should disappear to the maximum iteration so that we can reach to the real points ensuring the constrictions. This effect is shown on Figure 2. On the each iteration, original constriction value is stretched by a certain quantity. This elasticity changes according to the direction of the constriction too. Equation constrictions are positively and negatively stretched to reach an interval. If it is bigger than constriction, then the value is pulled to higher value, else the value is pulled to a lower value.

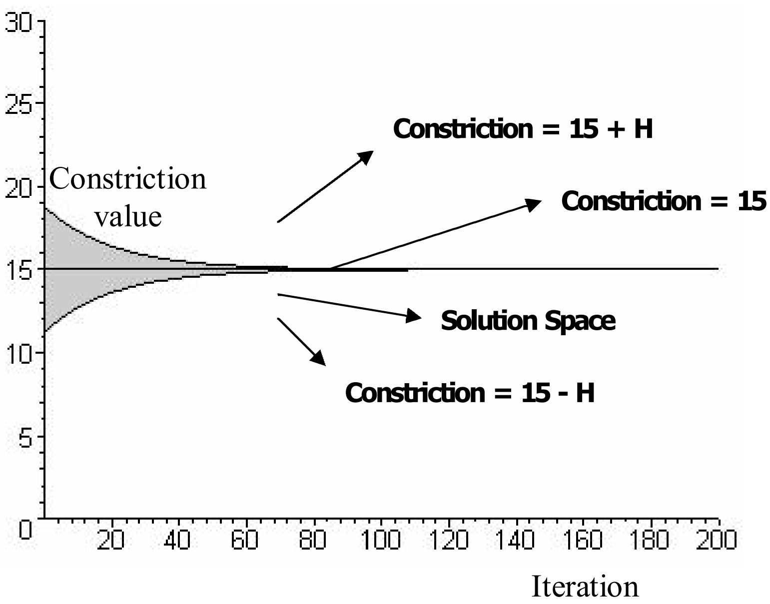


Figure 1. Funnel effect

+\- H value, shown on the graphic, is calculated as in Eq. (4);

$$H = Constriction * M_{ep} * \exp(-Itr / M_{itr} * 0,1) \quad (4)$$

where in the each iteration;
$M_{ep}$ : Maximum flexion portion
$M_{itr}$ : Maximum iteration number

so the constriction will be stretched by $M_{ep}$ on the first iteration.

To adapt standard PSO to this technique, some changes should be done into the criterions ensuring best point choice. According to this, if any point is the best, then it will continue on the solution set. However, if the point remains out of the solution set, even it is still the best one, the first point caught in the solution set will be chosen instead of that point. This will prevent missing a better point in the solution set.

## 3. Model Design

In this study, a warehouse layout design problem that tries to minimize material handling cost is considered. Bassan, Roll and Rosenblatt (1980) were examined the same problem by offering a comparison method for two alternative shelf arrangement for a rectangular warehouse. They were considered homogeneous items that have the equal probabilities for picking and putting away in a two dimensional warehouse. Here, we extended their study for heterogeneous items stocked three dimensional warehouse.

The yearly throughput of the warehouse is classified into three groups including A, B, and C, according to their turnovers. Considering the turnovers and stocking periods of the items, probabilities of (picking or putting away) orders belonging in A, B and C class is $P_A$, $P_B$, or $P_C$, respectively. The main reason of this classification is to locate the items in the warehouse basing on the closeness to the dock. The total capacity and yearly throughput of the warehouse, total storage spaces for each item class and the lengths of the aisles and shelves are entered to the model as the pre-determined parameters. The notation of the parameters and variables are shown in Table 1. Also, Figure 2 is given to visualize some of the dimensions given in Table 1.

Table 1. Nomenclatures

| | |
|---|---|
| w | width of double shelf |
| L | length of a storage space (pallet) |
| m | number of the storage spaces along a shelf |
| h | number of the storage levels in the vertical directions |
| n | number of the double shelves |
| K | total warehouse capacity in the storage spaces |
| a | width of an aisle |
| u | length of the whole warehouse |
| v | width of the whole warehouse |
| d | yearly throughput of the warehouse, in storage units |
| $P_i$ | Probability of an order belonging to class i items |
| $N_i$ | Total number of the storage spaces of i type items |
| $C_h$ | Material handling cost of moving an item in unit length |
| $T_v$ | Average travel distance in vertical axis |
| $T_u$ | Average travel distance in horizontal axis |
| $T_h$ | Average travel distance in height axis |

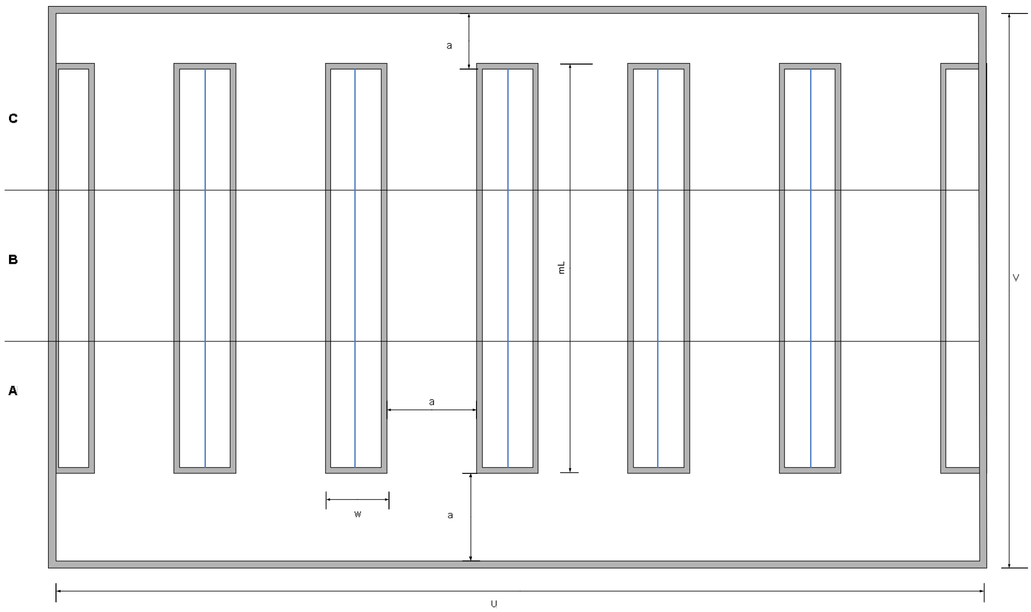


Figure 2. A cross section of the warehouse denoting the parameters

By using given details, a mathematical model providing the optimal number of storage spaces along a shelf and the optimum number of shelves is constituted. In other words, the three dimensions of the warehouse namely, length, width, and height are obtained by the model. The objective function of the model is constituted from the average travel distances in three dimensions and the unit material handling cost. The calculated average travel distances are represented in Eqs. (5-7);

$$T_v = \left[ a + \frac{m}{K} L \left[ (N_A + N_B)\left(1 - \frac{P_a}{2}\right) + \frac{P_c}{2}(N_B + N_C) - \frac{N_B}{2} \right] \right] \quad (5)$$

$$T_u = -\frac{a(a+u)}{2u} + \frac{(u+2a)^2}{ur(r+1)^2} \sum_{k=1}^{r} k^2 \quad (6)$$

$$T_h = \frac{h}{2} \quad (7)$$

Multiplying the total travel distances in all dimensions by the unit material handling cost and by total throughput of the warehouse will constitute the cost minimizing objective function as shown in Eq. (8);

$$C = 4dC_h \left[ a + \frac{m}{K} L \left[ (N_A + N_B)\left(1 - \frac{P_a}{2}\right) + \frac{P_c}{2}(N_B + N_C) - \frac{N_B}{2} \right] - \frac{a(a+u)}{2u} + \frac{(u+2a)^2}{ur(r+1)^2} \sum_{k=1}^{r} k^2 + \frac{h}{2} \right]$$

(8)

The constraints of the model are given in Eq. (9).The first constraint of the model satisfies the yearly demand and the others provide designing a warehouse in three dimension. The details of the calculation of total moving distance for picking and putting away the items through a year can be found in Bassan et al. (1980), but for only one type product and a two dimensional layout.

$$\begin{aligned} &K - 2mnh = 0 \\ &m \geq 1 \\ &n \geq 1 \\ &h \geq 1 \end{aligned} \quad (9)$$

## 4. A Numerical Example

The warehouse layout design model is applied to a hypothetical problem for illustrative purposes and the solution is obtained by using PSO algorithm. The example includes a distribution-type warehouse that will be designed for many kinds of items being stored for different periods. According to the turnover rates of all items, they are classified into A, B, and C groups which have the 0.6, 0.3, and 0.1 ordering probabilities. The throughput of the warehouse is 120,000 palletized products in a year and the capacity of the warehouse is 6,000 pallets. The total storage capacity of the warehouse is divided the item classes into the sizes of 3,000, 2,000, and 1,000 pallets, considering the ordering probabilities and storage periods.

The second data set is related with the dimensions in the storage area. A back to back shelve warehouse design is considered and the width of 2,2 m, length of 0,9 m, and height of 1,0 m for a storage space in a double shelf is determined. The width of an aisle between shelves is 2,0 m and also the width of a dock is 4 m which is determined considering the aisles' width. The width of a dock can be unconsidered in the situation of using one dock. But if the number of docks increases, it should be added to the formulation as a parameter. The only one cost factor, material handling cost, is calculated by taking the cost of workers, forklift usage, fuel consumption, and depreciations rates into account and 1.585 TL/m is obtained.

Above mentioned data is inserted to the model formulation as the parameters. Then, the model is simplified to make it convenient to solve with the PSO algorithm. The PSO algorithm, which uses funnel affect to be able to embedding the constraints to the objective function, is coded by using Visual Basic package program. Figure 2 shows the model inputs and obtained results screen of the program.

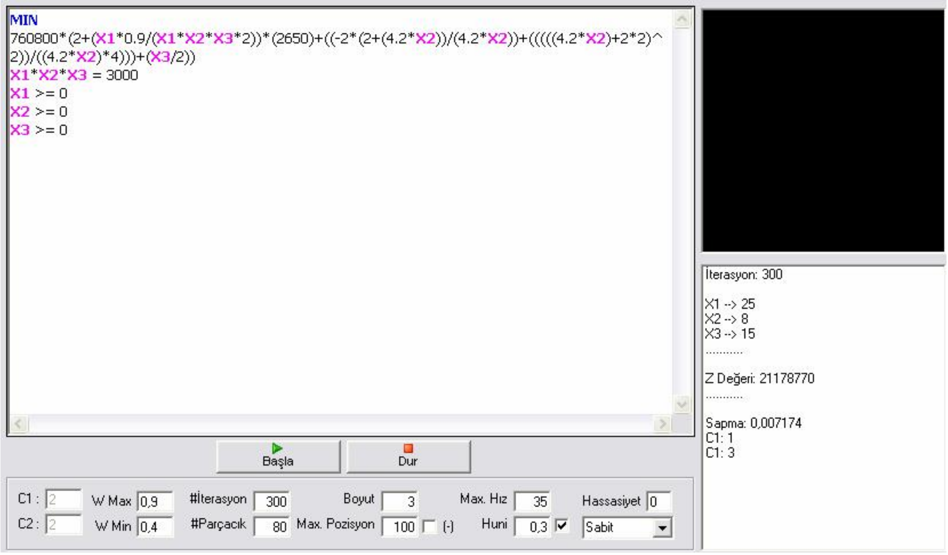

Figure 2. Model inputs and obtained results screen

X1, X2, and X3 variables shown in Figure 2 denote the *m*, *n* and *h* variables of the model, respectively. The obtained result is a warehouse which includes 25 shelves, 8 storage spaces in each shelf, and height of 15 storage spaces. The changes in the variable values and objective function value, while iterations are increasing, are shown in Figure 3.

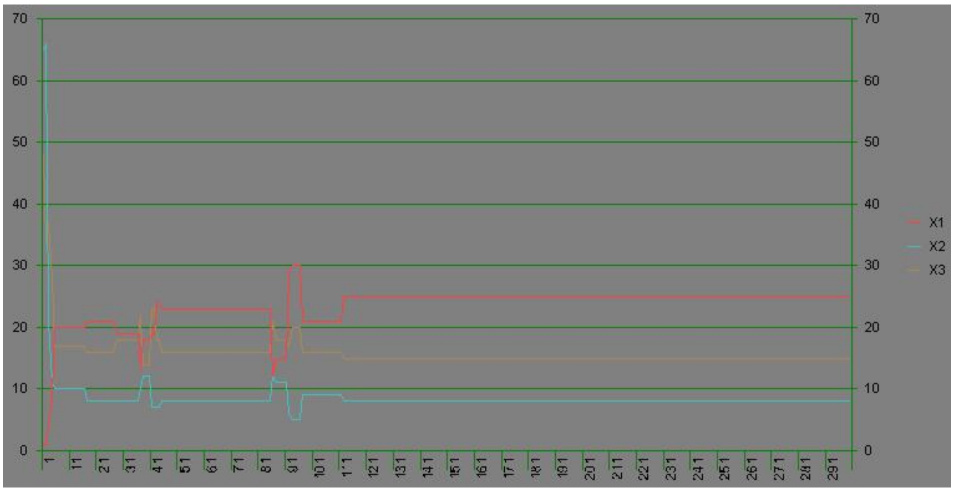

Figure 3. Improving of the model variables in the iterations

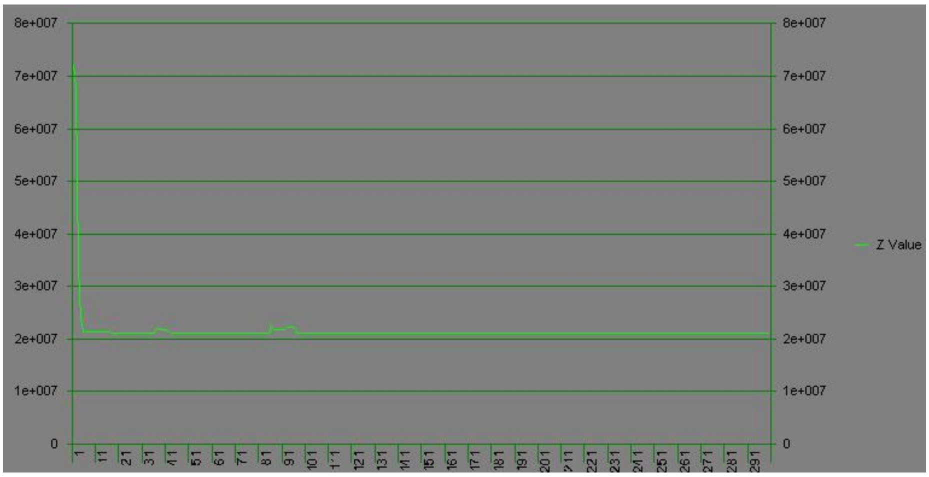

Figure 4. Improving of the objective function value in the iterations

The objective function value can also be denoted as the total distance of picking and putting away of the palletized products for one year as 13,362,000.00 m. This model does not consider any physical constraint, but it can provided by putting upper limits to the dimensions for getting more realistic results or solutions for specific situations.

## 5. Conclusions

This study aims to model the problem of designing a warehouse considering the handling costs in three dimensions. The contribution of our proposed model enhances the two dimensional designs to the three dimensional structure considering a class-based warehouse which includes three palletized product types. But, the main difficulty of solving this kind of designing problems is to struggle with nonlinear variables. To overcome this difficulty, we used a novel algorithm PSO which is able to find near optimal results in the short times. For future studies, the number of docks can be increased and the changes in the total distances can be compared. Also the trade offs between material handing cost in warehouse and vehicle waiting and related other costs can be investigated while the number of docks are increasing.

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# DECOMPOSITION OF THE TANKER SPOT FREIGHT RATE INDICES: TREND, CYCLICAL, SEASONALITY, RESIDUAL OR RANDOM FACTOR

Sinem Derindere[1], Burcu Adıgüzel[2]

## Abstract

*The purpose of this paper is to investigate the four components of tanker shipping freight rate indices (for VLCC) for the period January 1982 - December 2003. A time series consists of four components; trend (the underlying movement of the series), cyclical (the movement of series due to booms and slumps), seasonal factor (the movement of series due to the effects of changes in season), Residual or random factor (some factors which affect a time series occur at random)*

*Freight rates have historically been very volatile. The impact of unforeseen geopolitical events and the slow speed of adjusting supply to demand have often resulted in dramatic fluctuations in the level of freight rates. Tanker transportation serves a vital link in facilitating the movement of oil and petroleum products from their limited sources of origin to their innumerable destinations the world over. This particular segment of the ocean shipping industry constitutes the largest component of sea borne cargo movements today with tanker accounting for approximately one-third of all cargoes shipped by sea. Accordingly, this is a crucial transportation segment for the global community of oil consumers as well as for the oil suppliers and traders and also the owners of these ships. Thus it is very important to shed some light into existence of trend, cyclical, seasonality and residual or random factor in tanker shipping freight rates by concentrating on the movement of tanker freight rates within the year. These four components of freight rates is an important factor in the formation of transportation policy and affect the shipowners' cash flow and charterers' costs.*

Key words: Tanker freight rates; Shipping; Components of time series

## 1. Introduction

Tramp shipping freight markets, like any other market, are characterized by the interaction of supply and demand for freight services. As with all forms of transport, the demand for shipping services is derived from the demand for the commodities carried. The rate structure for tramps is therefore very simple, being the result of the competitive interplay of supply and demand (Branch, 1996:133-134).

Freight rates in the tanker shipping industry fluctuate considerably in short period of time. While part of these fluctuations are due to the general world economic activity as well as the state of the tanker shipping market, a large proportion of the within-the-year fluctuations is attributed to seasonal, cyclical and random factors. In addition, there is often a trend in tanker freight rate services (Kavussanos, Alizadeh, 2002).

Seasonal behavior of freight rates is an important factor in the formation of transportation policy and affects the shipowners' cash flow and charterers' costs. The economics of the oil markets and trade affect tanker shipping freight market considerably because the demand for tanker services is a derived demand. In general, there are seasonal elements in the petroleum and petroleum products trades. Because, in the petroleum trade there is a cycle that reflects the seasonal fluctuation in energy consumption in the northern hemisphere, with the result that more oil shipped during the autumn and early winter than during the spring and summer (Kavussanos, Alizadeh, 2002; Stopford, 1988:66).

The relationship between tanker shipping services and world business cycles is very significant. There is a good deal of evidence that under normal circumstances, the world economy goes through cycles of four or five years' duration during which there are alternate increase or reductions in the rate of economic growth. These fluctuations work through into seaborne trade with the result that the demand for sea transport is unlikely to grow smoothly, but rather as a sequence of periods of high and low growth (Stopford, 1988:64). Therefore, another reason of tanker shipping freight rate fluctuations is cyclical factors as well as seasonal factors.

Leaving aside the effect of cycles, the long-term trend of tanker shipping freight rates also have to be considered. Undoubtedly, the most important influence on tanker demand is the world economy. Thus, there is a close relationship between long term trend of tanker shipping freight market and the world economy. In this paper the trend of the tanker shipping freight market is also investigated.

Residual factors affect a time series occur at random such as shocks. These differ from cycles because they are unique, often precipitated by some particular event and their impact on the tanker shipping freight market is often

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very severe. During the 1970s there were two such occurrences, the first in 1975 and the second in 1980-82, both brought on by a sudden massive increase in oil prices. On these two occasions during a long period industrial output and seaborne trade suddenly declined, in each case setting off a protracted depression in the tanker shipping market.

## 2. Literature Review

Tanker freight rates have been a topic of interest in the tanker shipping industry for a long time. Because of the ongoing uncertainty in international shipping and especially the volatile nature of tanker freight rates, members of the shipping community have always expressed a strong interest in quantitative analysis of freight rates. Early empirical works on the freight market was undertaken by Tinbergen (1933, 1934) and Koopmans (1939). Since World War II there have been numerous contributions. Econometric studies have investigated supply and demand relationship in various shipping markets. Based on these, Hawdon (1978), Charemza and Gronicki (1981) have been constructed mathematical models of the tanker or dry cargo markets. Beside these studies, Kavussanos and Alizadeh (2001, 2002) investigated seasonality pattern in tanker and dry bulk spot freight rate markets. Klovland (2004) also investigated the relationship between shipping freight rates and business cycles, commodity prices. To our knowledge, there has been no an integrated study in the past to decompensate of the tanker spot freight rate series into four components of trend, cyclical, seasonality, residual or random factors. The aim of this paper is to fill this gap in the literature.

## 3. Tanker Shipping Market and Freight Rates

Tanker shipping sector serves as a vital link in facilitating the movement of petroleum and petroleum products from their limited sources of origin to their innumerable destination to the world. As it is known, the most important production areas of oil are the Middle East, Indonesia, North West Australia, Southern Russia, North Africa, North Sea, West Africa, Venezuela, Mexico and the USA. In addition tanker shipping is the most highly specialized sector of the shipping industry. Also, due to the strategic importance of petroleum, the importance of tanker shipping sector is more than the other shipping sector. This particular segment of the ocean shipping industry constitutes the largest component of sea-borne cargo movement.

Tanker shipping freight market is very cyclical in nature with no reliable forecasting mechanism to predict its vacillations. The freight market operates with a high degree of instability, where changes in rates can occur suddenly and, on occasions, for reasons not immediately apparent. This volatility relates to a number of factors, two of which are central. Firstly the inelastic derived demand for tanker tonnage reacts rapidly to particular events, changes in climate, and levels of international and national business opportunism. Secondly, on occasions, the limited opportunities to increase or decrease short-run supply, particularly in the region of full capacity, where total supply is active. The spot freight rate market can at times expose a combination of erratic demand with fixed supply in the short-run. The results bring a high fluctuating rate. As. Figure 1. illustrates, there are periods of rapid increasing rates, following periods of comparative stability (McConville, 1999:280-281).

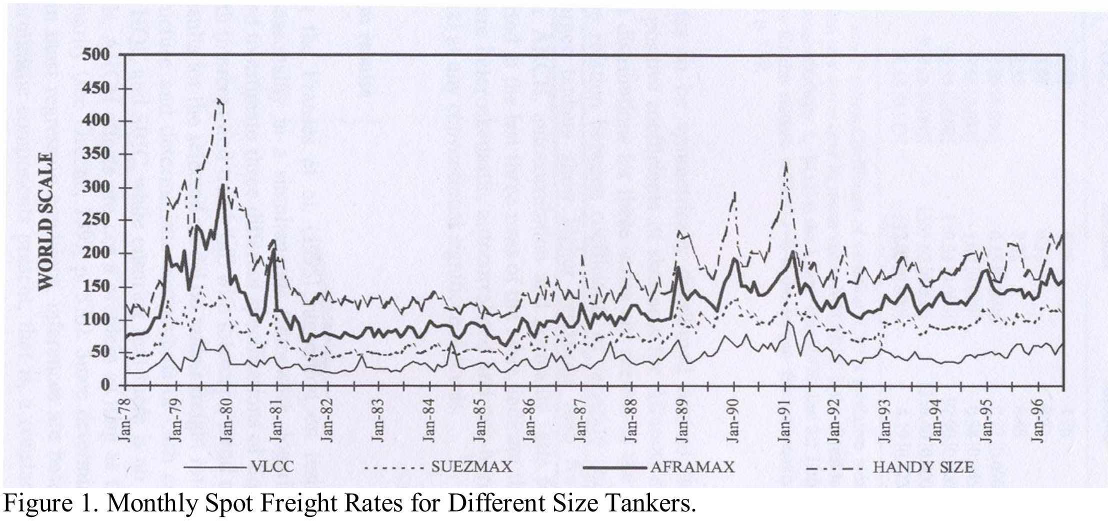

Figure 1. Monthly Spot Freight Rates for Different Size Tankers.

Tramp shipping is, and has been ever since, an international business, which means that there is strong competition between shipowners of a multitude of countries. In a strongly competitive environment, however, a shipowner can only survive if he offers his service at the lowest cost possible. This leads to the leads to the fact that most shipowners operate under the condition of similar costs. Since most shipowners have the same costs they all start to offer their ships at same minimum rate. The supply curve thus starts with the minimum rate and then moves parallel to the x-axes. At a certain demand situation, however, all ships are employed, and the question arises how supply curve can be further enlarged. This is possible, if the ships move quicker and try to reduce port times. This will only be done if the higher costs are paid by a higher freight rate. This results in an increase in the supply curve. However, the possibilities of increasing capacities are limited, and at one point no further increases are possible. The supply curve subsequently moves vertically. Shape of demand curve is much more easier. Demand for shipping services is rather inelastic (Volk, 2002:3-5).

The fact that the supply curve moves from being elastic to inelastic beyond some high level of active tonnage is further analyzed in Figure 2. The general situation for tonnage supplied can be seen from the lower part of the supply curve which is highly elastic. There is a substantial change in demand D to $D^1$ bringing a small increase in freight rate F to $F^1$. Such a minimal increase in freight rate brings forth a substantial increase in the quantity of tonnage supplied Q to $Q^1$ .The supply of tonnage is dependent on the different lay-up points, which is occasionally in discussions on the tanker supply curve referred to as the refusal freight rate of the marginal vessel. An important point about the position of $Q^1$ is that supply is nearing full capacity. At $Q^2$ full capacity is reached, at which point the only way quantity supplied can be increased is by raising the level of utilization. This is done by increasing vessel speed, delaying repairs and classification surveys, and shortening time spent in port. All these actions add considerably to cost. Shipowners will be reluctant to accept such additional expenditure if freight rates fail to cover them. In the model a small increase in demand $D^1$ to $D^2$ has brought a substantial increase in freight rates $F^1$ to $F^2$ and only a small increase in quantity $Q^1$ to $Q^2$, which is full capacity as indicated by the inelasticity of the supply curve. In the short-run, once laid up tonnage has joined the active supply, only extremely marginal increases in capacity are possible. The supply curve has an L shape similar to that of the dry bulk tramp market but far more acute. Hence once at full capacity a small increase in demand has lead to a very large increase in tanker freight rates. (McConville, 1999:294-295)

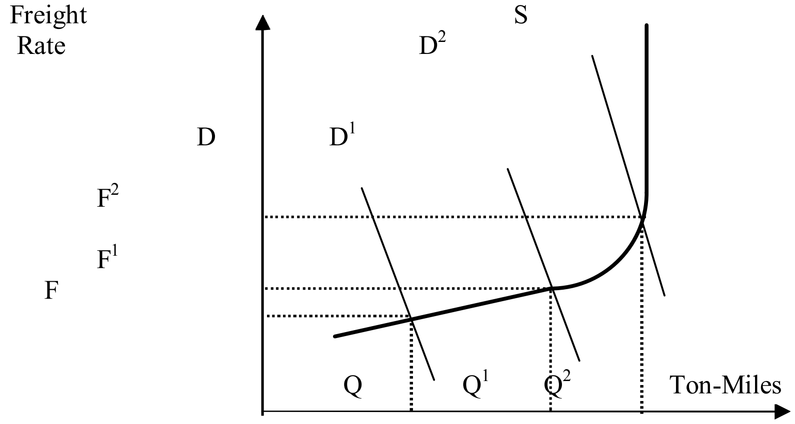

Figure 2. Tanker Spot Market: Increasing Demand

No discussion of tanker shipping market would be complete without reference to the impact of politics. The singular feature of political developments as far as the tanker shipping market is considered is that when they occur they are inclined to bring about sudden and unexpected change in freight market. The term ‘political event’ is used here to refer to such occurrences as a localized war, a revolution, or the political nationalization of foreign assets. Leaving aside the First and Second World Wars, since 1945 there have been at least seven political incidents that have had a significant influence on tanker shipping market. These kind of residual or random factors are given below:

- The Korean War, which started in early 1950. Although cargo associated directly with the war was mainly transported by ships of the US reserve fleet, political uncertainty sparked off a stockbuilding boom in Western countries;
- The Suez crisis and the nationalization of the Suez Canal by the Egyptian government in July 1956. Oil tankers trading to Europe were diverted round the Cape and this created a sudden increase in tanker demand;
- The Six Day War between Israel and Egypt in May 1967 resulted in the closure of the Canal. European oil imports were again diverted round the Cape;
- The closure of the Tap Line oil pipeline between Saudi Arabia and the Mediterranean in 1970 redirected crude oil previously shipped through the pipeline around the Cape;
- The nationalization of Libyan oil assets in August 1973 resulted in the oil companies turning to the more distant Middle East producers for oil supplies;
- The Yom Kippur War in October 1973 and the OPEC production cutback triggered the collapse of the tanker market. The associated oil price rise had an effect on the world economy and the shipping market that was to last more than a decade;
- The 1979 Iran Revolution and the temporary cessation of Iranian oil exports precipitated a major increase in the price of crude oil, with significant repercussions for the world economy and the tanker shipping market (Stopford, 1988:71-72).

## 4. The Data Set and Statistical Analysis

The data used are tanker freight rate indices based on spot market rates. The types of vessels operating in these markets are: ultra large and very large crude carriers (ULCC / VLCC – 150,000 dwt and over), medium-size crude carriers (70,000-150,000 dwt), small crude carriers and product carriers (30,000-70,000 dwt) and handy-size dirty carriers (below 35,000). The two larger size tankers (ULCC / VLCC) are involved in crude oil transportation. For our analysis, we used freight rates for ULCC and VLCC tankers. Because, these tankers of the shipping industry constitute the largest component of sea borne petroleum movement and are employed especially in long haul. Moreover, freight rates for larger tankers show more cyclical changes compared to smaller tankers (Kavussanos, Alizadeh, 2002). This is because, both the fact that demand for oil is inelastic at least in the short run. The demand for tanker transportation services will be more inelastic for countries which are far from the source of petroleum. Because, these countries are face to lack of alternatives or substitute services. For the countries, the possibility of transporting petroleum through pipelines, tanker trucks or tanker railcars is very low. And also the fact that in recent times freight costs for larger tankers have constituted a small percentage in the final price of petroleum due to the economy of scale. As an example, the study by Glen and Martin quotes that in the UK, the transportation cost component amounts to less than 1.3% of the landed cost of petroleum. The relatively minor incidence of the freight component in the landed cost makes it highly price inelastic in nature as predicted by economic theory and also as documented by various studies (Kumar, 2003:15).

Spot freight rate index for VLCC / ULCC is monthly worldscale based and obtained from the Institute of Shipping Economics and Logistics (Bremen) for the period January 1982 – December 2003. They are plotted in Figure 3. As can be seen from the vertical axis, tankers are 'fixed' chartered generally on *Worldscale* rates. This is an index published in London, and based on the costs of operating a standard tanker over a specific route (Mcconville, 1999:281) The rates for all size tankers are negotiated between the brokers and charterers as a percentage of this flat rate (worldscale flat or worldscale 100). The elements entering in the calculation of the flat rate such as costs, bunker prices, port dues, etc., are revised every year. (Kavussanos, 2002)

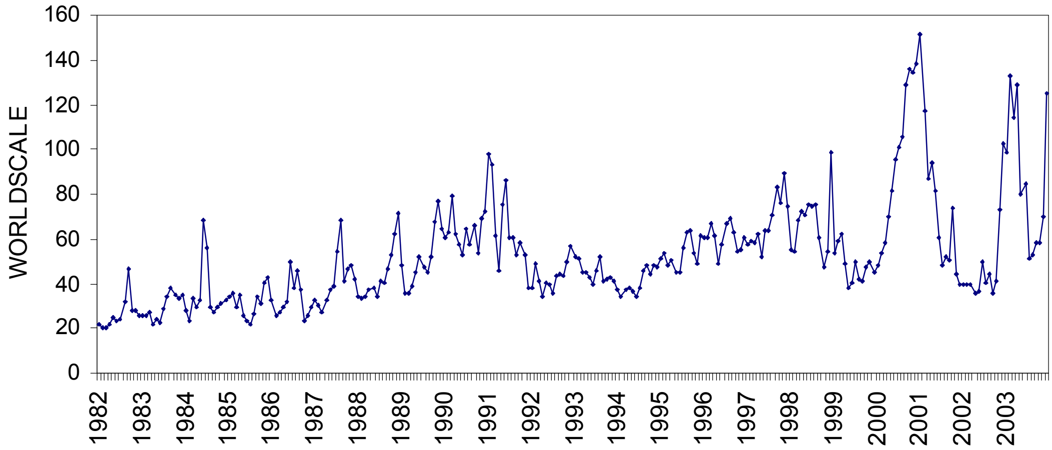


Figure 3. Monthly Spot Freight Rates for VLCC/ULCC

It is needed to decompose the freight rate indices for VLCC/ULCC into constituent components to understand long term behavior of tanker freight rate markets. A time series is thought to comprise four components: trend, cycle, seasonal and random. *Trend:* is growth or decay that is the tendencies for data to increase or decrease fairly steadily over time. *Cycle:* refers to patterns, or waves, in the data that are repeated after approximately equal intervals with approximately equal intensity. For instance, some economists believe that 'business cycles' repeat themselves every four or five years but occasionally a recession may last considerably longer than the usual 1-2 years. Seasonal: refers to a cycle of one year duration. There may, however, be one or more peaks in a year and, in high frequency data, a 'year' may refer to a week and daily variation corresponds to 'seasonal' behavior. Random: refers to (unpredictable) variation not covered by the above. This can be expressed in the 1. equation:

$$Y_t = T_t \times S_t \times C_t \times R_t \qquad (1)$$

The first three components are deterministic which are called "Signals", while the last component is a random variable, which is called "Noise". It could be able to make a proper forecast by market members, when it is known to what extent each component is present in the data. Hence, to understand and measure these components, the forecast procedure involves initially removing the component effects from the data (decomposition).

### 4.1. Trend Analyses

The techniques used to decompose the object series are least squares method and ratio to moving average computations. For our analysis, it is used least squares method to decompose the freight rate index for VLCC/ULCC. In this method, the function, which has the least sum of error squares within various functions, is decided as a trend function of the data set.Long-term trend is typically modeled as a linear, quadratic, logorithmic, growth, inverse, cubic, compound, power, S, logistic or exponential function. For the data set mentioned above in this section, trend analyze is applied by using least squares method. Sum of error squares of each function are calculated and given in table 1. The function which has the least sum of error squares is chosen as trend function of this data set. As it can be seen in table 1., the trend function of freight rate index for VLCC/ULCC is linear.

Table 1 Sum of standard errors

| | SUM OF ERROR SQUARES |
|---|---|
| LİNEAR | 94,119.205 |
| QUADRATİC | 94,135.362 |
| GROWTH | 97,050.73 |
| LOGORİTHMİC | 102,080.9 |
| INVERSE | 137,583.7 |
| CUBİC | 138,872.82 |
| COMPOUND | 137,583.71 |
| POWER | 94,119.21 |
| S | 102,080.95 |
| LOGİSTIC | 97,050.73 |
| EXPONENTİAL | 97,050.73 |

Table 2. Coefficients of Linear Trend Function

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. |
| Case Sequence | .186 | .015 | .600 | 12.132 | .000 |
| (Constant) | 27.770 | 2.340 | | 11.869 | .000 |

After deciding that the trend function is linear, it is written by using the coefficients in Table.2. Such that:

$$Y_t' = 27.770 + 0.186\ x + e_t \qquad (2)$$

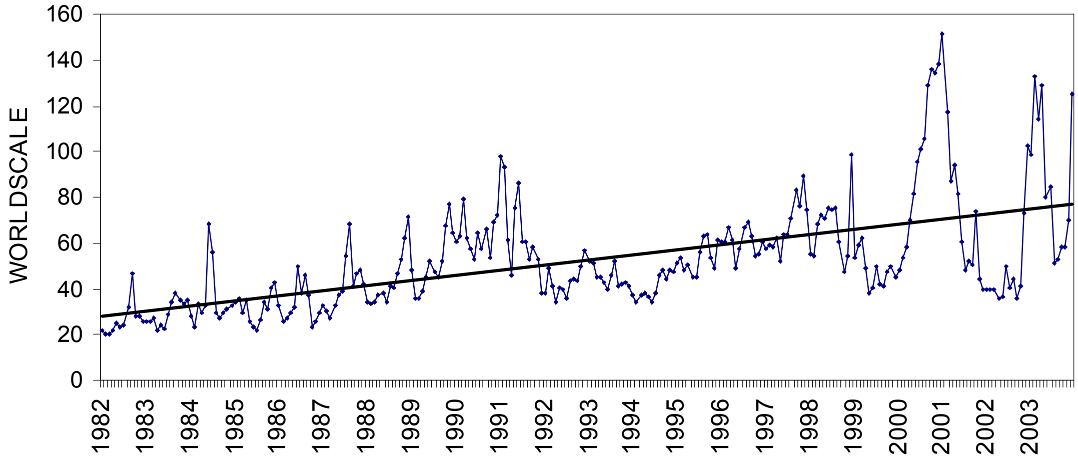


Figure. 4. Monthly Spot Freight Rates for VLCC/ULCC with linear trendline

As realizing in figure 4 and equation 2, there is an increasing trend of freight rate index for VLCC/ULCC.

4.2. Seasonality Analyses

After deciding the trend function by using the least error squares methods, the seasonal factors are investigated. The effects of seasonal factors in freight rates index for VLCC/ULCC is shown in Table.3.

Table.3 Seasonal Index

| Period | Seasonal Factor (%) |
|---|---|
| 1 Jan. | 99.7 |
| 2 Feb. | 98.3 |
| 3 Mar. | 95.8 |
| 4 Apr. | 93.9 |
| 5 May | 92.0 |
| 6 June | 98.1 |
| 7 July | 99.5 |
| 8 Aug. | 104.0 |
| 9 Sept. | 103.8 |
| 10 Oct. | 100.7 |
| 11 Nov. | 105.7 |
| 12 Dec. | 108.5 |

The results indicate that freight rates for VLCC/ULCC experience a significant increase between August-December. This increase is 4% in August, 3.8% in September, 0.7% in October, 05.7% in November, 8.5% in December. The increase in freight rates in August and September and early winter (November) is due to the increase in demand for oil by oil-importing countries which are in the process of building up sufficient inventory levels (crude oil) for winter. The coldest winter months are usually January and February; so excess demand for crude oil is generated sometime in November to give enough lead time for crude to be transported and refined (from the long haul, Middle East routes), which can take 6-8 weeks.

In January, VLCC/ULCC rates begins to decrease due to the decline in the need for inventory building using large vessels after the cold season in the Northern Hemisphere. This decline in demand continues and results in a further %1.7 drop in VLCC/ULCC rates in February. VLCC/ULCC rates again show a significant drop of %8 in May. This can be linked to the decline in the level of petroleum imports and trade activities during the spring months, and the routine maintenance program of refineries around the US Gulf and the Far East which takes place during this period.  VLCC/ULCC rates show a decline in June and July again but this time the share of decline is less than in April and May. This is due to inventory building that takes place after the end of routine maintenance programs of refineries and terminals during April and May, increase in Japanese imports, and to stock up for the US driving season taking place from mid-July to the end of August.

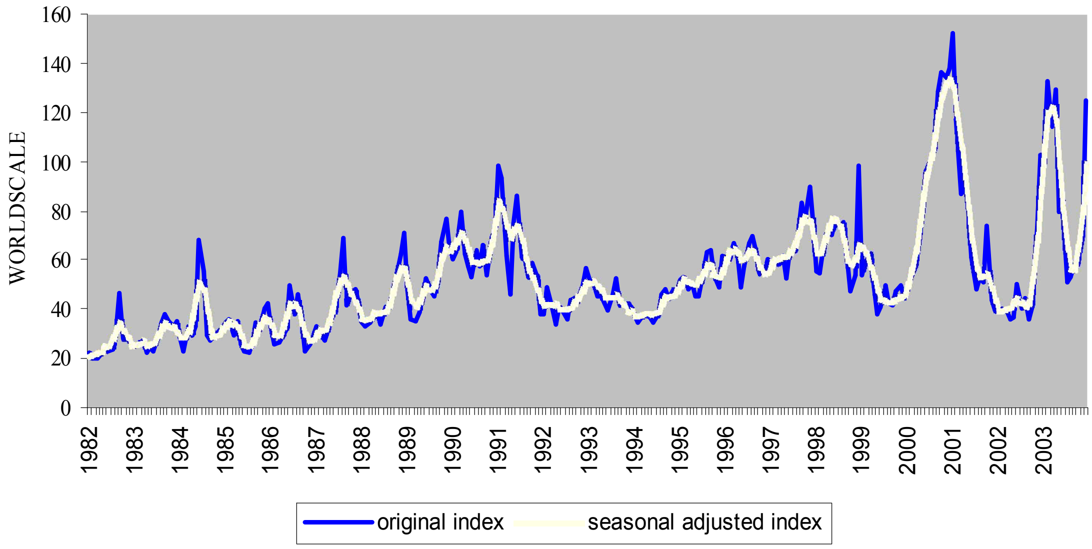


Figure 5. Original Monthly Spot Freight Rates for VLCC/ULCC and Seasonal Adjusted Index.

The existence and magnitude of seasonality in tanker shipping freight rates can be seen in figure 5. The index has the same seasonal behavior (peaks and troughs) every year. While there is an increase early winter, at the beginning of every year (January, February) there is a significant decline. When the original index is adjusted from seasonal factors, sudden peaks and troughs are becoming less than before.

4.3. Cyclical and Random Factors Analyses

After deciding proper linear trend function of monthly freight rate index for VLCC/ULCC and showing seasonal effects in the index, the cyclical and random factors are analyzed. For analyzing these factors we use the following equation:

$$\frac{Y_t}{\hat{Y}_t} = \frac{T_t \times C_t \times S_t \times R_t}{T_t \times S_t} = C_t \times R_t \qquad (3)$$

Cyclical and random factors are shown in the Table.4.

Table. 4. Cyclical and random factors of freight rate index for VLCC/ULCC

| | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 79 | 84 | 86 | 99 | 88 | 84 | 83 | 111 | 133 | 205 | 76 | 100 | 69 | 91 | 103 | 94 | 87 | 81 | 71 | 217 | 54 | 133 |
| Feb. | 74 | 85 | 72 | 106 | 71 | 78 | 81 | 84 | 140 | 197 | 99 | 99 | 63 | 95 | 103 | 98 | 87 | 90 | 79 | 169 | 56 | 181 |
| Mar. | 75 | 93 | 105 | 88 | 75 | 72 | 86 | 84 | 179 | 132 | 85 | 89 | 70 | 87 | 117 | 99 | 112 | 98 | 89 | 128 | 56 | 158 |
| Apr. | 81 | 76 | 95 | 107 | 84 | 87 | 95 | 94 | 143 | 101 | 71 | 91 | 73 | 93 | 109 | 107 | 120 | 78 | 108 | 141 | 52 | 182 |
| May | 93 | 86 | 108 | 78 | 91 | 101 | 99 | 110 | 134 | 168 | 87 | 87 | 72 | 85 | 89 | 92 | 119 | 62 | 129 | 125 | 54 | 115 |
| June | 82 | 75 | 209 | 66 | 134 | 100 | 82 | 119 | 116 | 179 | 79 | 76 | 63 | 79 | 97 | 104 | 119 | 62 | 142 | 87 | 69 | 115 |
| July | 83 | 93 | 167 | 62 | 101 | 136 | 97 | 106 | 138 | 124 | 70 | 86 | 68 | 97 | 111 | 103 | 115 | 74 | 147 | 68 | 55 | 68 |
| Aug. | 105 | 104 | 84 | 70 | 116 | 164 | 92 | 97 | 117 | 118 | 81 | 93 | 79 | 104 | 111 | 108 | 112 | 61 | 146 | 70 | 58 | 67 |
| Sept. | 151 | 115 | 78 | 91 | 94 | 98 | 105 | 111 | 135 | 103 | 83 | 74 | 82 | 105 | 100 | 128 | 89 | 59 | 178 | 68 | 46 | 73 |
| Oct. | 95 | 109 | 87 | 86 | 60 | 114 | 122 | 148 | 113 | 117 | 83 | 78 | 79 | 91 | 89 | 120 | 72 | 69 | 194 | 102 | 55 | 75 |
| Nov. | 88 | 98 | 86 | 105 | 64 | 111 | 136 | 160 | 137 | 101 | 90 | 74 | 81 | 79 | 85 | 134 | 78 | 69 | 182 | 58 | 93 | 86 |
| Dec. | 78 | 100 | 87 | 107 | 70 | 94 | 152 | 131 | 139 | 70 | 100 | 70 | 77 | 96 | 91 | 108 | 138 | 61 | 182 | 50 | 127 | 150 |
| Average | 90 | 93 | 105 | 89 | 87 | 103 | 103 | 113 | 135 | 135 | 84 | 85 | 73 | 92 | 100 | 108 | 104 | 72 | 137 | 107 | 65 | 117 |

As it can be seen in table 4., There was a tanker market doldrums in 1980s, because of the re-opening Suez Canal. The closure of the Suez Canal in 1967 was very important factor for tanker shipping freight market, because this caused a sudden and substantial increase in ton-miles demand. (Mcconville, 1999:39) This increased the sailing time to destinations in Europe and North America thereby increasing the demand for tankers and further consolidating the good fortune of some tanker owners. Tanker fleet increased to meet increased demand in ton-mile. When the canal re-opened there was a lot of tanker fleet surplus that cause a market doldrums.

What the table 4 illustrates is the expansion in tanker freight rates between 1989 and 1991. This expansion was remarkable comparing to 1980s. Its reason was the Kuwait War in 1990-91. In 1989, Iraqi President Saddam Hussein accused Kuwait of flooding the international oil market and consequently forcing oil prices down. Iraq invaded Kuwait on Aug. 2, 1990, and Hussein declared Kuwait annexed. Many native Kuwaitis, including the royal family, fled. Western and Arab coalition forces, the largest part of which were American, drove Iraqi forces from Kuwait in the Persian Gulf War. This crisis caused a sudden increase in freight rate for VLCC/ULCC.

After Kuwait War, another tanker market doldrums was lived. Between 1996 and 1998, tanker shipping freight market boom was lived again. This was primarily a result of an increasing amount of crude oil demand from the expanding economies of Asian nations such as the Republic of Korea, China, Taiwan Province of China, Thailand and the Philippines.

A comparison of the annual average freight indices for the year 2002 with those of the previous year, which was a bad one for tanker owners. Highlights the fact that rate levels are depressed for VLCC/ULCC. This might explain the call to pool tonnage made in early 2003 by Tanker International.

During 2003 tanker freight rates fluctuated widely in response to OPEC decisions concerning production levels, increased demand from major consumer countries and unforeseen events such as civil unrest in Venezuela and strikes in Nigeria at the beginning of the year, military operations in the Middle East Gulf during the second quarter, increased demand in Japan due to temporary summer closure of nuclear-fuelled power plans for inspection and, at the end of the year, bad weather and congestion in the Bosphorus Straits. In this year, rates were moving up after the major explosion and fire on the Limburg off the Yemeni coast following an attack by an unidentified small craft. The stockpiling concerns of major importers in case of conflict in the Gulf jacked up rates further for the destination Japan and the Republic of Korea.

There might be a lot of reasons which we are not realize that tanker shipping freight market is affected. However, it is obvious that cyclical and random factors are very significant impact in the market whether we know the reason or not.

Moreover, there are four or five years cycles in tanker freight rate index.

## 5. Conclusion

The existance and magnitude of four components of tanker freight rate index are examined in this paper. The freight rate index for VLCC/ULCC is decomposed into four components by uzing least square method. Results are significant. There is a increasing linear trend function of the index. Statistical analyse shows that there are seasonal increases between August and December to stock up for teh winter and declines in rates from January to May. In addition, the results show that the magnitude of random factors' effects is very significant. When political developments, such as a war, revolution and crises, occur, they are inclined to bring about sudden and unexpected change in tanker freight rate. Lastly, cycles are observed in the freight rate index, the tanker shipping market goes throgh cycles of four or five years.

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# EFFECTS OF RESOURCES SHARING STRATEGIES ON LOGISTIC POOLS PERFORMANCES

Milorad Vidovic[1], Jelena Vlajic[2], Nenad Bjelic[3], Isik Ozge Yumurtaci[4]

## Abstract

*Pooling models have been used extensively to analyze the performance of variety of systems, both in logistics, and other areas. Reason for so wide application of pooling concepts lies in fact that cyclic allocation of resources to multiple clients is quite natural, and brings numerous positive effects.*

*In logistics and supply chains, numerous examples of pools and pooling concepts exist. One example is related to collaboration of retailers, and multi-location inventory systems, where movement of stock between locations at the same echelon level can lead to cost reductions and improved service without increasing inventory level in the supply chain. Another example can be found in pools of empty logistic units (pallets and containers), where balancing flows equate differences between shortages and surpluses of empty logistics units in depots without increasing number of empty units in the system.*

*However, managing lateral transshipments and balancing flows needs appropriate strategies of sharing resources between pool members. Therefore, in this paper, several possible strategies of resources sharing are studied, and their effects are analyzed through the impact on different logistics performances. Research performed here is based on quantitative modeling and simulation approach, covering both, distribution systems, and pools of empty logistic units.*

*Keywords: logistic pools, pooling strategies, performances, modeling*

## 1. Introduction

Supply chain management is considered to be more significant than ever for many companies because of its effect on cost, inventory level and customer service level, as well as on other performances. Among other aspects, it requires managed and coordinated flows of goods/services, information and finance. However, since inventories represent one of the key issues in supply chains, their coordination from the aspect of replenishment and/or delivery must be considered.

Inputs into logistics play a vital role on the steady step to efficient logistics management. Therefore technical and technological resources (land, equipment and facilities), human resources, financial resources and information resources which are inputs of logistics have to be rationally used. Resource sharing is very significant to be able to realize logistics objective. Logistics objective is minimizing total costs given the customer service objective where total costs are equal to transportation costs, warehousing costs, order processing costs, information costs, lot quantity costs and inventory carrying costs. For this reason, resources sharing strategies should display the optimized way to have the best performance along the supply chain.

Along the supply chain, there are numerous partners. Effective resources' sharing requires satisfactory flow of information, goods and services between partners. Basically, in the logistics network there are four partners; these are suppliers, manufacturers, warehouses and distribution centers and customers. The support of the network has to be empowered by using IT applications, quantitative modeling and simulation approach. This paper aims to give a framework about the effects of resources sharing strategies when logistic pools performances are taken into consideration.

Particularly, this paper is concentrated on two, in the authors' opinion very important examples of logistics pools:

- *empty containers pools in reverse logistic, and*
- *inventory sharing pools between retailers in two-echelon systems*

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Empty logistic units pools in reverse logistics are pallet and container pools. Typical problems in this area are related to pallet/container quality, disposal and exchange between companies in the pool system. According to Bowersox at al. (2002), pallet pools are third-party suppliers that maintain and lease high-quality pallets throughout the country for a variable fee for a single cycle. Pallet pool systems, such as CHEP, which is one of the largest, assume responsibility for developing, purchasing, and maintaining pallets as well as providing control and management systems (Bowersox at al., 2002). Consequence of the use of returnable units is necessity of activation complex processes that comprise very wide area of different tasks which require adequate management decisions and operations. This include: pooling concept considerations; choosing locations for warehousing, repair, recycle and disposal plants; collecting, testing, sorting and transportation strategies considerations; solving allocation and balancing problems with empty units; vehicle routing; solving inventory control problems, etc.

Processes with empty units are related to depots, whose function is to provide customer with empty units, to pick up empty units from customers afterwards, and to keep current inventories of containers. One of important problems is repositioning empty units, i.e. balancing flows realization, from the surplus depots, to those with shortage, in order to satisfy customer demand. In case when some of depots have surplus, and some have shortage, important question is which repositioning strategy to apply. This paper attempts to give some general answers to that question, simulating different strategies, and analyzing their performances.

Another important example of logistics pools is based on the concept of inventories sharing between group of supply chain members. Namely, group of supply chain members in the same level of supply chain, mostly retailers, can form inventories' pool with the objective to decrease inventory level and costs, as well as to improve customer service and other performances. Pooling is based on the idea of sharing inventories between pool members, which means that pool member with surplus supplies another pool member who has experienced shortage, That is, pool serves as a source of emergency deliveries, while regular supply is realized from the warehouse at the higher level. Common name for this type of inventory coordination within supply chains is transshipment. This term is commonly used for inventory sharing between retailers. In the case of inventory sharing (but also some other resources or services), in the literature can be found term Distributor Integration as well (Simchi-Levi at al., 2000).

Similarly to the empty containers pools, in case when some of members have surplus, and some have shortage, here also arises question of transshipment strategies should be applied. Hence, this paper attempts to give some answers to the question of transshipment strategies as well, also by using appropriate simulation approach.

Obviously, while considering abstract presentation of those two mentioned pooling systems, certain similarities may be found between them. The Figure1. below accentuates basic differences and similarities between them.

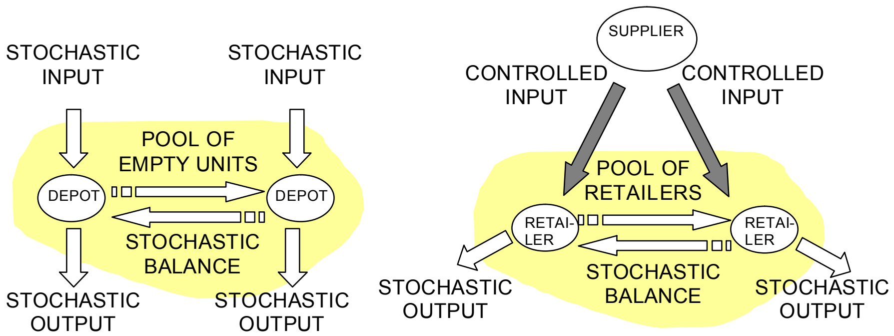



*Figure 1. – Similarities, and differences between empty logistic units pools, and inventories sharing pools*

As it may be seen from the Figure 1., because of the system nature, supplying of depots in the pools of empty logistic units is based on stochastic inputs, while supply of inventories' pools of retailers result from coordinated input based on certain inventory control strategy. However, in both cases, balancing flows help in system stability maintenance. In the depot system, because customer' return is stochastic in nature, balancing flows are the main instrument of system stabilization, while in inventory pool those flows serve as a source for emergency supply.

Obviously, it is of special importance for both systems to analyze effects of different balancing strategies that may applied. In this paper, three possible balancing strategies were analyzed:

- Proportional Balancing Strategy
- Minimal Cost Balancing Strategy, and
- Random Balancing Strategy

Effects all of those three resources sharing strategies are determined by simulation model, and their impact on systems' performances is analyzed for both of mentioned pooling systems. Therefore, in this paper two main contributions were made. First, empty logistic units pool, and pool of retailers in two-phase supply chain, were posed in the similar context by applying appropriate generalization approach. Second, balancing flows are analyzed on the operational planning level, by using three possible balancing strategies on ten nodes network, which represent extension of previous research, and good basis for further effort in lightening this area.

To explain authors intention and present concept of analysis, as well as results obtained, remaining of the paper is organized as follows.

Section 2 surveys the relevant literature. Section 3 describes the problem, and discusses applied strategies for balancing flows realization. Section 4 presents general concept of the simulation model. Section 5 discusses results of numerical experiment, and Section 6 presents summary conclusion.

## 2. Literature review

In the field of empty logistic units, and their pools, there have been several related approaches. In the same time, most of them cover strategic level decisions, and only few are dealing with operational level decisions.

Very detailed description of problems related to empty containers fleet management, in case of shipping containers, may be found in paper written by (Crainic, Dejax and Gendreau, 1990). Location problem with interdepot balancing requirements is formulated by (Crainic, Dejax and Delorme 1989). (Shen and Khoong 1995) proposed decision support system for empty container distribution planning. They describe main business process related to the empty containers management, and propose framework for solving the empty container flow problem, over a multiperiod planning horizon. Shipping container logistics and allocation is also studied by (Lai, Lam and Chan, 1995). Fleet sizing and empty equipment redistribution is studied by (Du and Hall, 1997). Also, dynamic empty container allocation problem is considered by (Cheung and Cheu, 1998).

In (S. T. Choong, et al. 2002) authors addresses the planning horizon problem related to the tactical management of empty containers for intermodal container-on-barge transportation networks. (Crainic et al. 1993) propose models for empty container allocation and distribution between a land transportation system and international maritime shipping network. (A. L. Erera, et al. 2005) consider the management problems faced by tank container operators, for a given imbalanced global trade flows. In (H. Jula, et al. 2006) the empty container movement problem in the port area is studied. The main objective of this paper is to model empty reuse in a dynamic environment analytically and develop optimization techniques to minimize the cost of dynamic empty reuse.

In the literature related to supply chains, different concepts of collaboration have received considerable attention. According to (Tagaras and Vlachos 2002), the risk of a stock out is pooled and therefore reduced in the system, resulting in more effective management of the total system inventory. In the specific case, one group of supply chain members in the same level can share their inventory, so they form a pool. Common name for this type of inventory coordination is transshipment. This term is commonly used for inventory sharing between retailers. In the case of inventory sharing (and some other resources or services), in the literature can be found term Distributor Integration (Simchi-Levi at al., 2000).

Transshipment represents shipment of items between different facilities at the same level in the supply chain to meet some immediate need (Simchi-Levi at al., 2000). However, there are two forms of transshipment. When the decision about the quantities to be moved laterally is made in anticipation of a stock out, this type of collaboration is called preventive lateral transshipment, as opposed to the redistribution of inventory between the stocking locations after a stock out is observed, which is called emergency lateral transshipment (Tagaras and Vlachos, 2002). Beside that, considered in the pooling context, it can be distinguished two types of pooling policies – complete and partial pooling. Situations when all members partially share inventory (only certain quantity of goods can be pooled) have been termed as "partial pooling" and when all members completely share any available inventory to avoid expensive shortages has been termed "complete pooling" (Tagaras and Cohen, 1992).

The first contributions to preventive transshipments were done by (Allen 1958), (Gross, 1963), (Karmarkar and Patel, 1977).

The first contribution referred to emergency lateral transshipment belongs to (Krishnan and Rao 1965), who derived the optimal order-up-to quantities assuming that the replenishment lead time is zero and all costs at each location are identical. (Tagaras, 1999), (Tagaras 1989), extended the two location version of Krishnan and Rao's model by allowing different costs at the two locations and by adding service level constraints. Recently, (Herer, and Tzur 2001) consider dynamic transshipment problem.

Also, there are a various articles about transshipment problem in two-echelon inventory system, mainly related to retail network or generally on stocking points within same echelon. Trigger for starting transshipment process is usually based on low stock level or inventory shortage at some echelon's member or inventory unbalance within echelon. In most of cases, transshipment implementation shows good results - inventory level reduction and customer service improvement, but level of total cost reduction depends on several factors[1]. However, many papers about transshipments problem suffer from the adoption of relatively simple problem structures involving only two stock locations and/or a single planning period, thus limiting their practical usefulness (Banerjee at al, 2003).

Alfredsson and Verrijdt (1999) analyzed two-echelon model consisting of a central warehouse supplying a number of local warehouses with spare parts. They allow transshipment between local warehouses and that activity is realized from randomly chosen local warehouse that has stock on hand. Possibility of direct delivery (from the plant which has infinite supply) is allowed, too. Grahovac and Chakravarty (2001) compare the performance of SC for several scenarios: with and without transshipment within the lows echelon, in centralized and decentralized type of supply chains with expensive, low-demand items. They evaluate overall transportation, inventory holding and customer waiting costs as supply chain's performance over the scenarios. Banerjee at al (2003) compared effects of

[1] That depends on the developed cost structure (cost elements which are respected within the model) on the one hand and on the cost of transport between supply chain members (vertically, across the supply chain and horizontally, within echelon members) on the other.

transshipment policies applied to two-echelon system in which inventory replenishment decisions are made centrally. Burton at al (2005) use same models to analyze sensitivity of transshipment policies to specific cost structure, as a function of the average unit days of shortage per retailer and average number of lateral shipments per retailer.

## 3. Problem description and strategies for balancing flows realization

Effective management of the supply chain is nowadays recognized as a key factor of competitiveness and success for most companies. In the literature can be found various strategies, policies, methods, quantitative models etc, which describe different ways and levels of management within supply chain. Analyzing and optimizing such complex system usually is very difficult task. Therefore, it is often desirable to concentrate on smaller parts of the system so as to gain a full understanding of its characteristics, performance and tradeoffs involved (Tagaras, 1999).

Hence, this paper concentrates on an analysis of the resources sharing in a pools consist of ten nodes, which represent depots, or retailers, depending on the type of the sistem being considered.

In those two pooling systems, important daily problem is related to making decision about repositioning resources between nodes in order to satisfy customer demand. Namely, when customers' demand has stochastic nature, although the network itself is balanced (which means that during the long period average supply and demand for all of network nodes are in balance), in any arbitrary period of time some of network nodes may experience shortage and some other excess, of inventories.

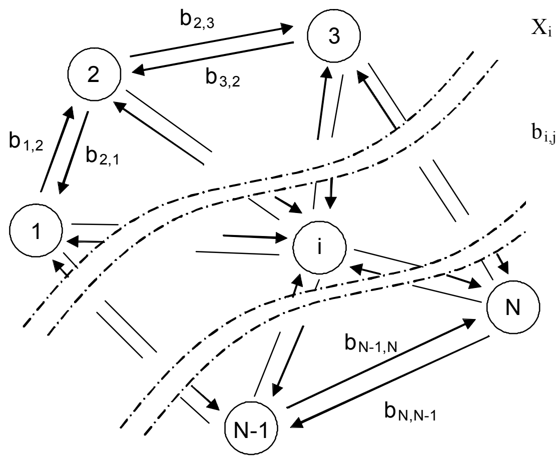
Shortage and excess of resources in case of empty logistic units pools result from short term imbalance between customer returns and demand, while in case of inventory pools of retailers, shortage results from higher customer demand between two supplies. In both cases, because nodes are in pools, imbalances may be compensate in certain extent through balancing flows realization.

To analyze the problem more detailed, let consider network shown in the Figure2.

Let G (N,A) is the network of N nodes (depots or retailers). Because the values of stochastic variables $X_i$, change their values in certain time intervals, obviously, in any given period of time, set of N nodes may be disjoined into two subsets:

- *S* *subset of "source" nodes* $i \in S$, *i=1,…,/S/,* $|S| \leq N$, $X_i > 0$ *for* $\forall i \in S$
- *D* *subset of "destination" nodes* $j \in D$, *j=1,…,/D/,* $|D| \leq N$, $X_j < 0$ *for* $\forall j \in D$

Obviously, $S \cap D = \varnothing$.




$X_i$ stochastic variable which denotes states in node i ($X_i < 0$ means that node i has demand for $X_i$ units, and $X_i > 0$ means that node i has surplus of $X_i$ units)

$b_{i,j}$ stochastic variable which denotes balancing flow from node i to node j ( i, j = 1,2,...N, $i \neq j$, in case $X_i > 0$ and $X_j < 0$)

*Figure 2. – Pool of network nodes with balancing flows*

Obviously, values of stochastic variables $b_{ij}$ depend on the balancing strategy applied, and in the same time overall system performances also depend on $b_{ij}$, since the customer demand realization depends directly on the quantity of resources being repositioned. From there, main question here is which balancing (repositioning) strategy to apply in order to achieve optimal system performances, in sense of repositioning costs minimization, and customer service maximization.

In this paper performances of three balancing strategies were considered, and effects of their application were analyzed on both of pooling systems.

Because of previously observed conceptual similarities between those two pooling systems, strategies analyzed here are described regarding to empty logistic units pools, while possibility of their application for the case of pools of retailers, is only made through appropriate comments.

*First strategy (Proportional Balancing Strategy - PBS)*

This strategy is based on repositioning units from all of nodes $i \in S$, to nodes $j \in D$, accordingly to the proportion of demand in node j in total demand, and total available supply from nodes $i \in S$.

By using previous notation, this strategy may be expressed as in Eqs. (1) ~ (6).

$$b_{.j} = \sum_{i=1}^{|S|}(1-\gamma)X_i \cdot \frac{X_j}{\sum_{j=1}^{|D|} X_j} \quad (1)$$

$$b_{i.} = (1-\gamma)X_i \quad (2)$$

Where $b_{i.}$ is available supply from node i, $b_{.j}$ is the supply of node j, and $\gamma$ is percent of inventories whish serve as safety stock which is not used in balancing flows realization. Instead of the percentage of available stock $\gamma$, some constant value may be also used.

Relocation of units between nodes, i.e. matching supply and demand nodes, is realized under the objective of minimizing total repositioning costs, what is solved by using transportation problem formulation Eq. (3)

$$\sum_{i \in S}\sum_{j \in D} b_{ij}c_{ij} \rightarrow \min \quad (3)$$

s.t.

$$\sum_{i \in S} b_{ij} = b_{.j},\ \forall j \in D \ (4)$$

$$\sum_{j \in D} b_{ij} = b_{i.},\ \forall i \in S \ (5)$$

$$b_{ij} \geq 0 \quad (6)$$

Where $c_{ij}$ are transportation costs between nodes i, and j.

*Second strategy (Minimal Cost Balancing Strategy - MCBS)*

This strategy is similar to the previous, where the main difference lies in fact that in case when total demand is greater than total available supply, instead of using Eq. (1), all available supply is relocated to demanding nodes under the criterion of minimal repositioning costs.

Hence, here $b_{.j} = X_j$, while relocation plan can be also obtained by solving transportation problem, which may be formulated in the same way as in previous strategy, but by using modified constraint given by Eq. (4), which becomes:

$$\sum_{i \in S} b_{ij} \leq b_{.j},\ \forall j \in D \ (7)$$

In case when total supply exceeds total demand, first and second strategy are the same..

*Third strategy (Random Balancing Strategy - RBS)*

This strategy differ from previously two in the concept of matching supplying and demanding nodes. Namely, in this strategy, nodes matching concept is based on random manner, where supplying quantity of node $i \in S$ is equal to the available, i.e. $b_{i.} = (1-\gamma)X_i$, but demand Xj is satisfied to the extent which depends on supply-demand ratio. That is, when $X_j \leq b_{i.}$, than demand is fully satisfied, but in case when $X_j > b_{i.}$, demand is satisfied only to extent of bi..

In the case of pool of retailers, regular orders are placed every defined period, and because of that regular supply is realized from the warehouse. However, when customer demand cannot be satisfied from the certain node, same strategies explained in the case of empty logistic units pools are applied.

## 4. The simulation model concept

In order to analyze impact of defined balancing strategies to the pooling system performances, simulation model written in Visual Basic 6.0 has been developed. The simulation model user interface is shown in the Figure 3.

Model is made flexible in sense of its flexibility to simulate pooling systems with any given number of nodes. However, for the purpose of the research related to this paper, only pools of ten nodes were analyzed.

Modeling concept was based on following scenario. At the end of each day, for every network node, model collects information about current inventory stock, as well as about demand and supply for the next day. Of course, depending on the pooling system which is considered, supply has different meaning. When pool of empty logistics unit is considered, supply denotes customer returns, but in case of pool of retailers, this denotes delivery from the warehouse. Inventory control strategy applied when regular supply of nodes is from the warehouse is based on constant reorder period, which can be changed through the user interface.

Based on those information, model calculates next day requirements, and determine which nodes will be faced with shortage, and which will have excess of inventories. In this way, every day during the given simulation period, two subsets of “source”, S, and “destination” D, nodes are created.

Then, after entering into next simulation period (next day), depending on the balancing strategy applied, model relocates inventories, and collects statistics needed for the pooling system performances estimation. It should be noted that the pool of retailers simulation includes certain rules related to supplying process. Namely, it is assumed that delivery from the warehouse is not available at the beginning of the day, but that will arrive during the day. Consequence is that nodes which have supply during the certain day don't participate in the pool.

As it can be seen from the Figure 3., simulation model can use three different probability distributions to describe customer demand, and gives opportunity for choosing percentage of inventories should be hold as safety stock in each node. Also, it should be noted that beside mentioned three balancing strategies, the model will be improved by adding two more balancing strategies, whose implementation is under development.

In addition to several system performances are shown as screen outputs, model also saves some other simulation outputs as text files.

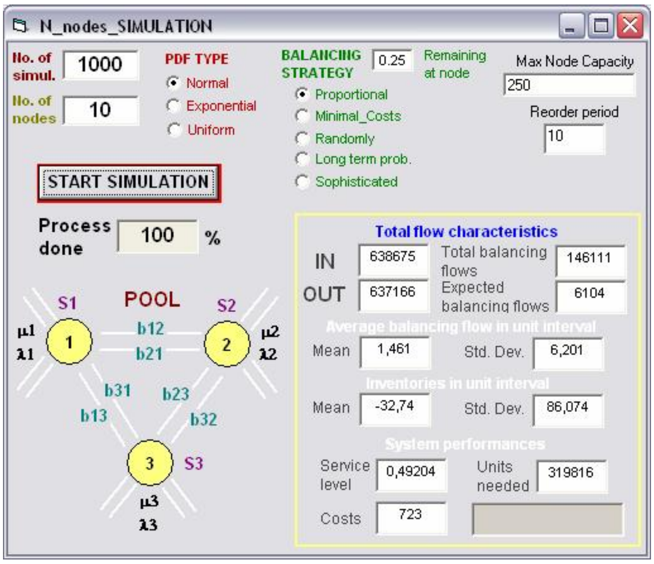



*Figure 3. Simulation software user interface*

## 5. Model application experience

Process of collecting simulation outputs which describe behavior and performances of mentioned pooling systems, under different balancing strategies is realized on 1000 simulations, after the system reached steady state.

Results shown here are based only on normally distributed customers' demand with parameters μ=50 i σ=10. In case of pools of retailers, maximal inventory level in nodes was limited to 250 units, while reorder period was varied as 3,5,7, and 10 days.

Network was generated randomly in the square of 1000x1000 distance units. Distance determination was based on Euclidean metrics. Distance from the warehouse is used as constant, same for each node, and amount used in the model was 15000 distance units. Because simulation experiments are realized for scenarios when 0%, 75%, and 100% of current inventories serve as safety stock, accordingly to (Tagaras and Cohen. 1992) notation, pooling systems were analyzed under "no pooling", "partial pooling", and "complete pooling" scenarios.

Performance measures used are following:

- service rate (rate of satisfying demand in nodes)
- total shortage of inventories per node (after repositioning)
- average inventory level per node
- total costs of balancing flows (transport costs of repositioning)

Simulation results for defined scenarios are presented in Tables 1, and 2. Table 1. shows results for the empty logistic units pools, and Table 2. shows simulation results for the pools of retailers.

Table 1. Simulation results for pools of empty logistic units

| Transshipment(balancing) strategy | Complete pooling | | | | Partial pooling | | | | No pooling | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Service rate | Total shortage | Total costs | Average inventory level | Service rate | Total shortage | Total costs | Average inventory level | Service rate | Total shortage | Total costs | Average inventory level |
| RBS | 0,99218 | 883 | 74 | 50,5779 | 0,9928 | 861 | 80 | 52,5275 | 0,9618 | 3980 | 0 | 265,9232 |
| MCBS | 0,99183 | 882 | 38 | 50,8686 | 0,99176 | 861 | 43 | 52,9543 | | | | |
| PBS | 0,99057 | 886 | 38 | 51,1713 | 0,99082 | 863 | 43 | 52,218 | | | | |

Table 2. Simulation results for pools of retailers

| Transshipment (balancing) strategy | Complete pooling | | | | Partial pooling | | | | No pooling | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Service rate | Total shortage | Total costs x1000 | Average inventory level | Service rate | Total shortage | Total costs x1000 | Average inventory level | Service rate | Total shortage | Total costs x1000 | Average inventory level |
| Replenishment period of 3 days | | | | | | | | | | | | |
| RBS | 1 | 0 | 95359,8 | 125,028 | 1 | 0 | 95359,8 | 125,027 | 0,9929 | 1818 | 95087,1 | 125,288 |
| MCBS | 1 | 0 | 93223,9 | 124,998 | 1 | 0 | 95359,8 | 124,998 | | | | |
| PBS | 1 | 0 | 95359,8 | 124,998 | 1 | 0 | 95359,8 | 124,998 | | | | |
| Replenishment period of 5 days | | | | | | | | | | | | |
| RBS | 0,9844 | 11628 | 93482,7 | 52,0261 | 0,9808 | 13163 | 93262,8 | 53,9213 | 0,8591 | 66304 | 85330,8 | 84,274 |
| MCBS | 0,98211 | 13243 | 66934,5 | 50,1852 | 0,9787 | 14339 | 93070,0 | 52,5519 | | | | |
| PBS | 0,98216 | 13283 | 93217,9 | 50,252 | 0,9787 | 14389 | 93062,8 | 52,6602 | | | | |
| Replenishment period of 7 days | | | | | | | | | | | | |
| RBS | 0,72201 | 187951 | 66934,9 | 27,8609 | 0,71488 | 188013 | 66934,6 | 29,2732 | 0,6573 | 193588 | 66163,5 | 60,161 |
| MCBS | 0,72091 | 187951 | 66934,5 | 27,8766 | 0,71688 | 188013 | 66934,3 | 29,2169 | | | | |
| PBS | 0,7134 | 187954 | 66934,7 | 27,9168 | 0,70239 | 188017 | 66934,5 | 29,3518 | | | | |
| Replenishment period of 10 days | | | | | | | | | | | | |
| RBS | 0,52023 | 319777 | 47160,6 | 19,2675 | 0,50893 | 319811 | 47160,4 | 20,2737 | 0,4767 | 320231 | 47150,5 | 44,399 |
| MCBS | 0,52356 | 319777 | 47160,2 | 19,2644 | 0,51412 | 319811 | 47160,1 | 20,2715 | | | | |
| PBS | 0,50638 | 319780 | 47160,6 | 19,2719 | 0,49204 | 319816 | 47160,4 | 20,418 | | | | |

Simulation results in the Table 1. show that the of pool of empty logistic units obviously needs application of certain strategy for balancing flows realization, for maintaining its main function. Namely, it is obvious that in this case “no pooling” scenario decreases service level, while in the same time dramatically increases inventories. Of course, this is quite normal, because those systems normally work as pools. In the same time, results obtained, even in this relatively small experiment, show that the modeling concept quite well represents real system, and that may be accepted as a very good basis for further research. On the other hand, transport costs which result from application of different repositioning strategies show in on obvious manner necessity, and importance of seeking for optimal balancing strategy. Although its impact to service level, and inventories isn’t so significant, impact to transportation costs is almost dramatically, since the difference between random, and other two “more sophisticated” strategies is almost double.

Simulation results in the Table 2. show that the pool of retailers may introduce very significant positive effects when applied, practically in all of system performances. However, because effects of application of pooling concept under different transshipment strategies has impact on all system performances, decision about the optimal strategy should be carefully considered, probably by using multicriteria approach. Also, since replenishment period in combination with pooling concept and transshipment strategies has huge impact on the system performances, as well, problem of choosing their optimal combination become even more complex, and require additional effort. Anyway, from the simulation model applicability point of view, as same as in previous case, modeling concept may be accepted as very promising.

## 6. Conclusion

In this paper, three strategies of resources sharing and balancing flows realization in pools of empty logistic units, and pools of retailers were studied. Effects of different strategies application are determined through simulation approach, whose application has given encouraging results that may be accepted as a very good base for future research.

In order to apply proposed concept of the simulation model, appropriate software application has been developed, and first results of its application were promising.

Although simulation experiment conducted was of relatively modest size, nevertheless some general pooling systems performances are estimated, and some basic interrelationships between pooling concepts, and balancing strategies could be identified.

From there, it may be concluded that the problem analyzed here, as well as approach proposed opened important and wide area for future research.

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# GEOGRAPHIC INFORMATION SYSTEM (GIS) AND LOGISTICS

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## Abstract

*Application of modern information technologies plays important role in improvement of efficiencies and effectives of logistic processes. Information technologies enable competitive advantages for all subjects in area of logistic. Area of logistic is tightly connected to geographical informations: from strategical decisions where to locate factories, warehouses, and distributive centers to tactical decisions in making choice of logistic service providers, as well as operative decision of, for example, defining vehicle routing etc. Application of information technology can significantly improve business both for users and providers of logistics services. The aim of this paper is to present different application possibilities of GIS in logistics.*

*Keywords*: Information Technology, Geographic Information System, Logistic, Decision Support

## 1. Introduction

Business surroundings of companies nowadays are characterized by expanding of market, changing of business conditions, raising number or participants, etc. Because of that, making quick and good decisions make the precaution of successful management. Various business decisions are made with the aim to provide harmony between potentials of company and demands for products and/or services of company. In that way, information systems have main role in making decisions and improvement of efficiency and effectives of realization of logistics processes. Within development of information technologies (IT), geographic information systems (GIS) surely have on of the main spots. GIS technologies today provide simpler, faster and better presentation and usage of all informations

Knowing that every sphere of man's activity is directly or indirectly connected with partial or total logistic system, there is always will for rationalization processes that are going on in this system, followed by simultaneous reduce of logistic expenses. It is clear that these two opposite aims demand continuous making proper decisions, which demand qualitative informations. In that sense, GIS supports making decisions on various levels of logistic decision-making: from decision-making about locations of factories and storages on highs to creation of optimal vehicle route on operative level.

The aim of this work is showing possibility of application GIS in logistic. The work is structured so that in its first part is description of GIS, its main components and application in various jobs in the USA. Business application of GIS, forming Open GIS consortium and structure of GIS network are given in second part. The last chapter is dedicated to possibilities of application GIS in logistic with description of most important software tools of ESRI company in this area.

## 2. Geographic Information Systems (GIS)

Geographic information systems (GIS) can be described as rationally organized group of computer hardware, software, geographical data and users, which is projected to provide efficient gathering, storing, analyzing and spatial displaying of geographical and all the other informations that can be worthy for the consumer. Term geographic information systems can be observed as following:

- *Geographic* – represents platforms for spatial data displayed as digital maps, tables, etc.
- *Information* – provides processing and insight of spatial and other data by using tools for their input, storage, processing and presentation.
- *System* – connecting user and computer for support in managing, analyzing and making decisions for projecting and exploitation of business systems.

GIS is information system on space and built infrastructure, and is based on idea of integrated information about whole competent surrounding. All the data on objects, their characteristics and events in specified geographical area that are important for the users are conjointed in this system. GIS is very hard to be clearly and precisely defined, mostly because of complexity and intensive development of IT. Various approaches and authors described GIS in various ways:

- GIS is system for support in deciding which provides integration spatial referent data in business surroundings in which specified problems should be solved. (Cowen, 1994)
- GIS represents many software tools used for input, storage, manipulation, analyzing and display of geographic information. (Kukrika, 2000)

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- GIS is system for processing, analyzing and display of geographical knowledge, and is displayed as groups of information such as digital maps, table data, data models and metadata. (www.esri.com)

There are many GIS products today which are used for various tasks, from simple packets for map making to very sophisticated software applications. GIS manufacturers offer various versions of systems and products, which have the same aim: users need adequate informations as support for business deciding. (Sonnen, 2000).

Regardless various definitions and approaches, it can be concluded that GIS technologies allows development of application for processing, analyzing and presentation of solution for specific problem. There are various GIS applications for different purpose (vehicle tracking, tracking loading/unloading equipment, display of retail objects, display of all suppliers' locations) within the scope of user's information system. Dependently by manner and level of usage, GIS can be treated as group of three basic components: (figure 1):

- geovisualization,
- geodatabase and
- geoprocessing.

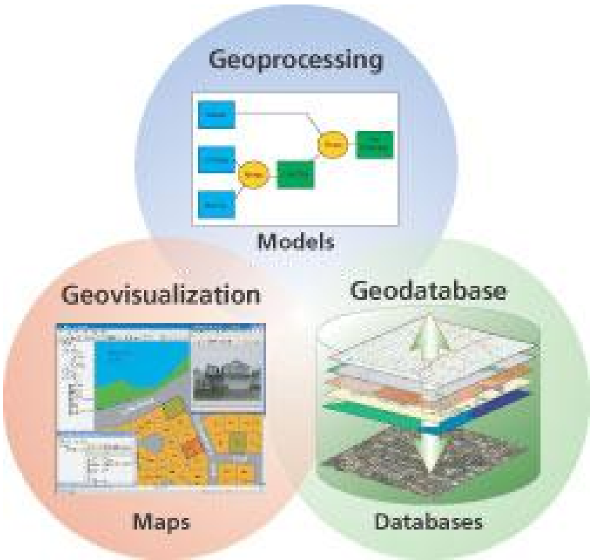



*Figure 1. Three basic components of overall GIS*
*(Source: www.geomatics.co.yu)*

*Geovisualisation* means that GIS has group of intelligent maps and other displays of area characteristics and their relations. These maps show different layers of spatial informations and can be used as "views on data base" and by that examination, analyzing, import and data editing are provided. *Geodatabase* are overall bases that imply data group in vector and raster form. *Geoprocessing implies* group of tools for data transformation and usage of analytic functions and model of data processing.

Users of geographical information systems are numerous: from experts that deal with development and maintenance of GIS, to operaters that execute everyday jobs. In wider sense, we can suppose that users of this technology are all business systems that on any way deal with space, management and exploitation of spatial objects. GIS is being used in federal government, education, health, financial sector, mining and geology, geodesy, architecture, agriculture, traffic and transport, army. Users of GIS are planners and analyst in all areas, teachers, demography, financial consultants, project engineers, dispatcher in all kind of transport, army and safety experts.

Percentage ratio of GIS users in USA is displayed on figure 2 (www.pobonline.com). According to these data, the biggest usage GIS has in government sector, about 35% (local, state and federal government). Significant usage GIS finds in scientific institutions, research centers and universities, which use GIS for realization of their projects.

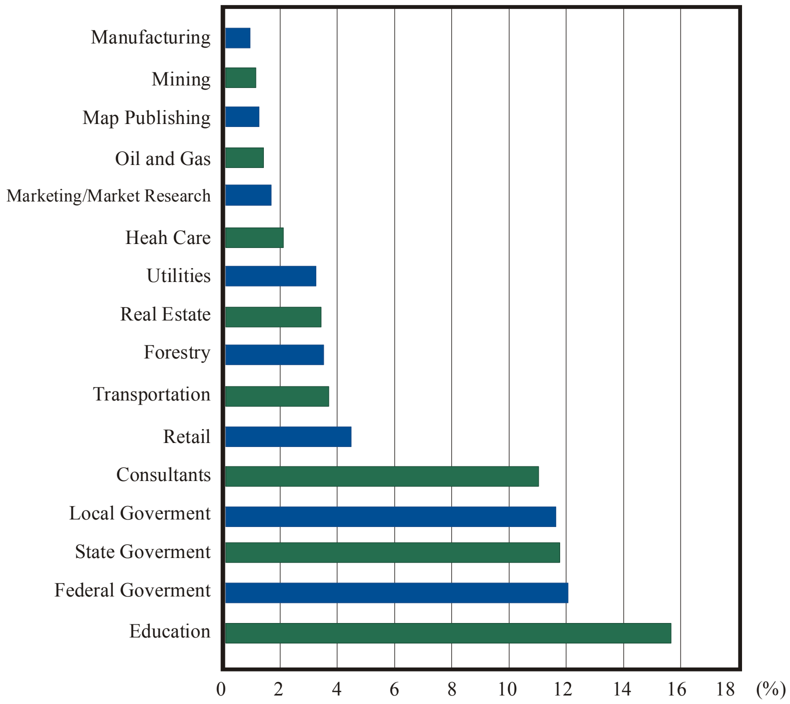



Figure 2. Display of most important GIS users (USA)
(Source*: www.directionsmag.com*)

## 3. GIS in business usage

Data in literature on GIS technology show that 80% of all business data has spatial component, which today shows the necessity for using GIS for data analyzing and bringing solutions. Users of this technology are all business and others systems, which deal with space in anyway or better with management and exploitation of spatial objects. Study made by marketing agency Daratech (2004) shows that worth of GIS industry was about $7.7 billions in 2004. On picture 3 is shown who profits from GIS and their participation in total worth on market.

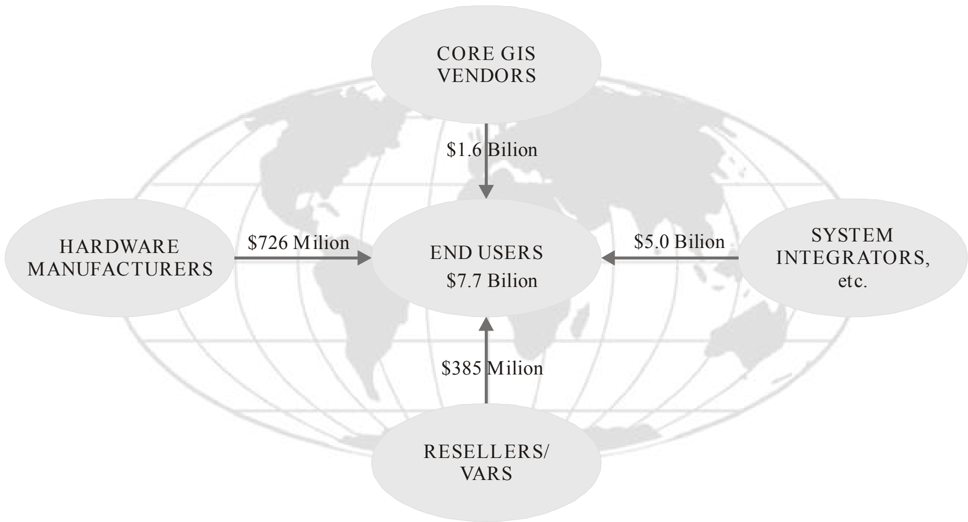



Figure 3. Value and participants of GIS market

Beside companies which have making GIS software as basic activity, hardware manufacturers, manufacturers and distributors of this products profits as well. According to this study, for many companies GIS is basic activity (ESRI, Mapinfo, Autodesk, ...), making them profit of about $1.6billions. The biggest share have providers that provides various service to end-users: consulting, integrating GIS systems in existing informational systems, gathering and conversion of data, forming data base, adding new and maintaining of existing systems and stuff education as well. Total value of these services on market is about $5 billions. Hardware manufacturers make profit from selling hardware vital for GIS operations (computers, digitizers, printers) to end users. Distributors make profit by selling GIS components through network of retail objects.

On figure 4 is a display of market participation of companies that deals with GIS as basic activity, and we can see that ESRI, Intergraph, GE Network Solutions and Autodesk are four companies that have the biggest share on market of GIS products. (Daratech, 2004). Beside them, big manufacturers are: Mapinfo, Leica, BM, Logica etc.

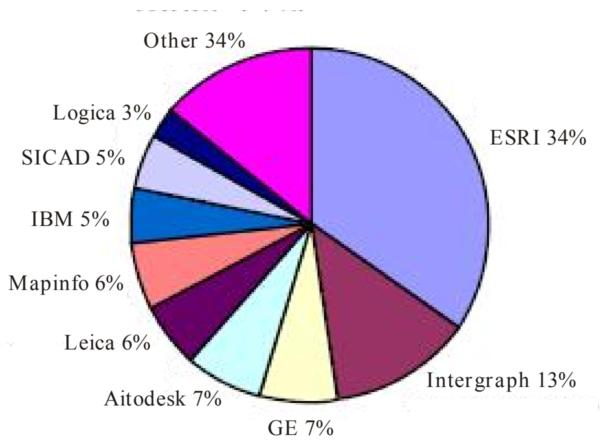



Figure 4. Participation of GIS software manufacturers in percentage

All indices show raise of GIS users and their demands. Amount of spatial data gathered and processed in digital form is rapidly rising by using new satellite video systems and global positioning systems (GPS), and also by raise of people and organizations that use these data. In order to In order to overcome widespread problem of lack of mutual coordination and pursuing, Open GIS Consortium (OGC) was founded in 1994 as non-profit association of various institutions, with aim to promote new technical and commercial approaches for better integration and availability of spatial data. (Daratech, 2004). Members of OGC tended to create national and global information infrastructures through which spatial data can be distributed and used freely, fully integrated through latest distributed computer technologies.

As possible solution, users of geographical information systems formed GIS network in which the data are being distributed through web. GIS network like this is made by the group of hubs, through which data are gathered, then storing in GIS catalog portal, so that they are available for large number of users. GIS network has three keys structural elements:

- GIS catalog portal, where user can look for relevant informations
- GIS hubs, in which users gather and publish data groups
- GIS users that search, find, connect and use GIS data and services

GIS catalog portal is important component of each GIS network. Numerous GIS users gather and publish their data groups in GIS catalog to make possible finding wanted informations for other organizations and users, so that they can use them. One example of GIS portal is Inspire geo-portal, organized on the European Union (EU) level, which allows easier, faster and more efficient approach to geographic informations (www.esri.com). On figure 5 is shown the way of functioning GIS network through web.

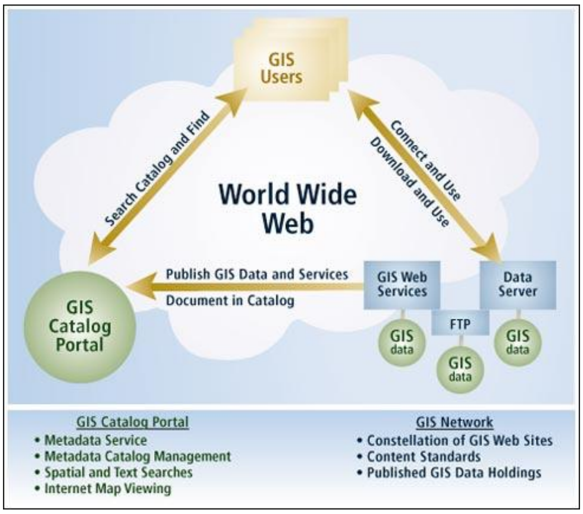



Figure 5. GIS network
(Source: www.esri.com)

4. GIS and logistic

Logistic is inseparable connected to geographical informations – as already said, from deciding on location of factories and storages on highest level, to deciding on choosing best vehicle rout on operating level. Efficient operations demand correct and time-precise making decisions to achieve basic logistic thesis: exact product on exact place at exact time… It is clear that fulfilling of this task asks owing qualitative informations. In other words, it is necessary to know vehicle position or delivery in any time moment to provide optimal delivery and to reduce expenses. For that thing , GIS tools today can provide necessary informations.

GIS systems provides display all needed data on adequate spatial surface when realizing logistic processes and making design about them. Spatial surface can be city plan, schematic area display, etc. Area data describes specified territory on which certain process is being watched and represents group of incoming data, based on which the real status can be visually described. By connecting with other applications and mathematic model, it is possible to follow realization of processes in real time, to follow process simulation or see estimated process status, which is very important in logistic. By integration GIS with company's information system, all the needed data can be shown spatial surface which covers company's working area.

The aim of each company is to provide service for which the consumer is ready to pay the amount that justifies invested resources. According to that, tending of management is nonstop improvement of logistic and other activities, in which GIS has big role. As answer for these aims, many companies that offer software tools based on GIS technology are present on the market. In this work, some software products of ESRI will be displayed, as ESRI has the biggest share in GIS market.

ESRI (Environmental Systems Research Institute) is at this moment the world biggest manufacturer of GIS software products. ArcGIS is group of ESRI's products, integrated software tools which allows usage of GIS in business logistic. Base for further software update in specific logistic activity consists of: ArcView, ArcInfo, ArcLogistic Route Software and ArcGIS Business Analyst (which won't be closer shown in this work). Specific software developed on ArcGIS basis provides solving of following logistic tasks (figure 6):

- Routing and Scheduling
- Asset Tracking
- Dispatching/Mobile
- Territory Optimization and Planning
- Site Selection
- Supply Chain Management

Due to great importance in practical use in logistic, ESRI software solutions for these logistic tasks are displayed.

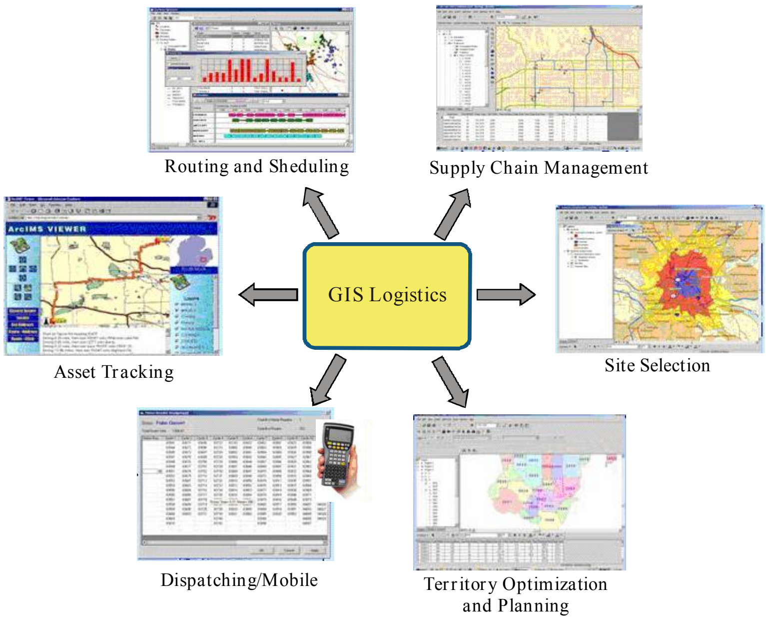



Figure 6. Logistic activities for which ESRI offers solutions

*Routing and Scheduling*

GIS software usually support finding optimal routes. Criteria when optimizing could be transport expenses, delivery time, distance or their combination. For example, ArcIMS Route Server calculates optimal route based on driving time, distance and road characteristics.. Users of this application can get instructions for driving on certain relation by internet. ArcWeb Service displays its users on-line guidance for driving through USA, Canada and Europe (www.esri.com). This software provides both operative routing and time schedule, including flowing route generation and issuing of documentation for various vehicles, and tracking and supervising of delivery. When routing, various data are being used to project the best route based on required criteria, current condition and quantity of transported cargo. On figure 7 is shown one example of visual display of created routes for different criteria.

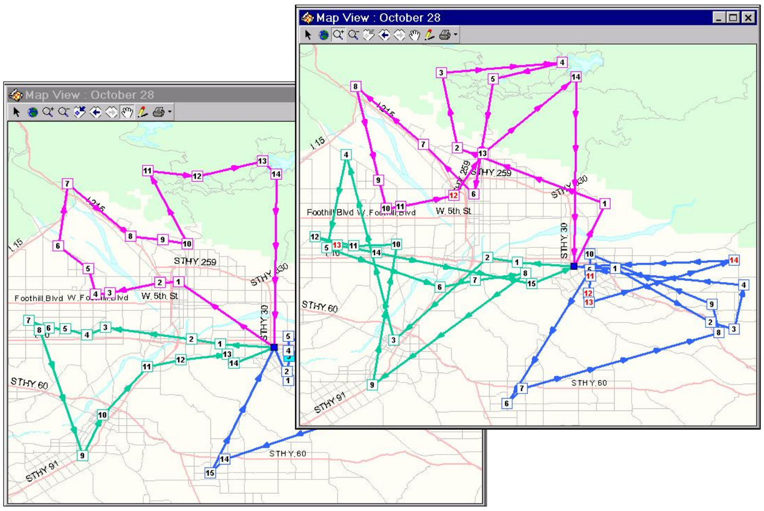


Figure 7. Screenshots on GIS applications for routing (Source:www.esri.com)

*Asset Tracking*

Software packet offered by ESRI as solution for object tracking is ArcView, with add-on ArcView Tracking Analyst. It provides supervising of locations and asset tracking in real time. Objects which transmit their geographical location through GPS or similar devices can be dynamically tracked on ArcView map. Software allows dispatcher to track other characteristic of objects on the map (abandoning of working area, vehicle mail-function, cargo status, crew communication etc). On figure 8 is shown an example of vehicle tracking on map and its surrounding by configured radius.

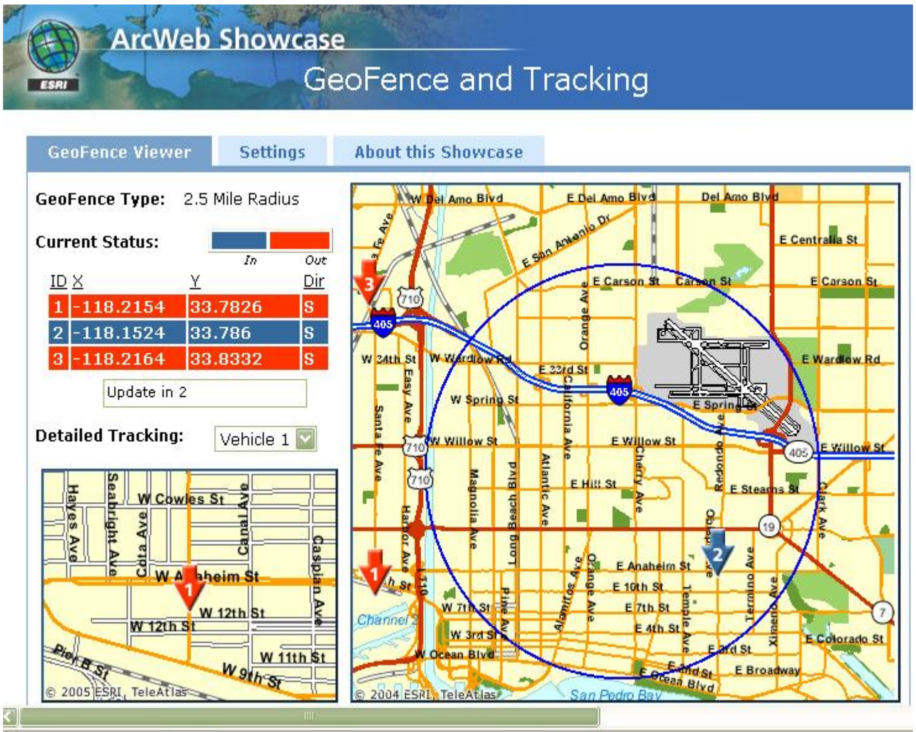



Figure 8. Screenshot on GIS application for vehicle tracking (Source:www.esri.com)

*Dispatching/Mobile*

ESRI provides possibilities for developments of application for optimal allocation of outdoor services and sectors, stuff working in sales, which allows:

- Correct worker routing,
- Knowledge of workers time-schedule,
- Efficient communications,

- More efficient time-management
- Simple control of mobile working force productivity

This look-alike access to problem solving provides time saving by identifying service closest to call location and displays possible travel route. By tracking location of vehicle, dispatcher can track level of realization of the demand. On figure 9 is shown part of the map, through which the driver gets detail instructions for reaching certain location. Typical examples of usage can be Emergency Medical Assistance, police, fire department etc.

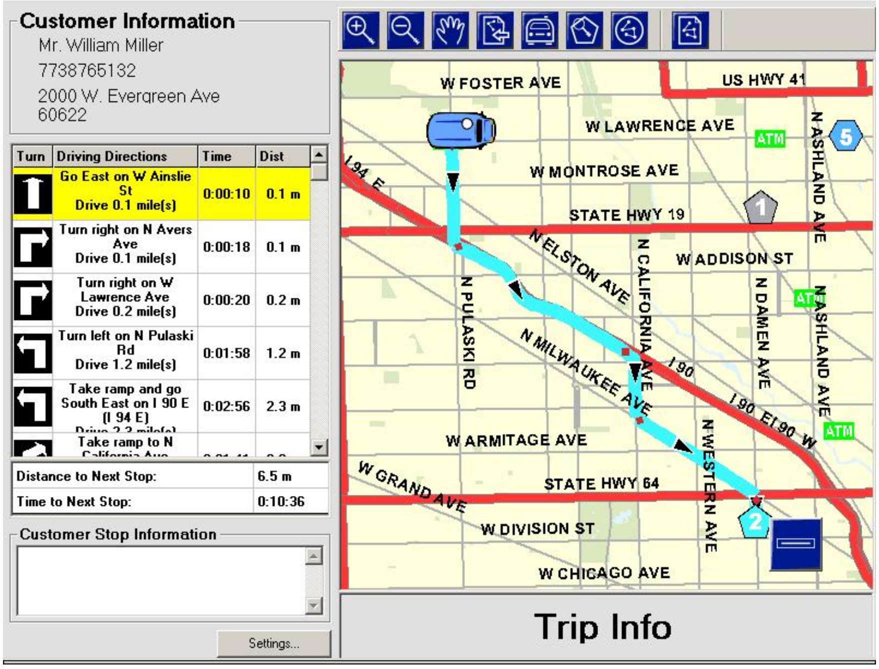



Figure 9. Display of map through which the driver gets the instructions for route-moving. (Source:www.esri.com)

*Territory Optimization and Planning*

Spatial projecting is specific task in logistic. For example, when projecting distributive or some other network, territory optimization and planning are the key for effective and productive system. No matter whether the planning is concerning distribution of goods, services or emergency, GIS provides the tools for dealing optimization. Availability of large number of data that are well organized and represented, allow logistic project engineer to give certain territories to the objects much easier. In combination with demographical data faster change tracking is provided, which are vital for getting optimal solutions. (figure 10).

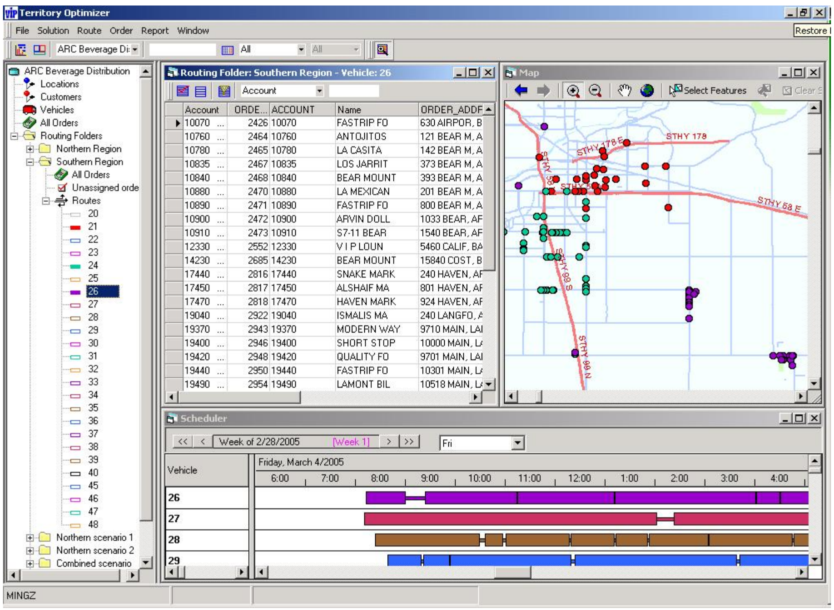



Figure 10. Display of spatial allocation of objects
(Source:www.esri.com)

*Site Selection*

Beside macro aspects, the preconditions for determining micro location of objects with help by GIS (whether it is storage, distribution center, service object etc.). By combining spatial and demographical data, user needs can be better seen and the situation on the market can be visualized. For these tasks, ESRI suggests ArcGIS Businesses Analyst. On figure 11 is shown application of software ArcGIS Businesses Analyst which analyze the best location for new service objects regarding surroundings, location of potential users etc.

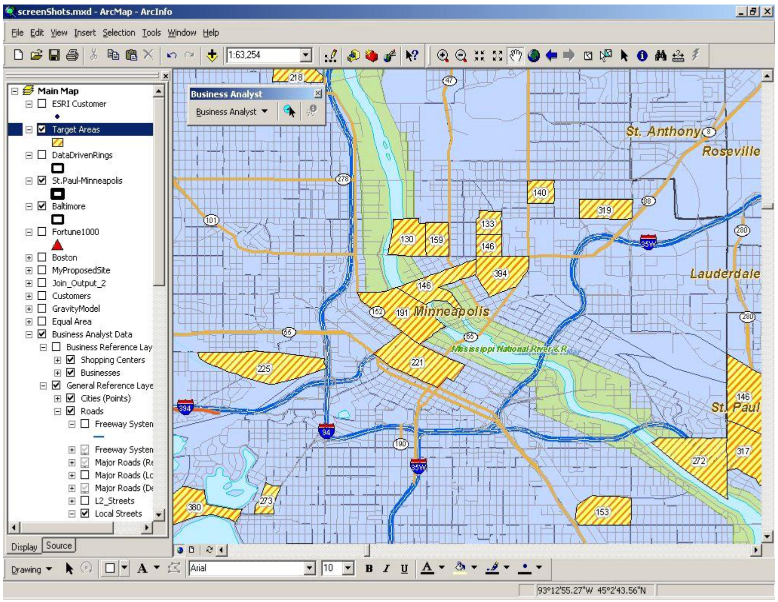
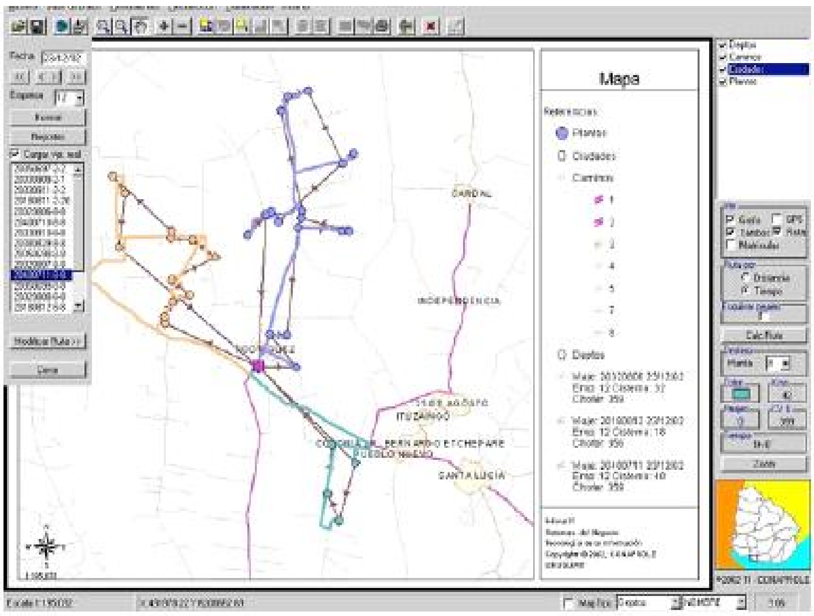



Figure 11. Screenshot on ArcGIS Businesses Analyst
(Source:www.esri.com)

*Supply Chain Management*

ArcGIS Network Analyst can be of great help for management which deals with whole supply chain. It provides result analysis for modeling of supply and devilry, network surveying, routing optimizations etc. This software also allows defining zones around the objects and analysis of user in each zone, in order to get evaluation of complete expenses and other parameters for realizations of logistics services. (figure 12). Here is necessary to underline the complexity of chains of supply can often make development and use of application very hard in concrete cases. No minding that, numerous experiences shows that companies that are using GIS tools in combination with optimization techniques reach decrease of logistics expenses up to 10-15%.




Picture 12. Visual display of routes and their characteristic for required chain of delivery
(Source:www.conaprole.com)

## 5. Conclusion

The harder market conditions demand making quick and good decisions. This is especially important in logistics where decision-making in real time is often a postulate of successful business. Having that in mind, IT development is from essential importance for logistic, and GIS has special place within IT. Development of vast and public GIS is for a long time one of the strategic concerns of developed countries because of the influence such system could have on the development of society. Because of that, GIS technologies are being invested and present systems are being continuously updated.

Because of that importance, this paper shows the review of basic components of GIS technology, variety of business application of GIS in the world, with special look on logistic area. Data in literature about GIS technology show that 80% of all business data has are component, which shows necessity of application GIS in data analysis and decision-making. Users of this technology are all business and other systems, which by any way deal by space, or processing and exploitation of spatial objects. In this work, some of the most important GIS software are being shown, and all the aspects points on remarkable development and raise of application of these tools in the world.

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# KNOWLEDGE MANAGEMENT AND SUCCESS FACTORS OF TCDD LOGISTICS VILLAGE PROJECTS

İnan Özalp, İbrahim Müjdat Başaran[1]

## Abstract

*This paper looks at strategies that may enable the incremental development of some poor regions of Turkey which is an European Union accession country. It's increasingly recognized that regional development is not only the result of a proper combination of private production factors such as labor and capital but also infrastructure in general and transport infrastructure in particular.*

*Neighboring business operations are embodied in the network of related functional activities such as manufacturing and distribution. The availability of a local manufacturing and distribution network is the key for successful knowledge seeking Foreign Direct Investments. In TCDD's Logistics Village (Super Hubs for rail transport, logistics and international business) projects, strategies of incremental development is based on a regional cluster model, where rail transport is used as a leverage for the growth of logistics clusters that will in turn become bases to develop regional clusters of other related industries.*

*Keywords: Knowledge Management, Knowledge Seeking FDI, Logistics Hubs, Global Sourcing, Collaborative Logistics, Information Systems*

## 1. Introduction

Turkey located between Europe and Asia but may not be able to make the most of the opportunities afforded by its strategic geographical position owing to a lack of international competitiveness in its railway transport activities. In the past, railway transport has not been given active support and attention by governments. On the other hand, the opening of TCDD Logistics Villages provides new opportunities for railway transport in Turkey.

It is increasingly recognized that regional development is not only the result of a proper combination of private production factors such as labor and capital, but also of infrastructure in general and transport infrastructure in particular. Improving infrastructure will then lead to a higher productivity of private production factors. Conversely, a neglect of infrastructure will lead to a lower productivity of the production factors. But current technological revolution in information and communications may weaken the links between transport growth and economic growth. Not only physical measures but also other forms of transactions that take place, such as movement of information, finance, commerce and document handling by informatics and technological means. This is where real substitution is taking place.

Supply side knowledge management strategies tend to focus only on the distribution of existing organizational knowledge, and are usually technology centric in their orientation. Demand side strategies, by contrast, focus instead on satisfying organizational needs for new knowledge, and therefore tend to be learning and innovation oriented. In other words, first-generation of knowledge management strategies focus on knowledge sharing and the second generation focus on knowledge making.

Regardless of its other advantages, first generation, supply side KM, with its myopic focus on capturing, codifying and sharing existing information, offers a poor prescription for improving organizational learning and business innovation. In the practice of knowledge management, only second generation thinking tackles these issues.

The answer to the question of how to improve organization learning and innovation lies in the recognition of knowledge production as a social process. People don't innovate, but supply chains do.

Firms uses a variety of computerized systems to support its knowledge management activities. These systems support large scale internal and external knowledge sharing.

According to knowledge management framework developed by Alavi and Leidner, organizations consist of four "knowledge processes":

1) Knowledge Creation Process,
2) Knowledge Storage and Retrieval Process,
3) Knowledge Transfer Process,
4) Knowledge Application Process

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## 2. Knowledge Creation Process

Knowledge is the most important source of wealth and basic economic factor in contemporary society. Organizations routinely engage in the generation, capture, and use of knowledge in order to develop and deliver their products and/or services, and to compete effectively in the marketplace (Easterby-Smith & Lyles, 2004). As a result of the changing marketplace, competition, and the rapid development of technology, organizations have started paying more attention to maximizing their knowledge based assets. More and more companies are starting to realize that knowledge is an organization's most important asset, and knowledge related assets will be the base of sustainable competitive advantage and the foundation of success in the 21st century (Xu & Quaddus, 2006).

Knowledge creation refers to the development of "new" organizational know-how and capability. Knowledge originates within individuals or social systems (groups of individuals). Some organizations allocate dedicated resources to the knowledge creation process. A useful example is employee training and development programs that aim to generate knowledge at the individual levels. Another example is the establishment of units or groups for the purpose of creating new knowledge. At the individual level, knowledge is created through cognitive processes such as reflection and learning. Social systems generate knowledge through collaborative interactions and joint problem solving. Information technology can thus play a role in the knowledge creation process as well as support of collaborative interactions among individuals (Easterby-Smith & Lyles, 2004).

Supply side knowledge management strategies tend to focus only on the distribution of existing organizational knowledge, and are usually technology-centric in their orientation. Demand-side strategies, by contrast, focus instead on satisfying organizational needs for new knowledge, and therefore tend to be learning –or innovation-oriented. One focuses on knowledge sharing; the other on knowledge making. Second-generation KM, unlike its first-generation supply-side cousin, attempts to strike a balance between supply and demand side thinking by addressing needs on both sides of the line. Only second generation KM takes a measured approach in this way (Mc Elroy, 2000).

## 3. Knowledge Storing and Retrieval Process

Many organizations collect large volumes of transactional data. Manufacturers collect data about retail sales, customers, suppliers, logistics and engineering designs. Much of this data mostly tends to be locked in functional silos and functionally separated databases. A data warehouse is a centralized repository that integrates, summaries, and creates a historical profile of such data, which would fragmented (Inmon, 1996).

Data warehouses transform large volumes of data to interlinked information. Basic assumption underlying data warehousing is that valuable information is embedded in large volumes of objective data. Data mining is a useful technique for uncovering such information. Data mining is defined as the process of automatically searching for unknown correlations in the data by looking for interesting patterns, anomalies, and clusters (Loeb, Rai & Ramapsasad, 1998).

Data warehouses provide a central access point for the real-time transactional data across the entire enterprise. Summaries and aggregations of transactional data in a data warehouse provide inputs for other knowledge management tools which support other knowledge management processes.

## 3. Knowledge Transfer Process

Development of the internet and the use of its technology to implement intranets provided the enterprise with an unprecedented tool for knowledge sharing and transfer, and thus for getting value out of their previously developed intellectual capital. Knowledge management has introduced to describe the management activity concerned with implementing such solutions, in order to gain competitive advantage and to increase productivity and effectiveness.

Effective knowledge management in organizations involves a combination of technological and behavioral elements (Easterby-Smith & Lyles, 2004). In recent years organizations worldwide have embraced formal knowledge management initiatives as a way to create value from their intangible assets. Knowledge has proven vital to organizational success that a new organizational form (knowledge based firms) has emerged (Montano, 2005).

Complex Adaptive Systems Theory is so relevant and important to KM. For living systems, composed of agents or organisms that learn, CAS theory brings much to table in terms of helping to explain the role and evolution of knowledge. Ideas related to the origin, dynamics, and impact of self-organization in living systems come largely from complexity theory (Mc Elroy, 2000).

CAS theory informs that learning is a self-organizing process and knowledge we produce through such processes is also emergent. So successfully meeting objectives of a knowledge management strategy may depend not only on the efficacy of the strategy itself or of the team that is responsible for its implementation, but also on the environment into which its being introduced. Existing informal communication networks will continue to operate independently of any formal strategy introduced. The significance of informal knowledge sharing activity may be in its incompatibility, or possible conflict, with any formal structures that are introduced. The success of any formally instigated knowledge management strategy might therefore depend on understanding of the existence and nature of already active informal knowledge sharing structures.

## 4. Knowledge Application Process

Knowledge application refers to the use of knowledge for decision-making and problem solving by individuals and groups in organizations. Knowledge in and of itself does not produce organizational value. Its application for taking effective action does. On the other hand, absorption and application of "new" knowledge by individuals is complex (Easterby-Smith & Lyles, 2004).

Invoking of only pre-existing knowledge and cognitive "routines", mostly creates a barrier to the search for and application of new knowledge in organizations. Information technology tools that facilitate knowledge application can potentially lead to significant organizational value. These tools include expert systems and decision support systems designed for the purpose of applying pertinent knowledge to the execution of organizational tasks.

## 5. Innovation as a Social Process

The process by which new knowledge is formulated by individuals, validated by communities, and embraced into practice by organizations is called innovation. According to second-generation Knowledge Management idea, organizational knowledge is produced, validated and then integrated within the overall behavior of a social system. In other words, new knowledge is produced by individuals collaborating in groups, who collectively formulate new ideas, validate them and then propagate their knowledge across the organization such that the individual and collective behavior of all of the organization's members changes in accordance with the new knowledge (Mc Elroy, 2000).

## 6. Logistics Hubs for Innovative Supply Chains

The trend toward an integrated world economy and global competitive arena is forcing companies to develop strategies for designing products for a global market and maximizing the firm's resources in producing them. Planning and operating in the global arena requires new management skills –for example, developing a truly global network of warehouses, distribution centers, and consolidation points; optimizing multiple transport service types; and designing information and communication systems that integrate the supply chain.

On the other hand, as a result of heightened competition in the marketplace and the shift from a resource based economy to a knowledge based economy, companies are looking more and more at gaining competitive advantage through managing and maximizing their most valuable asset: Knowledge.

Information Technologies, has been critical for logistics based infrastructure projects. For many years management teams have struggled to achieve both short-term profitability and long-term survival and growth through their IT investments. Usually, they have expected profitability from new business applications and have regarded IT infrastructure as something necessary for long term survival and growth. Large scale and complex knowledge management initiatives in organizational settings can be greatly enhanced and facilitated through the applications of advanced information technologies. Innovative Logistics Hubs idea pushes companies to collaborate effectively and facilitates knowledge management activities through information Technologies integration. As the strategic importance of logistics is enhanced, logistics management frameworks shift from in-house logistics management through outsourcing to strategic alliances. Such changes increases pressures for super regional hubs with functions that include, transshipment; localization and manufacturing; data processing and communication; international transaction support and exhibition; and international distribution. On the other hand, especially in peripheral regions to cope with physical logistics problems over the supply chains, absence of infrastructure projects is a serious problem.

## 7. Summary and Conclusion

Driven both by urgencies of national defense and the requirements of logistics based information technology solutions across the Turkey, TCDD has started a new project called "TCDD Logistics Villages". To do so, TCDD wants to encourage companies to collaborate on supply chains, contribute different regions' economic development and support innovation processes of particularly small and medium sized enterprises.

Multinational companies, small and medium sized enterprises and many other companies are expanding global sourcing of raw materials, equipment and finished goods, in conjunction with global manufacturing and marketing. This rapid trend of globalization has increased international material exchange, which in turn has enhanced the strategic importance of international logistics. In order to cope with these changes, countries may need to develop global logistics and economics hubs.

Innovation could be described as "New knowledge, formulated by individuals, validated by communities, and embraced into practice by organization". For the success of innovation activities executed on supply chains are greatly affected by different approaches of knowledge management.

Information technologies are important contributors of knowledge management processes so both for the logistics service providers and supply chain members information technology infrastructure provided by these hubs are critical.

Innovation is a social process and logistics hubs encourage all the members of the supply chains. So this collaboration makes it possible the formulation of new ides, validation of them and propagation of their knowledge across the supply chain. On the other hand, although technologic activities are "all over the map" in terms of implementations, different approaches to knowledge management implementations will be the critical success factors of innovative supply chain implementations.

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# EFFECTS OF RFID ON COURIER SECTOR: A CASE STUDY

Başar Öztayşi[1], Alp Üstündağ[2]

## Abstract

*Researches show that number of RFID applications increase continuously. According to these researches, cumulative sales of RFID tags until the beginning of 2006 are 2.4 billion. Alone in 2005 600 million tags were sold, that is 25% of total salary. And courier sector is expected to be one of the leading sectors for RFID applications.*

*The aim of the paper is to investigate the possibility of utilizing RFID as a tool for effectiveness and increasing service quality in courier sector. In this manner, firstly we introduce RFID technology its characteristics and importance for courier sector. Then we continue with the case study which is done in a middle-scale courier firm that serves more than 50 cities in Turkey.*

*The case study is composed of three major parts. In the first part of the study, the real time work flow is presented and some performance criteria are defined. In the second part, actual work flow is revised in order to increase the performance. In the work flow revision we aim to increase the service quality by RFID systems implementations. In this way a new hypothetical workflow is determined. In the last part of the study, the actual and hypothetical work flow of the courier firm is compared in order to indicate the effects of RFID in courier sector.*

*Keywords: RFID, Radio Frequency Identification, Courier Sector , Postal,*

## 1. Introduction

Radio Frequency Identification RFID is the reading of information on small devices using radio frequencies. It largely avoids the problems of human error and cost, of misorientation, obscuration and needing to read many at a time that barcodes, print and other alternatives in the postal and courier service.

Radio frequency identification (RFID) systems consist of electronic devices called tags that are attached to the items identified, and readers that communicate with the tags via electromagnetic waves (d'Hont and Frienden, 2000). The strengths of RFID is that it does not require line of sight between tags and a reader in order to be read, tags can be read through non metallic materials and about 60 tags can be read simultaneously (Jones, L., 1999). Most tags are also resistant to temperature and other environmental factors and can be read and written at least 300 000 times (DeJong, 1998).

Researches show that number of RFID applications increase continuously. According to these researches, cumulative sales of RFID tags until the beginning of 2006 are 2.4 billion. Alone in 2005 600 million tags were sold, that is 25% of total salary. Forecast reports show that, the total market including systems and services to be $26.23Bn from $2.71Bn in 2006 in value.

## 2. RFID on Courier Sector

Wal-Mart and some other leading retailers force postal and courier companies to fit RFID labels on cases and pallets of consumer packaged goods in order to maintain perfect product recall. This application it increases availability and thus sales and reduces costs, valued at billions of dollars yearly for that industry. RFID is so crucial to the future of courier and postal services that UPS has invested in four RFID companies.

Researches show the potential market for RFID in the postal and courier service is second. Figure 1 shows potential global market in billions of RFID tags yearly. (Harrop Peter, 2005)

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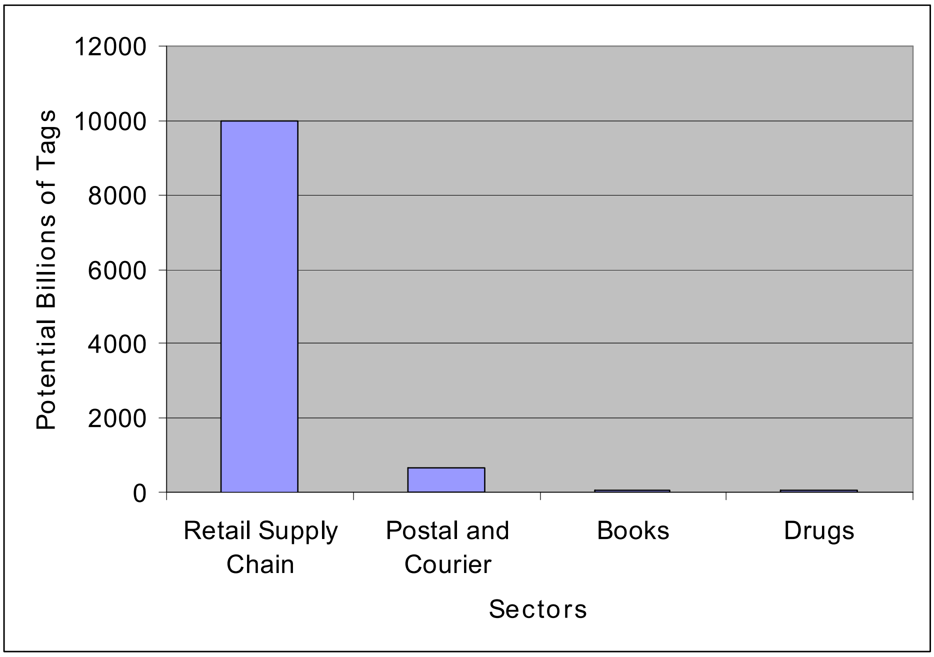


*Figure 1: Potential global market in billions of RFID tags yearly.*

Table 1 : Potential global market in billions of RFID tags yearly

| Sector | Potential billions of tags | Countries Pulling Ahead |
|---|---|---|
| Retail Supply Chain | 10,000 | US,Europe, Japan, Saudi Arabia |
| Postal and Courier | 650 | China,Korea, Taiwan,Saudi Arabia, Germany, US |
| Books | 50 | Korea, Japan |
| Drugs | 35 | US, Europe |

Both sectoral and technological improvements support RFID application in Courier sector. First of all, mandates from retailers are creating a yearly demand for billions of pallet/ case RFID tags (ultimately about 40 billion yearly), reducing the cost of both RFID tags and systems of interest to postal and courier services for similar applications. Technological advances offer passive tags and systems that work in wide ranges and more tolerant of water and metal. For longer distances up to 2 kilometers, tags with large batteries are needed. For this applications coin batteries are developed which are much more small that old ones. And at last, postal sorting machinery, fork lifts and other equipment is now increasingly available in RFID enabled form.

## 3. RFID Technology

Radio Frequency Identification (RFID) is an Auto-ID system consisting of a microchip with a coiled antenna and a reader. Data and energy are transmitted without any contact between the microchip and the reader. The reader sends out electromagnetic waves that form a magnetic field so the microchip's circuits are powered. The chip modulates the waves and sends back to the reader. The reader converts the new waves into digital data. (Fig. 2)

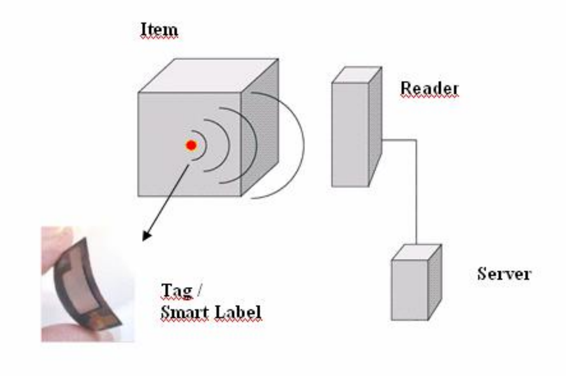


*Figure 2: RFID technology*

3.1 RFID and Auto-ID Technologies

Automatic Identification (Auto-ID) systems consist of different technologies. Using OCR (Optic Character Recognition) machines, different writing types can be recognized. However, because of the high cost of these systems, the usage area is not so wide. As an example, OCR technology is used by reading the checks and saving them to the database of the bank. Biometric systems are used to identify the humans by recognizing the biological characteristics of them like face, voice or eyes. Barcode systems are mostly used to identify and track the products or materials. As these systems are not expensive, they are not programmable and have few data storage capacity. By using chip cards, some inadequacies of Barcode systems can be eliminated, but the mechanic contact between microchip and reader also has some disadvantages. If the contact surface is dirty and damaged, the reader can have some problems by recognizing the cards. RFID systems are similar to chip cards and have superiorities over the other Auto-ID technologies. (Fig 3) (Finkenzeller, 2002)

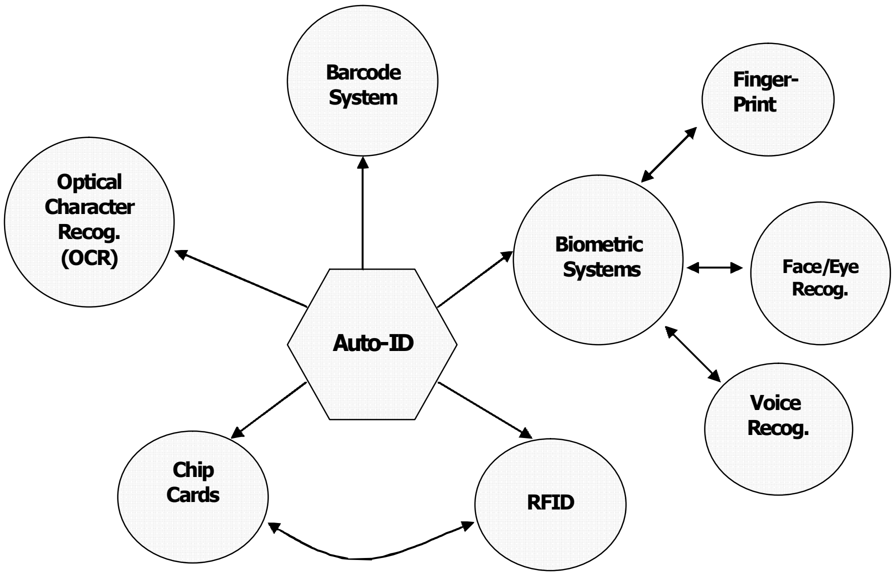


Figure 3 : Auto-ID Systems

3.2 The Characteristics of RFID Technology

A RFID tag can have very different forms. It can be formed as a small disk which has 1 to 10 mm diameter and a centered hole to screw. To inject under the skin of animals, it can be shaped as a glass capsule having length of 12 to 32 mm. (Fig 4) It can be put in a wrist watch to use for access control and it can also be a label to stick on a product in the supermarket.(Fig 5)

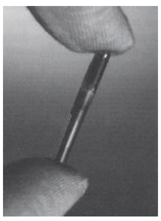

Figure 4: RFID glass capsule structure

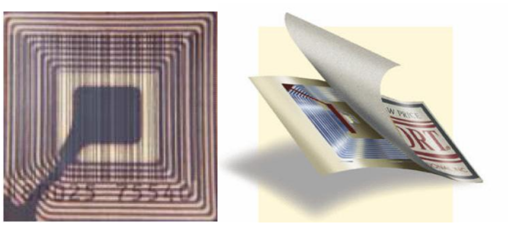

Figure 5: RFID smart label

RFID tags have two different types in terms of energy supply: Active vs. passive tags. Active RFID tags contain a battery to provide the microchip with power. This type of tag can send a signal independently to a reader. Active tags are often used to track high value goods over a distance of up to 300 meters.

Passive tags don't have a battery. This type of tag is powered indirectly via the electromagnetic radio waves from the reader. They have a limited read range and do not require maintenance.

RFID tags can be Read-Write, Read-Only or WORM (Write-Once, Read Many) types. The data on Read-Write tags can be changed or totally overwritten by any reader. Read-Only tags are written with a code by the tag manufacturer that can never be changed. WORM tags can be rewritten once by a reader. Read-Write tags are more expensive than WORM tags. So Read-Write tags can be better used in reusable packaging systems and WORM tags can be better used in disposable packaging systems.

In our courier case study, we planned to build the new RFID systems using passive smart tags and the readers associated with it.

## 4. Case Study

This study analyses the possibility of utilizing RFID as a tool for effectiveness and increasing service quality in courier sector in Turkey. In this manner, a middle-scale courier is selected and various system analyses are done both in center and branches of the firm.

The case study is composed of three major parts. In the first part of the study, the real time work flow is presented and some performance criteria are defined. In the second part, actual work flow is revised in order to increase the performance. While revising the workflow, we take care of two points, first point is keeping the same service quality level and second point is making changes only RFID components. In this way a new possible workflow is determined. In the last part of the study, the actual and hypothetical work flow of the courier firm is compared in order to indicate the effects of RFID in courier sector.

### 4.1 Corporate Context

Courier Firm (CF) we analyzed is a domestic courier firm serving more than 50 cities in Turkey. The center of the firm operates in Istanbul; also there are regional offices in İzmir and Ankara. Firm's major operation is Istanbul that is followed by Izmir and Ankara.

CF has offices in Istanbul, Ankara and Izmir. The operation in these cities is executed by CF. But for other cities CF works with 3. Party local courier firms. Daily dispatches are done to these parties and the firms deliver the cargo the following day.

CF makes yearly agreements with firms; nearly 95% of CF's deliveries are from corporate customers. Documents, invoices, magazines of these firms are delivered to their customers periodically. We can generalize 3 types of deliveries. Deliveries of Individuals, Periodical Deliveries of Corporate Customers, On-Demand Logistical Deliveries.

Deliveries of Individuals: This kind of deliveries are mostly local, CF picks a cargo from one place and delivers to another.

Periodical Deliveries of Corporate Customers: Corporate customers generally have a customer list, and cargos to send. Generally booklets and invoices are delivered. In this delivery, CF picks the distribution list and cargos from the customer and delivers to declared address.

On-Demand Logistical Deliveries: In this service, CF holds the deliveries in its own warehouse. The customer generally calls CF and declares which item (in the warehouse) will be delivered to which address. Being a customized and value added service, this operation is the most profitable delivery type.

CF has developed a delivery tracing software. Every step from the incoming customer call, to delivery is submitted to software. As a result both firm managers and delivery owners can trace their deliveries online.

### 4.2 Work Flow

In this part we will focus on the work flow of On-Demand Logistical Deliveries and Periodical Deliveries of Corporate Customers which provides 95% of total deliveries.

Basic work flow of Periodical Deliveries of Corporate Customers is shown in Table 2. The table considers the basic jobs by turns. Also short descriptions are given in the same row. The work flow starts from the customer call, deliveries between center –office and personnel is described and finished with the gathering of reports back to the center office.

Table 2. Basic work flow of Periodical Deliveries of Corporate Customers

| # | Job Title | Description |
|---|---|---|
| 1. | Customer Call or Periodical Agreement | Customer calls CF or it's a scheduled delivery time |
| 2. | Getting the deliveries | CF Personal reaches to the customer, gets the delivery list and cargos. |
| 3. | Delivery Data Entry | The delivery list is submitted to the software |
| 4. | Barcoding | New barcodes are printed and pasted to the cargos. |
| 5. | Regional Parsing | The delivery list is parsed according to delivery regions |
| 6. | Delivery Grouping (DG) | Each cargo in a delivery group passes from a barcode reader in order form a delivery group in the software |
| 7. | Delivery Grouping Assignment and Delivery | Groups are assigned to personnel that will bring the cargo group to related region office. |
| 8. | Dispatching of DG | As the personnel reaches to regional office cargos in the DG is passed from a barcode reader, determining that the office gets the sent cargos. |
| 9. | Route Planning (RP) and Assignment | Cargos are regrouped according to delivery destinations. The groups are assigned to personals that will deliver them. Again this process is done by passing the cargos from a barcode reader. |
| 10. | Deliveries | The cargos are delivered to related addresses. During the delivery, the recipient is asked to sign to the list. |

| | | |
|---|---|---|
| 11. | Returning to Office | As the deliveries finish, all the reports and un delivered cargos return to the office. |
| 12. | Back to Center | At end of day (some time 2 times a day) all the reports and undelivered cargos are sent back to the center. Again during this process the cargos are assigned to a personnel, |
| 13. | Finishing | All the reports and undelivered cargos are consolidated in the center office. The data in the reports are submitted to software. And undelivered cargos are located to warehouse. |

Another work flow is shown in Table 3, which explain the On-Demand Logistical Deliveries. In this service courier firm holds a stock for customer and delivers from this stock as the order comes.

Table 3. Basic work flow of On-Demand Logistical Deliveries

| # | Job Title | Description |
|---|---|---|
| 1. | Customer Call | Customer calls CF and gives the delivery order |
| 2. | Getting/finding the deliveries | Warehouse is searched to find the ordered delivery. |
| 3. | Delivery Data Entry | The delivery order is submitted to the software |
| 4. | Bar coding | New barcodes are printed and pasted to the cargos. |
| 5. | Regional Parsing | The delivery list is parsed according to delivery regions |
| 6. | Delivery Grouping (DG) | Each cargo in a delivery group passes from a barcode reader in order form a delivery group in the software |
| 7. | Delivery Grouping Assignment and Delivery | Groups are assigned to personnel that will bring the cargo group to related region office. |
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| 10. | Deliveries | The cargos are delivered to related addresses. During the delivery, the recipient is asked to sign to the list. |
| 11. | Returning to Office | As the deliveries finish, all the reports and un delivered cargos return to the office. |
| 12. | Back to Center | At end of day (some time 2 times a day) all the reports and undelivered cargos are sent back to the center. Again during this process the cargos are assigned to a personnel, |
| 13. | Finishing | All the reports and undelivered cargos are consolidated in the center office. The data in the reports are submitted to software. And undelivered cargos are located to warehouse. |

Both Periodical deliveries and On-Demand Logistical deliveries may have undelivered cargos. For this situation a common re-distribution work flow is defined. This flow can be seen in Table 4.

Table 4. Undelivered Cargo Re-distribution

| # | Job Title | Description |
|---|---|---|
| 1. | Customer Call | Customer calls CF (when the recipient can not be reached the CF personal leaves a message about the delivery) and a new time/place is planned for the delivery |
| 2. | Getting/finding the deliveries | The delivery is picked up form the warehouse |
| 3. | Delivery Data Entry | The redelivery order is submitted to the software |
| 4. | Regional Parsing | After all redelivery orders are ready they are parsed according to delivery regions |
| 5. | Delivery Grouping (DG) | Each cargo in a delivery group passes from a barcode reader in order form a delivery group in the software |
| 6. | Delivery Grouping Assignment and Delivery | Groups are assigned to personnel that will bring the cargo group to related region office. |
| 7. | Dispatching of DG | As the personnel reaches to regional office cargos in the DG is passed from a barcode reader, determining that the office gets the sent cargos. |
| 8. | Route Planning (RP) and Assignment | Cargos are regrouped according to delivery destinations. The groups are assigned to personals that will deliver them. Again this process is |

| | | |
|---|---|---|
| | | done by passing the cargos from a barcode reader. |
| 9. | Deliveries | The cargos are delivered to related addresses. During the delivery, the recipient is asked to sign to the list. |
| 10. | Returning to Office | As the deliveries finish, all the reports and un delivered cargos return to the office. |
| 11. | Back to Center | At end of day (some time 2 times a day) all the reports and undelivered cargos are sent back to the center. Again during this process the cargos are assigned to a personnel, |
| 12. | Finishing | All the reports and undelivered cargos are consolidated in the center office. The data in the reports are submitted to software. And undelivered cargos are located to warehouse. |

### 4.3 RFID Improvements

As one can see from the work flows, an integrated barcode system is currently in use. This integrated system enables visibility of deliveries during the process. Besides since every data is saved by the software, historical data can be reported by the system.

Since, the system is capable of giving relevant data; we focus on gathering the same data by a more reliable and simple way and with a less time cost. We can provide this by changing barcode system with an RFID system.

In the work flow of both, Periodical Deliveries of Corporate Customers (shown in Table 2) and On-Demand Logistical Deliveries (shown in Table 3) 4. job is barcoding – that is New barcodes are printed and pasted to the cargos. Barcoding is indeed a defining process of cargos to software by labeling it with a barcode. After this definition process, every change in cargos situation is inserted to the software by the help of a barcode reader.

It can be analyzed from the work flows that, there are at least 5 changes in delivery situations; (Delivery Grouping Assignment, Dispatching of DG, Dispatching of DG, Returning to Office and Back to Center office) . It is obvious that, barcode reading is not a time consuming process, but as the number of items increase, it causes waiting and delays in the system.

In the new work flow every cargo in the system, is tagged just after the delivery data is entered to the system. The cargos' definition information is written to each tag by RFID writers. And the data transfer points which are the entries of the center and branch offices are equipped with RFID reader. In layout, every cargo enter-exit function is done from these readers which provide automatic control of the cargos with the distribution list.

All the delivery personnel are equipped with handheld RFID devices also. With these devices, the delivery date, and other information is also stored in the database. After turning back to office the devices is synchronized with software which eliminates the manual data enter.

### 4.4 Effects of Improvements

The RFID application in this work flow has three major effects. First of all, the time required for a delivery to enter the system and reach to the recipient is decreased with these improvements. In the current system, every delivery passes from at lease 5 barcode readers. A barcode reading takes nearly 1, 5 seconds. There are nearly 3000 deliveries are sent every day this means 22500 seconds, more than 6 hours is spend on barcode reader every day. Also this process decreases the waiting times of personnel, a queue is formed in front of the barcode reader operator, so time reduction has much more effect on waiting times.

Another effect of the system is avoiding the human error and costs associated with it. If a cargo is left in the center or mixed with another, it cannot be realized unless it reaches to another checkpoint. But in the new system, since an RFID control system is placed the control of delivery groups can be done simultaneously. Also since the barcode reader system is removed, operators associated with this job can be assigned to other departments.

## Conclusion

Courier sector seams to be one of the frontier sectors for RFID implementations. In this study, we tried to shed a light on the sector by a case study. In the case study we defined the process flow a selected courier firm. Then a system improvement is realized by RFID implementation. In the implementation, barcode system is changed with RFID systems. By these changes, the system gets rid of time consuming bar code reading process. As a result of these improvements, decrease in time that cargo spends in the system, personnel waiting time and human caused errors are expected.

In the further studies, other courier systems can be analyzed by performance indicators; on time-delivery, average cargo waiting time, total waiting time and human errors percentage.

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# INFORMATION TECHNOLOGIES FOR CONTEMPORARY LOGISTICS CENTERS

Kaan Kurtel [1], Serap Atay[2], and Ahmet Tunçay[3]

## Abstract

*Emerging trends increased the role of sharing and management of information in logistics so the utilization of the appropriate information technology is important more than ever. Choosing of appropriate information technology infrastructure, and a process management technique to go with it, and the execution of a real-time integrated systems with high functionality and reliability always establish the efficient and effective supply chain management services. This paper includes descriptive and analytical understanding role of information systems in logistics and supply chain management. Logistics professionals are the main beneficiaries of this work. In this study we explain the capabilities of the contemporary Logistics Center information system and necessary parts of information technology infrastructure. We also provide some details as to the definition of information systems together with the roadmap to gain competitive advantage through the utilization of new information technologies; In addition to those, we present a guidance to be followed by the logistics centers to serve its stakeholders and for them to operate and manage its core logistics activities by applying information systems with process management approach. And, also covered are the multifaceted aspects of the power of information systems integration within a supply chain.*

*Keywords: Logistics Centers, Logistics Information System, Process Management, ERP, Supply Chain Management, Semantic Web.*

## 1. Introduction

Currently none of the information systems packages (specifically ERPs) are satisfying to the requirements of the contemporary Logistics Centers from the perspective of the Information Systems. The main reason for this deficiency is that all these packages have not necessarily been designed to satisfy the requirements of the Logistics Centers. The problem is the scope of the requirements of the Logistics Centers, which goes beyond the ERP boundaries. Therefore, in this paper we intended to define the capabilities and the required technologies of information systems that will fully satisfy the needs of Logistics Centers.

The paper is structured around six sections including the introduction. The second section defines the problem currently we are facing. The third section draws the framework and the business domain of the Logistics Centers in general terms that focus on definition of the Vision and Mission statements of a Logistics Center including Strategies the Policies and execution plans. The fourth section explains the ERP systems' competency of Logistics Center and the new trends. The final section contains the future of logistics information system.

## 2. Problem Definition

The competitive environment of the logistics business necessitates the heavily use of information technologies. These needs are creating the significant driving force for the local and global ERP vendors. Almost all vendors establish a base for a growth as a respond to this dynamics positively and promptly.

However, this being the case, records shows the significant failure rates in several ERP based projects[4]. Even well designed ERP packages so far have failed to satisfy the needs of a logistics centers due to the lack of definition of the requirements and improper process designs.

From the users' standpoint, the lack of integrated perspective, insufficient analysis, and resistance to change in the organization and of the misperception of the environment can be counted as the deficiencies for the causes of failure.

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[4] "Statistics show that more than 70 percent of ERP implementations, whether self-created or designed by established software vendors, fail to achieve their corporate goals. The primary reason, according to a Booz Allen & Hamilton study, is that companies have not made the appropriate strategic choices needed to configure the systems and processes." (Kulik G. August 1999. Supply-chain logistics. Global Logistics & Supply Chain Strategies. http://www.supplychainbrain.com )

The major problem can be identified as, "Currently available ERP packages are not compatible with the business domain of the contemporary logistics centers and they create an environment causing some integration gaps among supply chain participants".

The reason of this problem is related to the aim of design and implementations of these packages. ERP is the label that has been given to all back office activities of manufacturing based_organizations. Unfortunately ERP packages do not fully support the orchestration of the processes among the enterprises of a logistics center because the very package is not in compliance with the contemporary business dynamics. This problem has been determined by some of the authors who have focused on ERP's future. For example, Kalakota and Robinson (2001) have denoted that the ERP's future is related with customer and interenterprise integration and they named the new level of ERP as Extended Resource Planning (XRP). Similarly, Ross (2003) has cited that, the existing ERP systems should transcend their origins that would be more appropriate and the new systems must be called as the enterprise business systems (EBS). Possibly most forceful argument comes from Griffin and Scherrer (2004); they consider major ERP vendors such as SAP and Oracle no longer as ERP producers. Even it is difficult to find the term ERP anywhere in their web pages. Those vendors are positioned themselves as an IT company that provide the comprehensive range of enterprise software applications to help the organizations to consolidate, manage, use, share, and to protect the business information that comes in the format of customer relationship management (CRM), supply chain management (SCM). All of these examples and the conditions are directing us to focus on the business processes and the process management.

## 3. Characterization of the Logistics Centers

A Logistics Center (LC) should organize all the logistics activities regarding layout, business processes, and information systems for several enterprises under one roof. In this paper customer is assumed to be a manufacturing company who wants to outsource all of her logistics operations to an LC. As shown in Figure 1, the LC plays a central role for orchestration of the activities among all the participants of the supply chain such as manufacturers, sellers, transporters, suppliers and, retailers. Moreover, all of the already mentioned components here gather to fulfill the specific requests of the customer.

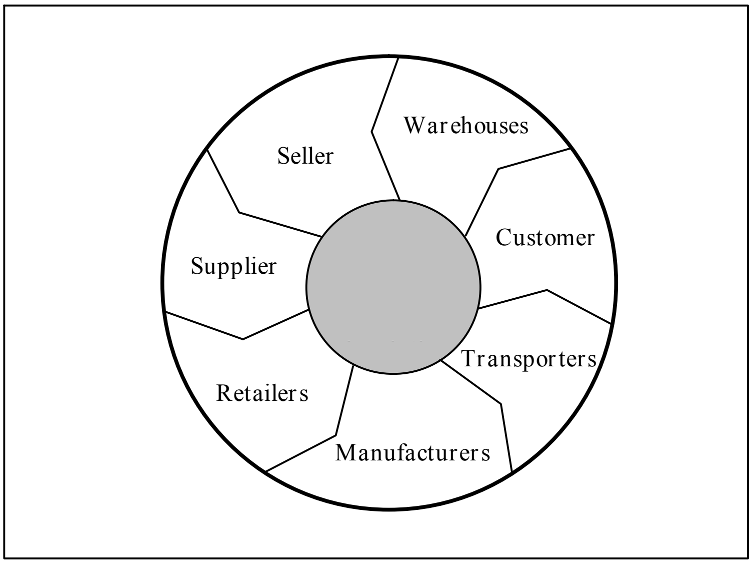


Figure 1. The central role of an LC.

The overall goal of an LC is defined as to add a value to the participants of the LC operations by introducing logistics systems which in turn incorporate the newest technological solutions. Several industrial practices help us to understand the concept of an LC. For instance, some of the LC objectives are "quick and integrated distribution processes, paperless control of all goods movements and, map all logistics processes in an integrated system"[1]. The objectives listed above show how an LC has a unique role in supply chain and consequently, we represent the benefits of an LC to its customers' logistics operations such as:

- The significant reduction in order lead times,
- A notable increase in capacity and flexibility,
- An increased customer satisfaction with delivery quality and punctuality,
- Some monetary advantages and fiscal benefits,
- The sizeable, measurable and controlled logistics operations,
- To provide an environment in order to concentrate somewhat deeper in main business functions.

Basically an LC plays an intermediary role, but this role does not explain the full positions of an LC under contemporary business conditions. The logistics dynamics causes an increased collaboration between LC and its

[1] http://www.sap.com/industries/machinery/pdf/CS_Stauff.pdf

customers. Same dynamics defined as a much-closed partnership rather than a relationship between the sides under the win-win philosophy. An LC does not only realize some core logistics functions such as transportation, warehousing, shipment consolidation and but also provide service to the customers' own resources, capabilities, and technologies. Most of the LC has to share and fulfill its customers' strategy. Therefore, an LC is responsible to analyze, redesign and rebuilt of all logistics processes of its customers if necessary. The LC should have the necessary information technology, human, management and support resources to satisfy all of these innovative requirements. Thus an LC should clearly state the common target and the reason as to why this company has been established for all her stakeholders after all. And this is what we call as the statements of both vision and mission.

A Typical Vision Statement for an LC might be: "An LC of X by guaranteeing the balanced satisfaction of her stakeholders will be the MARKET LEADER in Turkey for the Integrated Logistics Services for sector Y latest by the year 2010 as an interim target and will be the Market Leader within the European Union for the same sector by year 2020 and finally by enlarging its service spectrum to include the sectors V, W, Z will be either number 2 or number 1 in the World Market and sustain its position for a long time."

Parallel to this Vision, a typical Mission Statement might follows such as: "By fully satisfying her stakeholders and gaining competitive advantage for sectors Y, V, W, Z for the Logistics services, LC of X has a clear goal to add value to the enterprises in its target sectors by combining the newest and long lasting solutions in conjunction with the innovative systems designs and implementations."

Following these definitions for the common objectives of an LC, the company values, policies and of the strategies are to be defined to reach to the Vision. Consequently, the careful and detailed analysis of the operational, support and managerial processes will be the key milestones to go further on the requirements and systems definitions which will define the means of realizing the vision plus will constitute the domain upon which the implementations and realizations of the strategies will take place. Therefore the system requirements will be identified and created as if it is a replica of the physical system or corresponding activities system in a virtual world. This aim will be reached if and only if the operational processes are precisely defined at each and every step. And thus, the corresponding software transactions environment gets to be acquired naturally.

The vision and mission statements together with associated strategies and policies are realized through the precisely designed processes and that way they will provide a way to create a competitive advantage to the LC,, to her customers and, to the satisfaction for all logistics supply chain participants, what we called as the stakeholders.

## 4. The Capabilities of an ERP Systems and the New Trends

The business activities and the information technology (IT) of an LC are comprised of numerous dependent and independent components. The IT is the largest context that includes information systems (IS) and infrastructural parts such as the communication networks, hardware and software technologies. The IT model is depicted in Figure 2. In this study, we are especially focused to LC's ERP requirements since as a whole the ERP has a vital role for the execution of the business plans of a competitive LC.

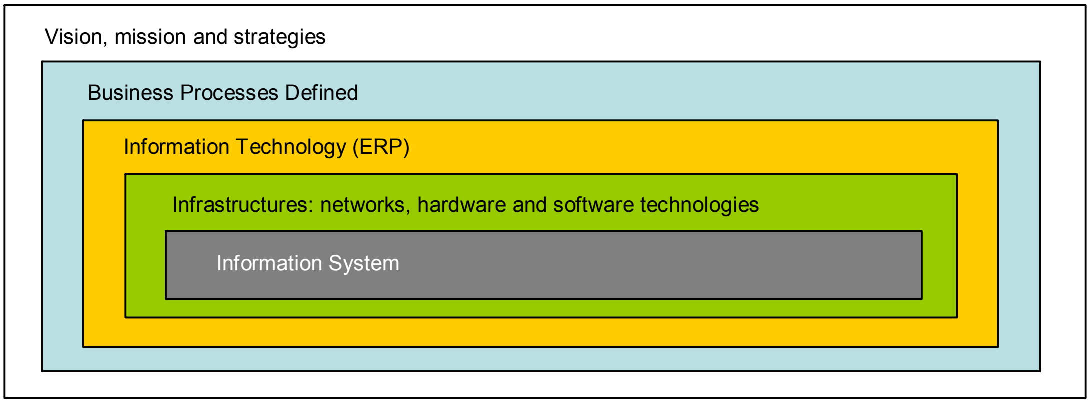


Figure 2. Information technology model.

The ERP system of an LC (LC-ERP) has two major characteristics as already mentioned in section 2 and explained below:

#1 The LC-ERP must be exercising all necessary controls, flexibility and dynamism functions over the LC operations. The major gap here is; the design goals of ERP systems might be over specific for the manufacturer company, since the ERP systems originally have been developed under MRP philosophy. However; since an LC operates in service sector, the ERP has to include many patches to satisfy in-house LC requirements accordingly. On the other hand the patches might present some real threats for LC's major business activities since they may present some real technical problems in the format of the potential implementations and upgrades. For example; the core logistics domain concepts such as navigation, landing, airport, seaport and, warehouse operations are some kind of a patch for ERP.

An LC-ERP must be responding to the contemporary LC requirements and it must be providing highly integrated, manageable, and well-matched infrastructures between the LC's strategic business units and ERP itself as shown in

Figure 3. An LC-ERP can be communicating with each of these sub-systems in order to create a value plus to provide a progress in the roadmap to reach the vision by performing the mission.

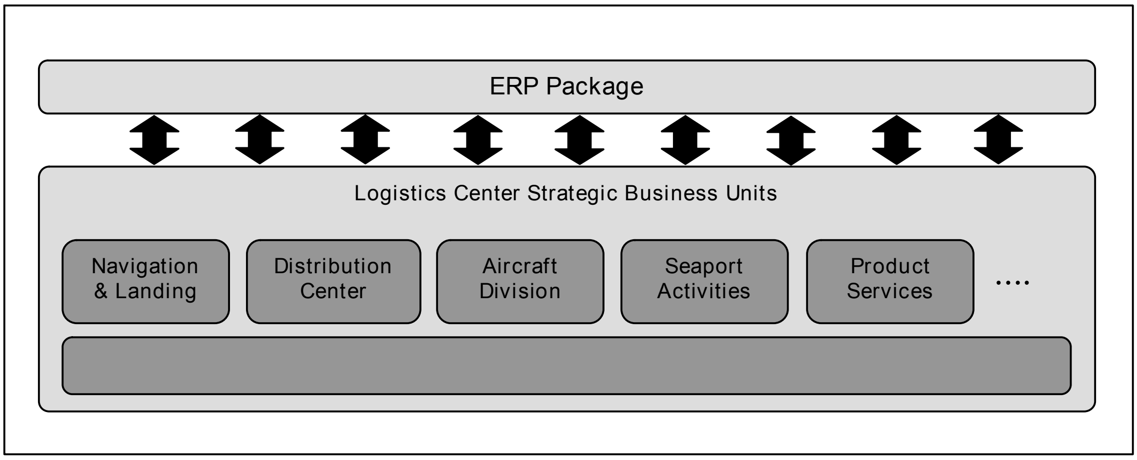


Figure 3. A simple relationship between LC's business units and ERP.

#2 LC requirements are more complex in the multiple heterogeneous business worlds as aforementioned. Each and every customer has unique logistics and business processes. Thus a competitive LC needs integrated solutions among all participants together with a process based customized solution for its customers and members of supply chain. At this point, an LC-ERP should have capabilities to design, implement, support, manage and handle different logistics operations for LC's value chain, which require different ERP products and infrastructures. One unique ERP package cannot manage and satisfy separately each of the customer's logistic processes as shown in Figure 4 and there is no any shortest way to a successful solution of the problem.

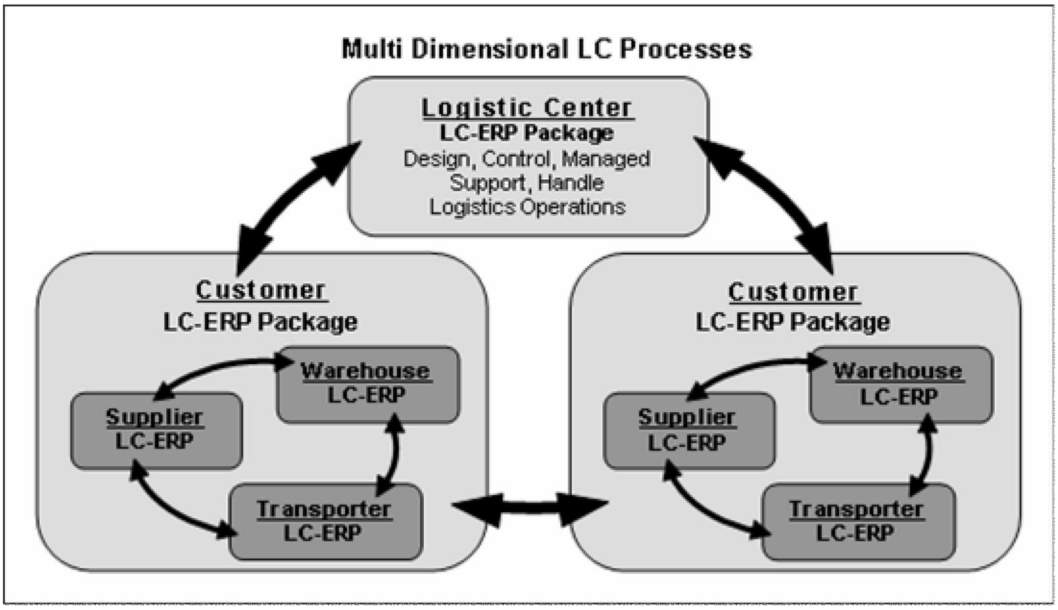


Figure 4. Multi dimensional LC Processes.

Creating a major logistics operation means the adding of intelligence to the LC-ERP services, delivering interactive and timely information to the right people, synchronizing customized business operations, and executing and managing all activities which one can attain only through the integration of information and the services. Even though there are a lot of advantageous of an information possession, it is not always enough when the managing the business processes and functions are in question The Company must share related information among members of supply chain, and also LC must develop knowledge based IT infrastructure for intelligence gathering and analysis.

Integration is the dominant theme for a success of the entire supply chain, thus, this objective is obtained by powerful, safe, reliable, timely, and process based integration that takes place among the LC channel partners and customer itself. The integration attributes discussed below are remarked from Singletary (2002):

- Working together,

- Data sharing,
- Common database utilization,
- Real-time processing,
- Seamless operation,
- Record once and use many times, in everywhere.

Supply chain integration has important attributes, such as; design concepts, functionality, security, and scalability. It should also be process based as well. The security is one of the most important concepts and SCM must include sophisticated security capabilities in the e-commerce and in the e-business environment and also should be able to support current as well as legacy technologies without a fuss.

Fulfilling of the vision and mission statements that were defined in section two, the job of an LC-ERP is to establish the best orchestration and managerial harmony between the members of supply chain. An LC-ERP should control and identify the risks in order to manage them and coordinate the related processes for each of the alliance in the multi dimensional logistics operation as shown in Figure 4. Also, an LC-ERP package should use the new technologies to do real time integration among all supply chain virtual participants. This real time integration is the main philosophy of SCM whose success depends upon the fulfillment of well-known logistics keywords "the right product, the right place, the right price, the right time, and the right condition". Under this assumption, an LC-ERP implementation is a collaborative effort and the integration of supply chain activities or partners each of which is one of the key concepts for ERP package. For example, planning is one of the important process integration subject that refers to joint design of supply chain members' resources such as manpower, container, warehousing with the customers requests such as time, destination and so on. On the other hand, planning activities should contain some other logistics activities such as forecasting, manufacturing scheduling and product design for logistic customers. Therefore; the planning synchronization needs task sharing, determining the interactions, development of cooperative actions, coordinating the activities and sharing the results among business partners of SCM.

This type of integration is called the Business Process Integration (BPI) and it allows the exchange of information between applications as part of a business process among different supply chain participants. The key point here is that the business requirements can be a process-based model. In process-based model; activities, flows, transactions, and roles are defined and organized by an LC as well as other LCs, customers and other suppliers. Also BPI gives a chance to optimize company resources and to provide business-reengineering facilities for all supply chain members.

The architecture of BPI should be based on eXtensible Markup Language (XML). The XML is a programming language, which provides the means of describing and exchanging data in a common, open and universal format for structural documents, database integration and a data transfer. The standard XML format coordinates information flow, application connectivity, and process management among key partners and business units. XML services can maintain IT based service providers in both internal and external processes.

Despite of the many positive items of XML it is not enough for a solution of integration problems. An example from Dacontas helps to understand this problem: If labeling something in XML price should define in one label <price>$12</price> and another label in the invoice <cost>$12</cost>, there is no way that a machine will know that those two mean the same thing. The problem stems from the heterogeneous database structures and organizations. That means that an LC may have many commercial relationships and in turn every relation may have its own specific data structures. In this example every company has got her own metadata model thus, there are significant difficulties to consolidate. Eventually, these types of conflicts and/or contradictions will pose a threat to the integration processes.

This complex and highly heterogeneous environment needs carefully analyzed business functions and requirements, and also highly technical background. The very nature of this problem forces the solution to move to the information level integration. It means that the integration tools of an LC should answer all integration problems concerning the processes at information level first. Here, the data has a central importance and information integration involves structured data. So, the LC should establish a shared metadata model; that provides a common view of the data across the chain, of which provides solutions for the integration and migration of all business application data. This is also useful for business intelligence, data warehousing, data mining, CRM, and data analysis.

Currently the existing ERP packages utilize the traditional solutions for integration. And that requires the utilization of master data which is unified data storage across partners in a heterogeneous landscape. So, the LC and her customer have to share the semantically familiar master data which is a common practice and a common problem of an ERP domain.

The traditional tools, which were developed as a countermeasure to the problems of ERP are B2B and B2C and these applications are embedded in BPI. However, traditional B2B and B2C applications are so specific to integration problems faced at application level. One of the proposed solutions is the electronic data interchange (EDI) format but it needs so much effort to build and it is by no means flexible and open to improvements. The metadata model with EDI facilities might propose a solution but not without a high costs of software development, hardware and support. As a result some solutions do exist but they are neither flexible nor easy to implement. Also a multi-organizational information sharing needs some other systematic approach to find a solution to the existing integration problem.

Defining a common set of terms is important stage for adaptable and reusable logistics framework. Essentially logistics is a larger information ecosystem that is quite similar to the business domain model; which emphasizes four major areas successively listed as the products, customer, infrastructure, and financial aspects (Osterwalder (2004).

Modeling of logistics domain means that the extending of semantics of logistics data to cover the whole value system. As an example to the concept of extending the partial transport domain model (Nichols, 2003) is depicted as Figure 5 below.

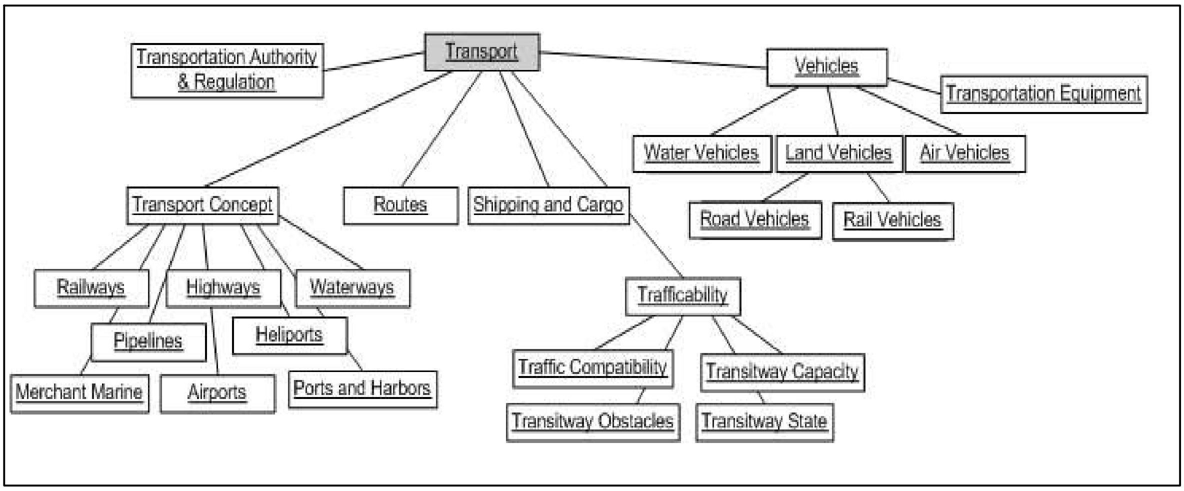


Figure 5. A partial transport domain model.

In this stage we can mention a hierarchical classification system, that's called taxonomy. A Taxonomy provides classification of a specific domain and the domain appears to be a collaborative environment to every parts of logistics business. In other words, taxonomy is a good way of describing the domain models. Therefore, sharing the information automatically from a general repository via Web should be possible. This situation creates some advantages for business integration and provides intelligence to logistics data. This is called knowledge-based operations and it has named as Semantic Web by Berners-Lee (2001) since all these activations occur on the current Web environment. The World Wide Web is an enormous success in business life. All trends show that the web is changing life and creating growth in the business outputs; especially logistics dynamics are affected from that.

Despite of many positive advantages, the web does not have enough intelligence. Actually, logistics business and value chain relationships require more sophisticated solutions. The Semantic Web provides a transformation from HTML pages that are well understood by humans to machine-readable format, so that the web gains meaningful, understandable, more sophisticated and machine-process able information specializations by a series of new standards such as XML, Web Ontology Language (OWL), Resource Description Framework (RDF), and other W3C standards.

The ontology is a shared and machine-executable conceptual model in a specific domain of interest such as Logistics. The machine-processing ability is the central difference between taxonomy and ontology (Daconda et al., 2003). By definition, ontology is rigid and inflexible, and assumes one absolute definition that exists for each knowledge element. The idea is to establish a set structure of definitions and relationships between different models that are canonical[1] and eternal (Brock, 2005). OWL is an ontology language currently defined for the Semantic Web by W3C in early 2003. OWL allows for class hierarchies, constrained properties, and relations between classes. RDF is an XML-based language for representing information in the Web and a general method of knowledge modeling.

The Semantic Web might propose a way of changing the LC operations due to reasons stated below:

- Data, system and content integration.
- Enterprise application interoperability.
- Being able to manage the cross-organizational business processes.
- Customizable service-oriented architectures.

## 5. Conclusion

In this paper we have defined a problem and explained the possible integration approaches and the opportunities as a solution. By implementing the process management approach an LC can effectively solve this problem and may gain a competitive edge from this after all. And, from this perspective the major attributes that a successful LC-ERP should have are

- *LC-ERP systems satisfy all of the requirements of all stakeholders under the defined vision and mission.*
- *LC-ERP systems are process based.*
- *LC-ERP systems are adaptable to the changing business dynamics.*

[1] Canonical refers to a common set of rules used to classify the relationship between things.

- *LC-ERP systems focus to the knowledge-based integration for all the stakeholders.*

A good knowledge of logistics domain and good software engineering abilities & practices coupled by experiences, planning, management, plus having a direct relationship with companies' vision and mission statements yield an enterprise level success for an LC. The concept of semantic web will possibly provide a new solution to the existing integration problems.

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# AN INTEGRATED MODEL FOR SUPPLIER SELECTION IN THE STEEL INDUSTRY

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## Abstract

*Supply Chain Management is an integration of business processes from end-user through original suppliers that provide products, services, and information that add value to customers. Every organization buys materials and services to support operations. Today's companies are looking for suppliers which not only offer the lowest price but also optimize other difficulties which brings procurement process to a strategic point in SCM. In that process, one of the most important activities is selecting the best supplier. As the selection problem has variety of incommensurable and conflicting evaluation criteria, it necessitates a multiple criteria decision making process. In this study, an integrated model is proposed for supporting such a process of supplier(s) selection for procurement of different types of rolled steel which is the main raw material for steel pipes produced by a pipe company which is one of the top five steel pipe producers in Europe. In the first stage of the process, based on the literature review conducted and interviews made with purchasing professionals, the criteria are revealed. Then, the relative importance of the related criteria as well as the global preferences of suppliers for procurement of each type of rolled steel are computed by applying Analytic Network Process (ANP) approach. Finally, a mathematical programming model is constructed to specify the appropriate procurement policy.*

*Keywords: Supplier Selection, Steel Industry, ANP, Mathematical Programming*

## Introduction

Global competitiveness has been forcing companies to consider elaborately every detail and aspect of their operations. Within these operations, logistics deal with materials management, procurement, handling, etc. All these logistic related matters have an important part on which is defined as "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers." by the Council of Supply Chain Management Professionals (http://www.cscmp.org).

One of the elements that affect the Supply Chain Performance is supplier selection process since it is the initial phase of every material movement in the company. Because of not only this significance but also its availability to be solved by lots of modeling techniques, supplier selection issue has created a wide area of scientific research. The most worked-up technique used for solving supplier selection problems is Multi-Criteria Decision Making (MCDM) methods, inasmuch as it consists of both tangible and intangible criteria. Besides, mathematical modelling techniques are used to reach out more reliable results. The purpose of this study is to select appropriate suppliers for different products and allocate orders into suitable batches by combining MCDM and mathematical modelling methods in the steel industry. In literature, mostly one phased MCDM technique is used but the allocations are not calculated. However, some studies allocate orders with different techniques (Demirtas, & Ustun, 2005).

Wang et al. considers 12 SCOR (Supply Chain Operations Reference) models which are constructed by Supply Chain Council (SCC) as criteria which (2003) are clustered in four groups – delivery reliability, flexibility and responsiveness, cost, assets (Wang, G., Huang, S. H., Dismukes, J. P. 2003 ). As another consideration, Liu and Hai (2004), Demirtaş and Üstün (2005) are impressed by the past studies of Dickson's 23 criteria. On the other hand Verma and Pullman (1997) used five criteria (price, quality, lead time, on time delivery, flexibility) and admitted that these would be open for further extensions (Verma, R., Pullman, M. E. 1998). Wu et al. (2004) groups his 19 criteria in 6 according to the source of the criteria and their controllability (Wu, T., Blackhurst, J., Chidambaram, V. 2004). However, the most interesting clustering of criteria is made by Dulmin and Miminno (2002) introducing the terms as prototype cost or design revision type, defined for the specialty of their model (Dulmin, R., Mininno, V. 2003).

The evaluation methods and models is another step for the supplier selection. Different methods are complemented by different authors. Liu and Hai (2004), uses a bit different method from Analytic Hierarchy Process (AHP) proposed by Saaty (1980), in fact a revised AHP method, called The Voting Analytical Hierarchy

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Process (VAHP) (Liu, F. F., & Hai, H. L. 2004). The main difference of this method is the minor changes in the steps of AHP algorithm. In order to decide the total ranking of the suppliers, they compare the weighted sum of the selection number of rank vote, after determining the weights in a selected rank. Berge et al.(2003) use decision trees technique (decision analysis under risk method) in order to evaluate the risks that emerge with the interactions with the suppliers (Berger, P. D., Gerstenfeld, A., Zeng, A. Z. 2003). The main difference of this paper is that it calculates the optimum number of suppliers since not many authors work on quantitative methods on that issue. Another risk analyzers are Wu et al. (2004) implementing an AHP model together with the probability. Wang et al. (2003) and Demirtaş and Üstün (2005) studied on almost same sub-issues of supplier selection. They both architect models for the aim of selecting suppliers with respective to tangible and intangible features and after that step, they also used mathematical models for allocating the optimum quantities to the suppliers. When they were forming the mathematical model they both use the output values of the first step (weight values of suppliers) as coefficients for the second step. In spite of the similarities between these two papers, there also exist differences. First difference is the method they used in the first step where the weights of suppliers are evaluated. Demirtaş and Üstün (2005) used Analytic Network Process (ANP) proposed by Saaty (1996) for determining the weights of suppliers. Four clusters (Benefit, Opportunity, Cost and Risks –BOCR) that are formed with subnets and finally criteria exists. As a feature of ANP, there are feedback and dependency relations between and among criteria. On the other hand Wang et al. (2003) used AHP with 4 criteria and 12 sub-criteria. Finally in both paper we can see the weight values of suppliers. After this step, Demirtaş and Üstün (2005) use Multi-Objective Mixed Integer Linear Programming (MOMILP) techniques, Wang et al. (2003) use Preemptive Goal Programming (PGP) techniques for determining order quantities to suitable suppliers. In Verma and Pullman's (1997) research show that managers think they select suppliers considering quantity but in practise it appears that the real selection is decided upon cost and on time delivery[]. To get this result an AHP method is applied. Dulmin and Miminno (2002) use a new technique called PROMETHEE algorithm and GAIA interface. In this algorithm, the weights are assumed to be dynamic, not static as other papers work on. Another mathematical model is used by Degraeve and Roodhooft (1997), and the total cost is minimized at four levels uf cost: supplier level, order level, batch level and the unit level (Degraeve, Z., Roodhooft, F. 1997).

If we assess the previous works on this issue according to application areas, we get the following view. Demirtaş and Üstün (2005) applied their two step model to a refrigerator plant that is one of the leading refrigerator producers in the world. Said suppliers are the four different suppliers that produce the plastic parts of the refrigerator plant. During all stages they work together with the employees of purchasing department. According to them, the study is an extremely interactive work. Finally they got the values of suppliers' weights with respect to three strategic perspectives (competitive advantage, economic benefits, and the other benefits of company) and then the order quantities with constraints (capacity, demand…). Wang et al. (2003) applied their model to GW Inc. a hypothetical car manufacturer that can produce various functional components except three components (tires, electronics and peripherals). There exist many suppliers for each of three components that have certain quality criteria. They assume for three kind of supplier group consist of three alternatives. Another application is constructed by Wu et al. (2004) in a PC manufacturing company with a risk analysis using AHP and 2 suppliers are evaluated among themselves. In Dulmin and Miminno's (2002) study implements in a public road and rail transportation company, considering 3 suppliers and 7 attributes resulted in selecting two of the three suppliers while the weights are changed. This sensitivity analysis is made by Monte Carlo Simulation.

Degraeve and Roodhooft (1997), apply their method on a large-scaled steel company on the procurement of heating electrode and minimize the total cost of ownership which means the total cost of buying a good or a service. Another application made in the steel industry by Tang et al. (2000) is about scheduling for hot rolling production modeled as a multiple traveling salesman problem (Tang, L., Liu J., Rong A., Yang Z. 2000). It is applied in Shanghai Baoshan Iron and Steel Co. However, this article is chosen in order to gain information on the steel industry, in spite of not concerning the supplier selection process.

All in all, during the studies criteria are defined first and classified or ranked when needed. The criteria options are many when all studies are combined. Then by using different decision analysis techniques such as AHP, ANP or decision trees, etc... Sometimes two techniques, such as AHP and mathematical modelling, are combined. In these studies the input of the second technique can be the output for the first technique.

This study involves evaluation of different suppliers for a multi-product process in the steel industry using Analytical Network Process approach. Following, the results of ANP will be used as coefficients in a mathematical model which is structured in order to allocate orders. The raw materials are determined as galvanized coil, hot-rolled coil, and cold-rolled coil. Under these three qualities focused groups there exists many subgroups of coils. In this study, we collect 29 main subgroups with the opinion of purchasing professionals from steel industry. In the steel industry, not all quality types of coil can be purchased from any supplier plant for the inadequacy of production capacity and quality. For this reason, we have formed a table of types of raw coils and the suppliers that provide them.

Table 1.1 Types of Most Used Coils and List of Suppliers

| | Quality | Standard | Supplier 1 | Supplier 2 | Supplier 3 | Supplier 4 | Supplier 5 | Supplier 6 | Supplier 7 | Supplier 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| Galvanized Coil | DX51D+Z | EN 10142 | x | x | x | x | | | | |
| | DX52D+Z | EN 10142 | x | x | x | x | | | | |
| | DX53D+Z | EN 10142 | x | x | x | | | | | |
| | DX54D+Z | EN 10142 | x | | x | | | | | |
| Cold Rolled Coil | St12 | EN 10130 | x | x | x | x | x | x | X | x |
| | DC01 | EN 10130 | x | x | x | x | x | x | X | x |
| | DC03 | EN 10130 | x | | x | x | | | X | |
| | DC04 | EN 10130 | x | | x | x | | | X | |
| | H400 | EN 10268 | x | | x | x | | | X | |
| Hot Rolled Coil | S235 (St37) | EN 10025 | x | x | | x | x | x | X | x |
| | S275 JR | EN 10025 | x | x | | x | x | x | X | x |
| | S355 (St52) | EN 10025 | x | | | x | | | | x |
| | S275 JRC | EN 10025 | x | x | | x | | | X | x |
| | S355 MC | EN 10149 | x | x | | | | | X | x |
| | S420 MC | EN 10149 | x | x | | x | | | X | x |
| | 1020 | SAE J403 | x | | | | | | X | |
| | 1008 | SAE J403 | x | | | | | | X | |
| | St22 | DIN 1614 | x | x | | | | | X | x |
| | St24 | DIN 1614 | x | x | | | | | X | x |
| | X52 | API 5L | x | | | | | | | |
| | X60 | API 5L | x | | | | | | | |
| | S235 | EN 10025 | x | x | | x | | | X | x |
| | S275 | EN 10025 | x | x | | x | | | X | |
| | SM 490 A | JIS G 3106 | x | x | | x | | | X | |
| | S355 | EN 10025 | x | x | | x | | | X | |
| | B PSL 1 | API 5L | x | x | | x | | | | x |
| | X56 PSL 1 | API 5L | x | x | | x | | | | x |
| | J55 | API 5CT | x | x | | x | | | | x |
| | N80 | API 5CT | x | | | | | | | |

As we mentioned before, our main purpose is to select the best suppliers and allocate optimum order quantities to selected suppliers. There exists many quality types of coil, 29 types of which are the most used ones for the production of steel pipes, as can be seen from Table 1.1. For sake of simplicity, our model is only applied on galvanized coils but the application area can be expanded. Table 1.2 shows the raw materials and the suppliers that will be using in the model.

Table 1.2 Galvanized Coil Types and Suppliers

| | Supplier 1 | Supplier 2 | Supplier 3 | Supplier 4 |
|---|---|---|---|---|
| DX51D+Z | X | X | X | X |
| DX52D+Z | X | X | X | X |
| DX53D+Z | X | X | X | |
| DX54D+Z | X | | X | |

In Chapter 2, after giving basic information about ANP, we propose an ANP utilization model for galvanized coil types, get preference rates of suppliers for each product and normalize these values using Manhattan Normalization method. These weight values are used in the proposed mathematical model in Chapter 3 which allocates the order quantities proportional to relative weights. Finally, Chapter 4 offers a conclusion and suggestions about the issue.

## 2. ANP and Mathematical Programming integration in supplier selection and order allocation problem for different types of raw materials.

### 2.1. ANP phase of the study

Multi Criteria Decision Making approaches such as AHP and ANP allows to take into consideration the intangible criteria as well as tangible criteria. The main difference between these two approaches is, ANP - differently from AHP - allows both interaction and feedback within clusters of elements (inner dependence) and between clusters (outer dependence) [http://www.superdecisions.com/anp_intro.php3].

While using ANP, we must organize the criteria and prioritize them in the framework of a network, perform comparisons and synthesize to obtain the priorities of these properties. We then derive the influence of elements in the feedback system with respect to each of these properties. Finally, we weight the resulting influences by the importance of the properties and add to obtain the overall influence of each element.

In our study we prefer the ANP approach, concerning that setting up a hierarchy is not suitable for our multi criteria decion problem. During the structuring phase of Multi Criteria Decision Making Problem we realised that we needed a network.

As indicated by Von Winterfeld (1980), structuring the problem is an imaginative creative process of translating an initially ill-defined problem into a set of well-defined elements, relations and operations, we all get forced mainly at this stage of our project. Becuse the employees who are crowded with all operational processes look at the problem in a complex point of view and also explain the problem in a complex way. During the setting up process we ask the DM all of the relations between the criteria After the interviews we get these data:

- *Price* (PR): Prices denotes the unit cost of the raw material and is affected by cost of low quality (LW), on time delivery (OT), collaboration duration (CD), quality (Q), capacity (C) and all alternatives.
- *Taxes* (T): Taxes denote taxes applied by each alternative. It is only affected by alternatives.
- *Cost of Low Quality* (LW): Cost of low quality denotes the cost due to defected raw materials that arrive in the core firm. It is affected by price, quick responsiveness, collaboration duration, effectiveness, reliability and all alternatives.
- *Lead Time* (LT): Lead time denotes the time between the order and the arrival of raw materials. It is affected by effectiveness, capacity and all alternatives.
- *On Time Delivery* (OT): It denotes if the raw materials arrive on time or not. It is affected by price, collaboration duration, effectiveness, quick risponsiveness and all alternatives.
- *Flexibility* (F): Flexibility denotes if the arrival of raw materials can be seperated in smaller lots with more frequency. It is affected by quick responsiveness, collaboration duration, effectiveness and all alternatives.
- *Quick Responsiveness/Risk Sharing* (QR): Quick Responsiveness denotess the ağabeylity of the supplier to return on calls and complaints and its eagerness to share risks. It is affected by price, collaboration duration, effectiveness, reliability and all alternatives.
- *Collaboration Duration* (CD): Collaboration duration denotes the span of time that the copre firm and the supplier work together. It is affected by price, taxes, cost of low quality, lead time, on time delivery, flexibility, quick responsiveness, effectiveness, reliability, quality and all alternatives.
- *Effectiveness* (E): Effectivenss denotes the efficiency of supplier's departments concerning services, e.g. sales. It is affected by the alternatives.
- *Reliability* (R): Reliability denotes how much the core firm can rely on the supplier. It is affected by cost of low quality, on time delivery, quick responsiveness, collaboration duration, effectiveness, quality and all alternatives.
- *Quality* (Q): Quality denotes how qualified the raw materials are. It is affected by price and all aternatives.
- *Capacity* (C): Capacity denotes the maximum number that the supplier can produce. It is affected only by the alternatives.

In total we have 12 criteria and 4 suppliers (alternatives) that were defined in the structuring part. Clustering the criteria, we get 4 categories plus the alternatives cluster as shown below:

- Costs
  - Price (PR)
  - Taxes (T)
  - Cost of Low Quality (LW)
- Logistics
  - Lead Time (LT)
  - On Time Delivery (OT)
  - Flexibility (F)
- Services
  - Quick Responsiveness / Risk Sharing (QR)
  - Collaboration Duration (CD)
  - Effectiveness (E)
  - Reliability (R)
- Production

- Quality (Q)
- Capacity (C)
- Alternatives
  - Supplier 1
  - Supplier 2
  - Supplier 3
  - Supplier 4

Now we have all the criteria, the cluster that the criteria belong to and the relations between that nodes. Finally, we arrive at that ANP Utilization. The utilization is shown in Figure 2.1. This figure also shows the structure of Super Decisions Software which we used for calculating ANP results.

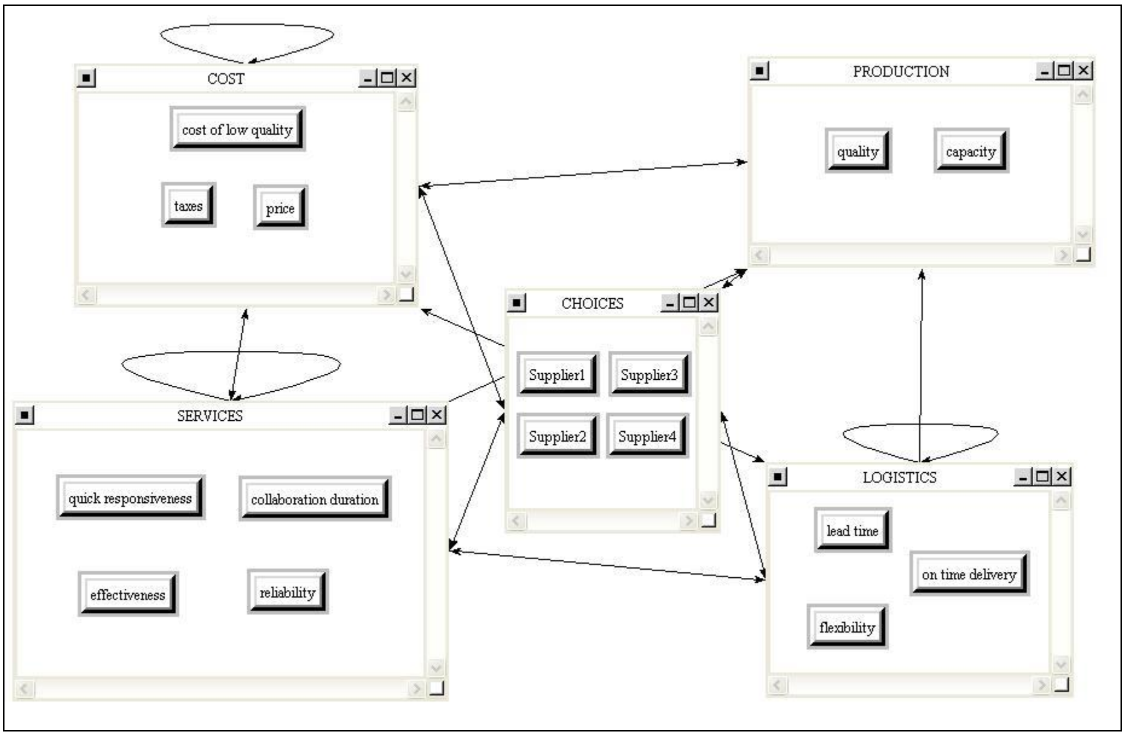


Figure 2.1 ANP Clusters of the Supplier Selection Problem

## The Results Obtained From ANP Utilization

After the structuring phase, a questionnaire is constructed and answered by two purchasing professionals from the steel industry. The answers are calculated by Super Decision Software and the results are shown in Table 2.1 with the Manhattan Normalized weights.

Table 2.1 ANP Results of Each Supplier

| | DX51D+Z | | DX52D+Z | | DX53D+Z | | DX54D+Z | |
|---|---|---|---|---|---|---|---|---|
| | Global Weights Obtained from ANP | Normalized Weights of Suppliers | Global Weights Obtained from ANP | Normalized Weights of Suppliers | Global Weights Obtained from ANP | Normalized Weights of Suppliers | Global Weights Obtained from ANP | Normalized Weights of Suppliers |
| Supplier 1 | 0,099648 | 0,344451 | 0,085404 | 0,286592 | 0,107186 | 0,37882 | 0,157748 | 0,537481 |
| Supplier 2 | 0,061202 | 0,211556 | 0,067813 | 0,227561 | 0,09031 | 0,319176 | - | - |
| Supplier 3 | 0,05663 | 0,195752 | 0,067856 | 0,227705 | 0,085451 | 0,302004 | 0,135747 | 0,462519 |
| Supplier 4 | 0,071815 | 0,248241 | 0,076926 | 0,258142 | - | - | - | - |

According to Table 2.1, for DX51D+Z, Supplier 1 is the most preferable plant among all and the ranking from the most preferable to the least is Supplier 4, Supplier 2 and Supplier 3. Likely, for DX52D+Z, the ranking is Supplier 1, Supplier 4, Supplier 3 and Supplier 2. For DX53D+Z, it is Supplier 1, Supplier 2, Supplier 3. Lastly, for DX54D+Z, Supplier 1 is more preferable than Supplier 3. Once the ANP results are obtained, it can be easily seen that among all suppliers, the overall winner is Supplier 1 for all products.

## 3. Mathematical Modeling of The Problem

Using one supplier is sensible for collaboration duration and building a foundation with the supplier but what about the other suppliers? In real world applications, mostly at least a number of suppliers are picked for several reasons. One reason is that the supplier firms' capacities may not be enough for the core firm's production capacity. Another cause for selecting multiple suppliers is the core firm's strategic decisions. It can be thought in two ways: (1) when there exists more than one supplier firm; the suppliers can get competitive and reduce their prices. (2) when there exists a problem with a supplier, the core firm can easily switch between the other suppliers. There are various studies in literature aiming to calculate the optimum number of suppliers considering various risk factors. For instance Berger at al. used decision tree approach to determine the optimal number of suppliers (Berger, P. D., Gerstenfeld, A., Zeng, A. Z. 2003). For the capacity and strategic reasons, a firm cannot merely select the best supplier among all and pick all the orders on that supplier. This paper provides a mathematical model for an optimum allocation of orders considering demands of the core firm and capacities of the supplier firm in all product types. The model mentioned is given and explained below:

*Variables and Parameters*

$i$ Product
$j$ Supplier
$W_{ij}$ The normalized weights of each product for each supplier (obtained from ANP results)
$Q_{ij}$ Quantity of the order of product $i$ from supplier $j$
$X_{ij}$ The decision if the firm Works with supplier $j$ for product $i$
$C_{ij}$ Capacity of supplier $j$ in terms of product $i$
$D_i$ Demand of product $i$
$num_i$ Critical number of suppliers

*Objective Function*

$$Max\, Z = \sum_{j=1}^{m}\sum_{i=1}^{n} W_{ij} \cdot Q_{ij}$$

*Constraints*

$$X_{ij} \cdot Q_{ij} \le C_{ij} \qquad (1)$$

$$X_{ij} \le Q_{ij} \qquad (2)$$

$$\sum_{i=1}^{n} Q_{ij} = D_i \qquad (3)$$

$$\sum_{i=1}^{n} X_{ij} \ge num_i \qquad (4)$$

$$Q_{ij} - 100 \cdot x_{ij} \ge 0 \qquad (5)$$

$$Q_{ij} \quad \textit{integer variable} \qquad (6)$$

$$X_{ij} \quad \textit{binary variable} \qquad (7)$$

The objective function aims to allocate orders in such a way that the best supplier gets the largest amount of orders, the second supplier gets the second largest amount of orders and so on.

Constraint (1) assures that the amount ordered will not be greater than the capacity of the supplier for a particular product.

Constraint (2) makes sure that for a particular product if an amount order is given to a supplier than that means we work with that supplier.

Constraint (3) equals the total amount ordered to the demand for a certain product and Constraint (4) aims the core firm to work with at least the critical number of suppliers in a product based way.

Constraint (5) enables that if an order is given then the ordered quantity (minimum order quantity) must be at least 100 tons.

Constraints (6) and (7) denotes that the quantity ordered are in terms of integers and the decision to work with the supplier is either 0 if we do not and 1 if we do.

In the stated problem, there exist 4 products and 4 suppliers. To solve the model, the capacities of the products related to that suppliers, the minimum number of suppliers need to be worked for each material and the demand for each material must be known. The related capacities are given in Table 3.1.

Table 3.1 Capacities of Suppliers and Demands for Each Product

| | Supplier 1 | Supplier 2 | Supplier 3 | Supplier 4 | Demand |
|---|---|---|---|---|---|
| DX51D+Z | 2500 | 6000 | 12000 | 5000 | 3500 |
| DX52D+Z | 1000 | 5000 | 5000 | 4500 | 2000 |
| DX53D+Z | 350 | 450 | 2000 | 0 | 500 |
| DX54D+Z | 100 | 0 | 500 | 0 | 300 |

The minimum number of suppliers are determined as 3 for DX51D+Z, 2 for DX52D+Z, 2 for DX53D+Z and 1 for DX54D+Z by the purchasing department of the company. Lastly the monthly demand for materials are estimated as 3500 for DX51D+Z, 2000 for DX52D+Z, 500 for DX53D+Z and 300 for DX54D+Z.

For the solution of the mathematical problem GAMS IDE software is used. Unsurprisingly, the model distributes the orders according to decreasing weights of suppliers. The results obtained from GAMS IDE are given in Table 3.2.

Table 3.2 Optimum Order Quantities

| | Supplier 1 | Supplier 2 | Supplier 3 | Supplier 4 |
|---|---|---|---|---|
| DX51D+Z | 2500 | 100 | 0 | 900 |
| DX52D+Z | 1000 | 0 | 0 | 1000 |
| DX53D+Z | 350 | 150 | 0 | 0 |
| DX54D+Z | 100 | 0 | 200 | 0 |

According to these order quantities, the utility value of that allocation is computed as 1976.4493 by GAMS Software (http://www.gams.com).

## 4. Conclusion

Supplier selection issue is a vital multi-criteria decision making problem as containing many tangible and intangible factors, so there exist many studies on that subject in literature. As aforementioned, one or multi-phased methods are appropriate to solve this important issue. Here, we have used a two-phased solution concerning the integration of an ANP utilization approach and a mathematical modeling phase. Additionally, we have extended this problem in the way of a multi-product stage. By the ANP utilization, we have obtained the global preference rates of suppliers for each products considering multiple criteria determined by purchasing professionals. Combining the normalized global weights, with the mathematical model considering both strategic and tactical constraints, we have gained order quantities for each product supplier by supplier. By that way, a mathematical and a more reliable method is developed for the use of purchasing professionals.

In future studies, we aim to extend this problem to a volume-discount problem also in a multiproduct environment.

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# A SUPPLY CHAIN CONTRACT MODEL AS A SUPPLY CHAIN PERFORMANCE DRIVER

Semra Birgün [1] and Murat Özmızrak[2]

## Abstract

*A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. In this paper, we introduced supply chain contracts as a new supply chain performance driver to increase supply chain profitability by determining the optimal level of product availability. We also proposed two solutions to the issue of profit sharing related to the distribution of the additional supply chain profit generated by using the contracts. Furthermore, through numerical experiments, we showed that our model maximizes total supply chain surplus by incorporating demand elasticity and profit sharing into quantity-flexible contracts.*

*Keywords: Supply Chain, Quantity-flexible Contracts, Demand Elasticity*

## 1. Introduction

A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The objective of every supply chain is to maximize the overall value generated. The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request. For most commercial supply chains, this value will be strongly correlated with the supply chain profitability, the difference between the revenue generated from the customer and the overall cost across the entire supply chain. The objective of maximizing this supply chain surplus can be achieved by improving the supply chain performance in terms of efficiency and responsiveness using the four supply chain drivers: inventory, transportation, facilities, and information.

In this paper, we briefly discussed these drivers and introduced supply chain contracts as a new driver to maximize supply chain profitability. Effective use of the contracts can substantially increase the overall supply chain profitability and its competitive advantage by forcing the companies into an intercompany scope of strategic fit to evaluate every action in the context of the entire supply chain. This broad scope increases the size of the surplus to be shared among all stages of the supply chain.

A contract specifies the parameters within which a buyer places orders and a supplier fulfills them. It may contain specifications regarding quantity, price, time, and quality. As contracts change, the risk different stages of the supply chain bear changes, which affects the buyer's and supplier's decisions and supply chain profitability. By entering into such a contract, the buyer often stands to gain guaranteed delivery of the product which is very useful in times of scarcity, shorter delivery times, lower purchasing price, and a lower safety stock level. The supplier will also benefit with a better production plan, reduced variance of demand, economies of scale, and less paperwork. Harder to measure, but also important, is the increased level of trust and cooperation which can develop between a buyer and a supplier who decide to engage in such a contract.

Of particular interest here are contracts that specify the parameters within which a buyer places orders and a supplier fulfills them in order to maximize the total supply chain surplus.

We analyzed two supply chain contract models. First, where a retailer facing price sensitive demand may obtain a discount by committing a fixed quantity over a finite horizon (Thomas, 1999), and second where a manufacturer offering quantity-flexible contracts may increase the total supply chain profit (Chopra & Meindl, 2001). We concluded that the first model incorporates demand as a function of the selling price but does not address the crucial issue of total supply chain surplus maximization. On the other hand, the second model, although it increases the total supply chain surplus, does not incorporate the demand elasticity.

We then developed a model to address the individual weaknesses of the models discussed by incorporating the price sensitive demand into quantity-flexible contracts by determining the optimal level of product availability, as a function of the selling price, which maximizes the total supply chain profit. Furthermore, we proposed two solutions to the issue of profit sharing related to the distribution of the additional supply chain profit generated by using the contracts. We also used a computer program to help simulate the system to find optimum contract parameters (Özmızrak, 2006; Özmızrak & Birgün, 2006).

It is our belief that the supply chain contract model developed in this dissertation can be an integral part of an Advanced Planning and Scheduling (APS) system.

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## 2. Strategic Fit and Supply Chain Performance Drivers

Strategic fit means that both the competitive and supply chain strategies of a company have the same goal. It refers to consistency between the customer priorities that the competitive strategy is designed to satisfy, and the supply chain capabilities that the supply chain strategy aims to build. In other words, the trade-off between responsiveness to customer demands and efficiency of making and delivering the products to the customers defines a supply chain's performance. This trade-off can be represented by the cost-responsiveness efficient frontier curve shown in Figure 1.

The drivers of supply chain performance not only determine its performance in terms of responsiveness and efficiency, they also determine whether strategic fit is achieved across the supply chain. The objective of maximizing the supply chain surplus can be achieved by improving the supply chain performance in terms of efficiency and responsiveness using the four supply chain drivers: inventory, transportation, facilities, and information (Chopra & Meindl, 2001). In this paper, we introduce a supply chain contract model as a new driver to maximize supply chain profitability.

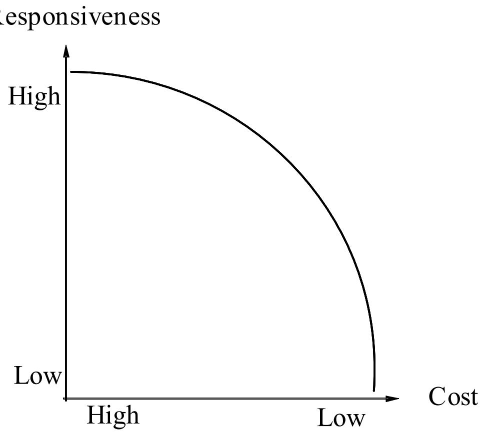


*Figure 1. Cost-Responsiveness Efficient Frontier*

### 2.1 Inventory

Increasing the inventory will generally make the supply chain more responsive to the customer. However, this choice comes as at a cost as the added inventory decreases efficiency. Inventory exists in the supply chain because of a mismatch between supply and demand. This mismatch is intentional at the retailer in anticipation of future demand. An important role that inventory plays in the supply chain is to increase the amount of demand that can be satisfied by having the product ready and available when the customer wants it. Supply chain contracts play a significant role to achieve this purpose. Another significant role inventory plays is to reduce cost by exploiting any economies of scale that may exist during both production and distribution.

### 2.2 Transportation

The fundamental trade-off for transportation is between efficiency, the cost of transporting a given product, and responsiveness, the speed with which the product is transported. Transportation moves the product between different stages in a supply chain. Like the other supply chain drivers, transportation has a large impact on both responsiveness and efficiency. Faster transportation, whether in the form of different modes of transportation or different amounts being transported, allows a supply chain to be more responsive but reduces its efficiency. The type of transportation a company uses also affects the inventory and facility locations in the supply chain.

### 2.3 Facilities

The fundamental trade-off for facilities is between efficiency, the cost of the number, location, and type of facilities, and the level of responsiveness that these facilities provide the company's customers. If inventory is what is being passed along the supply chain and transportation as how it is passed along, then facilities are the where of the supply chain. They are the locations to or from which the inventory is transported. Within a facility, inventory is either transformed into another state, manufacturing, or stored before being shipped to the next stage, warehousing.

### 2.4 Information

Many information systems increase both responsiveness and efficiency. The trade-off is between the cost of information which comes with a reduction in efficiency and the responsiveness that information creates in the supply chain. It serves as the connection between the supply chain's various stages, allowing them to coordinate their actions and bring about many of the benefits of maximizing total supply chain profitability. Information is also crucial to the daily operations of each stage in a supply chain.

## 3. Supply Chain Contracts

Supply chain contracts can be used to maximize supply chain profitability by specifying the parameters within which a buyer places orders and a supplier fulfills them. In this paper, we first analyzed two supply chain contract models. First, where a retailer facing price sensitive demand may obtain a discount by committing a fixed quantity over a finite horizon (Thomas, 1999), and second where a manufacturer offering quantity-flexible contracts may increase the total supply chain profit (Chopra & Meindl, 2001).

We then developed a model to address the individual weaknesses of the models discussed by incorporating the price sensitive demand into quantity-flexible contracts by determining the optimal level of product availability, as a function of the selling price, which maximizes the total supply chain profit. Furthermore, we proposed two solutions to the issue of profit sharing related to the distribution of the additional supply chain profit generated by using the contracts. We also used a computer program to help simulate the system to find optimum contract parameters

### 3.1 Price-sensitive Supply Chain Contract Models

Without the opportunity to obtain a discount for commitment, a retailer will seek to maximize its expected profit:

$$\max_p \pi(p) = (p - c)\,\mu(p) \qquad (1)$$

where $\pi(p)$ is the expected profit, p is the selling price set by the retailer, c is the total unit cost (including transportation) and $\mu(p)$ is the expected demand as a function of the selling price (Lau & Lau, 1997; Thomas, 1999; Barnes-Schuster, 1996).

Assuming the demand function is linear:

$$\mu(p) = d(a - p) / b \quad : a - b \leq p \leq a \qquad (2)$$

or with constant elasticity:

$$\mu(p) = dp^{-\varepsilon} \quad : p \geq 0,\ \varepsilon > 1 \qquad (3)$$

For the linear form, d is a scale value representing the size of the market. For p in the specified range, $(a - p) / b$ will be between zero and one and represents the retailer's market share. On the other hand, the elasticity of demand measures the percentage increase in demand for a 1% increase in price and is formally defined as:

$$\varepsilon_\mu(p) = p\mu'(p) / \mu(p) \qquad (4)$$

The percentage markup can then be defined as:

$$m = (p - c) / c \qquad (5)$$

The optimal prices, markups, and corresponding profits for the mean demand functions are shown in Table 1. For the two demand functions considered here, it is clear that a reduction in the unit cost results in a reduction in the optimal price. In other words, a reduction in cost cannot result in an increase in the optimal price for any non-increasing expected demand function (Thomas, 1999).

Table 1. Optimal Prices and Profits

| $\mu(p)$ | $P^*$ | $m^*$ |
|---|---|---|
| $dp^{-\varepsilon}$ | $c\varepsilon / (\varepsilon - 1)$ | $1 / (\varepsilon - 1)$ |
| $d(a - p) / b$ | $(a + c) / 2$ | $[(a + c) / 2c] - 1$ |

Thomas then (1999) presents a model where the retailer permits the manufacturer and transportation provider to efficiently utilize their resources by accepting periodic deliveries. In exchange for absorbing this variability, the manufacturer offers a percentage discount $\delta$ for these committed deliveries. The manufacturer and the retailer jointly choose a total commitment quantity Q at unit cost $c(1 - \delta)$. The retailer may still place supplemental orders at any time during the horizon at unit cost c. The model assumes that both committed supply and demand occur at a constant rate during the horizon. He then shows that commitment strategies can offer market opportunities by contributing to the profit improvement in two ways: reduction in effective unit cost and improved pricing. However, this model does not address the crucial issue of total supply chain surplus maximization.

### 3.2 Quantity-flexible Supply Chain Contract Models

In quantity-flexibile contracts, the manufacturer allows the retailer to change the quantity ordered after observing demand. If a retailer orders Q units, the manufacturer commits to providing $Q^+ = (1 + \alpha)Q$ units, and the retailer is committed to buying at least $Q^- = (1 - \beta)Q$ units. Both $\alpha$ and $\beta$ are between 0 and 1. The retailer can purchase up to $Q^+$ units depending on the demand observed. In this type of contracts, the manufacturer bears some of the risk of having excess inventory. Quantity flexibility contracts increase the average amount the retailer purchases and may increase total supply chain profits (Chopra & Meindl, 2001). The manufacturer produces $Q^+$ units and the retailer purchases $Q^-$ units if demand D is less than $Q^-$, D units if demand D is between $Q^-$ and $Q^+$, and $Q^+$ units if demand D is greater than $Q^+$.

Consider a supply chain consisting of one manufacturer and one retailer. To simplify the discussion, assume that the product is seasonal and exclusively sold through the retailer. Each product costs v = $10 to produce, including transportation, and the manufacturer plans to charge a wholesale price c = $100 per unit. The retailer plans to sell the product for a price p = $200. At this price, the retailer estimates the demand to be normally distributed with a mean of $\mu$ = 1,000 and a standard deviation of $\sigma$ = 300. Also assume that the retailer is unable to salvage anything for unsold products, resulting in a salvage value of s = $0.

From Table 2, we can observe that quantity-flexible contracts allow the supply chain to increase its profits. It is often in the manufacturer's best interest to offer a quantity flexibility contract to the retailer.

However, the values of $\alpha$ and $\beta$ which maximize the expected supply chain profit may have an adverse affect on either the manufacturer or the retailer. As it can be observed from the same table, a quantity-flexible contract with both $\alpha$ and $\beta$ = 0.6 increases the total expected supply chain profit by more than 10%. However, the manufacturer's profit actually decreases by roughly 7% due to a much higher retailer's profit increase of 30%.

Although this second model, the quantity-flexible supply chain contract model, increases the total supply chain surplus, it does not incorporate the demand elasticity of the first model, thus it is not price-sensitive and will not necessarily maximize the total supply chain surplus.

In the next sections, we will first develop our own price-sensitive *and* quantity-flexible supply chain contract model to maximize the total supply chain surplus and then address the issue of the distribution of the additional supply chain profit generated by using the contract.

Table 2. Order Sizes and Profits at the Manufacturer and the Retailer with Constant Wholesale Price and Order Size

| $\alpha$ | $\beta$ | Whole sale Price ($) | Order Size | Expected Purchase (Retailer) | Expected Sale (Retailer) | Expected Profit (Retailer) ($) | Expected Profit (Man.) ($) | Expected Supply Chain Profit ($) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 100 | 1000 | 1000 | 880 | 76063 | 90000 | 166063 |
| 0.2 | 0.2 | 100 | 900 | 944 | 916 | 88775 | 83642 | 172417 |
| 0.4 | 0.4 | 100 | 1000 | 1000 | 987 | 97456 | 86000 | 183456 |
| 0.6 | 0.6 | 100 | 1000 | 1000 | 997 | 99491 | 84000 | 183491 |
| 0.7 | 0.7 | 100 | 1000 | 1000 | 999 | 99801 | 83000 | 182801 |

## 4. A Price-sensitive and Quantity-flexible Supply Chain Contract Model

We have so far seen that commitment strategies where demand is a function of the selling price can improve retailer's profit but are restricted with the intracompany scope leading to each stage of the supply chain trying to maximize its own profits which does not necessarily result in the maximization of supply chain surplus. Supply chain surplus is maximized only when all supply chain stages coordinate strategy together. On the other hand, we have also seen that the each company can evaluate its actions in the context of the entire supply chain using quantity-flexible contracts where demand is normally distributed, but not a function of the selling price. Therefore both methodologies are limited in their respective scopes. Combining both methodologies, we developed a model for committed deliveries using quantity flexibility contracts to maximize supply chain surplus with demand as a function of the selling price.

Table 3 shows the impact of selling price on the expected supply chain profit with $\alpha = \beta = 0.6$ for a restricted selling price range of $180 to $220. Since demand is now treated as a function of the selling price, by lowering the selling price, the supply chain can expect a higher demand and potentially higher expected supply chain profit. Although the retailer's expected profit is maximized for a selling price of $200 when the wholesale price is $100, for the range of values considered, the supply chain's surplus is maximized when the selling price is set to $180. The increase in expected sales (from 997 to 1,199) offsets the decrease in selling price (from $200 to $180) with a net increase of expected supply chain profit of approximately 7%.

Table 3. Order Sizes and Profits at the Manufacturer and the Retailer with Demand as a Function of the Selling Price $\alpha = \beta = 0.6$

| α | β | Whole sale Price ($) | Order Size | Expected Purchase (Retailer) | Expected Sale (Retailer) | Expected Profit (Retailer) ($) | Expected Profit (Man.) ($) | Expected Supply Chain Profit ($) |
|---|---|---|---|---|---|---|---|---|
| 0.6 | 0.6 | 180 | 1200 | 1200 | 1199 | 95853 | 100800 | 196653 |
| 0.6 | 0.6 | 190 | 1100 | 1100 | 1099 | 98721 | 92400 | 191121 |
| 0.6 | 0.6 | 200 | 1000 | 1000 | 997 | 99491 | 84000 | 183491 |
| 0.6 | 0.6 | 210 | 900 | 900 | 896 | 98101 | 75600 | 173701 |
| 0.6 | 0.6 | 220 | 800 | 800 | 793 | 94466 | 67200 | 161666 |

It should be emphasized that the additional supply chain surplus thus generated is not attributable only to the inclusion of demand as a function of the selling price but also to the quantity flexibility contracts as well.

To simulate and calculate the optimum supply chain contract values for the entire system, we also used a VBA (Visual Basic for Applications) computer program (Özmızrak, 2006). Figure 2 is a run of the procedure Simulate_p with unrestricted selling price for $\alpha = \beta = 0.6$. It should be noted that by removing the restriction, supply chain profit is now maximized at $p = 158$ with $SCP = 201{,}608$.

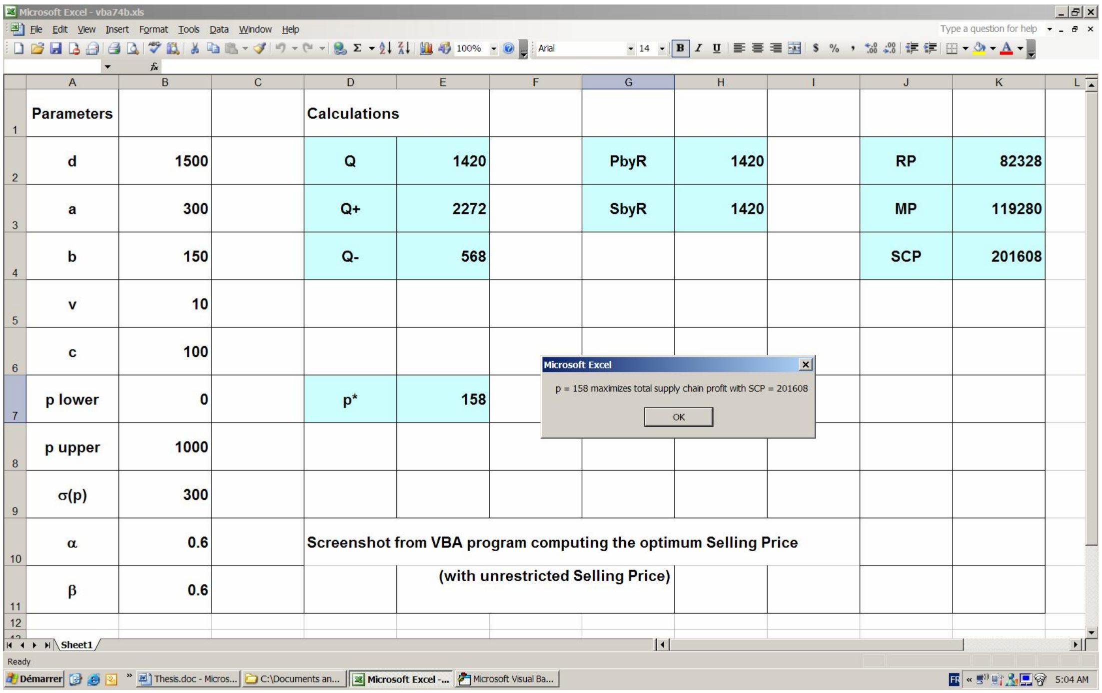


Figure 2. Screenshot from VBA program Simulate_p

Optimizing the selling price for a chosen α value may only result to local maximums. Therefore, both the selling price and the α value need to be simulated simultaneously. This is achieved by running the procedure Simulate_p_alpha. Figure 3 shows the screenshot output of simulate_p_alpha to compute the optimum selling price and the alpha value combination maximizing the supply chain profit with unrestricted selling price.

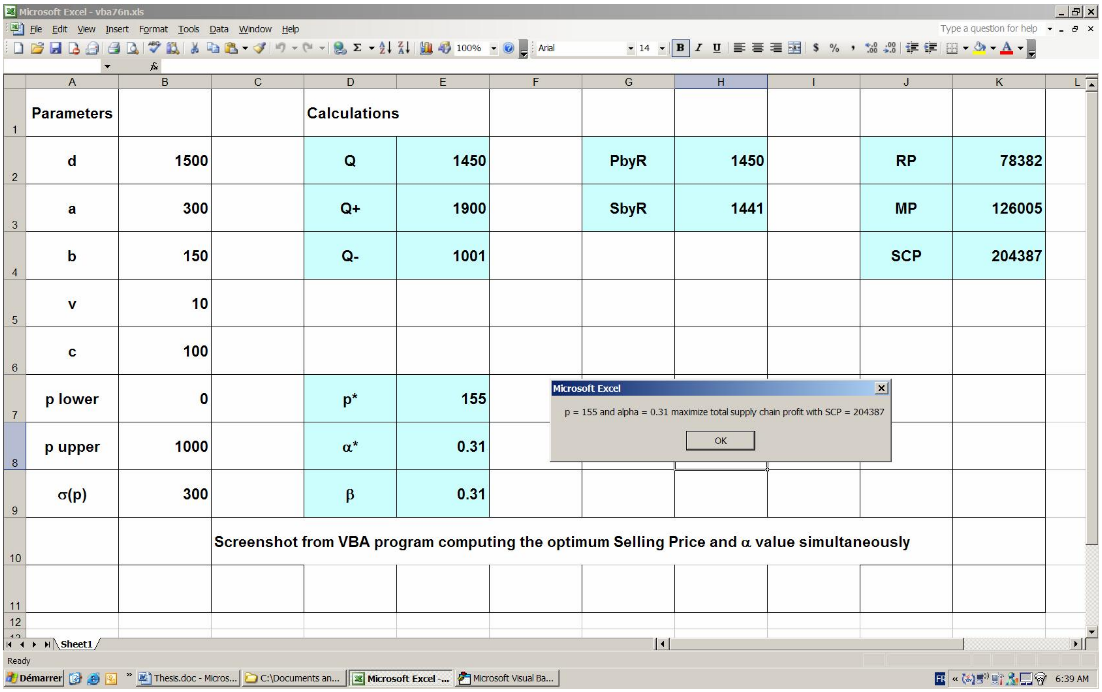


Figure 3. Screenshot from VBA program
Simulate_p_alpha

## 4.1 Profit sharing

Quantity-flexible contracts help increase the total supply chain profit. However, there is an issue related to profit sharing, i.e., how to share the additional supply chain surplus thus generated.

Since the expected quantity sold by retailer is a function of $\alpha$ whereas the expected quantity purchased by retailer is a function of both $\alpha$ and $\beta$, we can move the unsold units inventory from manufacturer to retailer by decreasing $\beta$ while keeping $\alpha$ constant to guarantee the same total expected supply chain profit. Similarly, increasing $\beta$ will move the unsold units from retailer to manufacturer. Therefore, using $\beta$ as a parameter, the expected supply chain profit can be redistributed between the manufacturer and the retailer.

The use of wholesale price as a parameter can also achieve the same profit sharing objective in a similar way. Wholesale price, being an internal parameter within the manufacturing and/or replenishment cycle of the supply chain, has no effect on the total expected supply chain profit. It merely redistributes the total supply chain surplus between the manufacturer and the retailer. Figure 4, the screenshot output of simulate_c, shows the impact of using the wholesale price as a parameter on the distribution of the total expected supply chain profit. Setting the wholesale price at $83.58 will approximately redistribute the profit evenly between the manufacturer and the retailer. Again, similar approach can be used to distribute only the additional supply chain profit generated by the use of the quantity-flexible contract rather than equally distributing the total supply chain profit. The manufacturer can still guarantee a certain profit level to the retailer in exchange of charging a higher wholesale price. Finally, a combination of using both $\beta$ and the wholesale price as parameters can also achieve the desired profit sharing mechanism.

## 5. Conclusion

In this paper we have explored several models addressing the implications of supply chain contracts as a supply chain driver. Our work has focused on the decisions jointly made by a manufacturer and a retailer to determine the optimal level of product availability. The central theme in these models has been the notion of contracts that specify the parameters within which a retailer places orders and a manufacturer fulfills them in order to maximize the total supply chain surplus.

We then presented a model to address the individual weaknesses of the models discussed by incorporating the price sensitive demand into quantity-flexible contracts by determining the optimal level of product availability, as a function of the selling price, which maximizes the total supply chain profit. We also proposed two solutions to the issue of profit sharing related to the additional supply chain profit generated. Through numerical experiments, we showed that our model maximizes total supply chain surplus by incorporating demand elasticity and profit sharing.

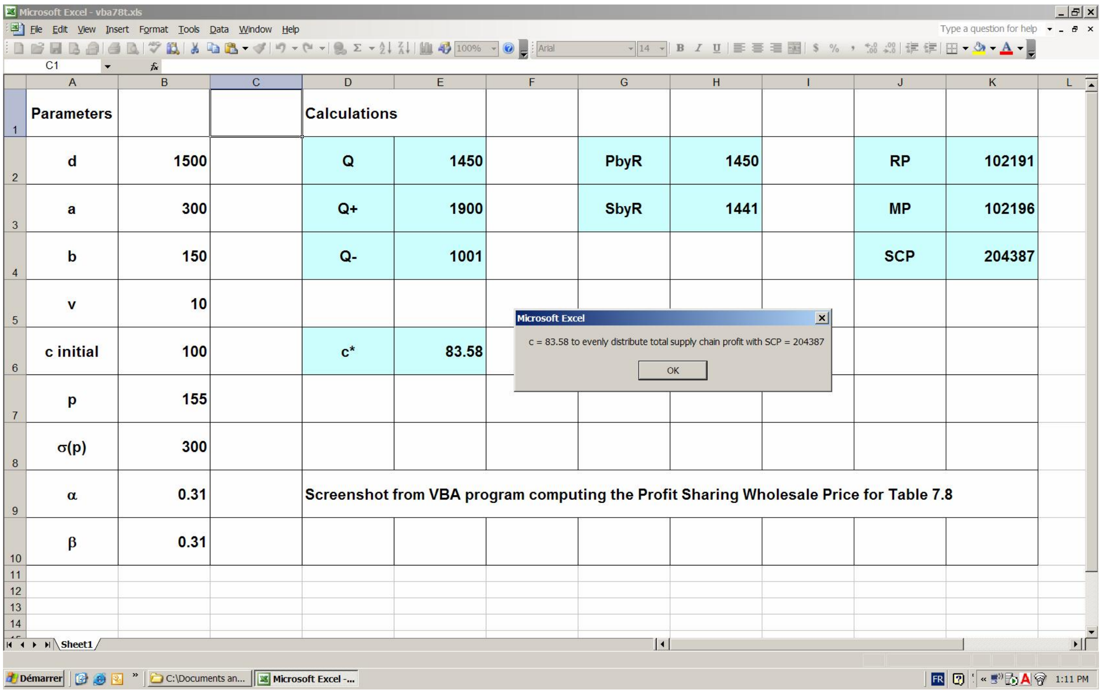


Figure 4. Screenshot from VBA program
Simulate_c

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# CONCEPTION FOR OPERATION OF CARPATHIAN SUPPLIER CLUSTER AND THE PROCESS OF SUPPLIER EVALUATION

Ferenc Mészáros[1], József Cselényi[2], Béla Illés[3]


## Abstract

*The paper describes the tasks and objectives of the Carpathian Automotive Supplier Cluster and the joining possibilities to the Hungarian and International Logistical Networks. It introduces the cluster structure which operates like a Virtual Enerprise with a decision making entity called: virtual business and logistical center (VBLC) which serves as a basis of the cluster. The paper details the structure of the supplier audit elaborated to evaluate the possible suppier members of the cluster. Finally application of the Potential Star Method is introduced in the paper for comparing the potential of the possible suppliers.*


*Keywords*: Industry cluster, Automotive industry, Supplier evaluation, Supplier audit

## 1. Introduction

Nowadays, the cluster-based approach is one of the most significant tendencies of economic development, which aim is to create and intensify the cooperation between production companies (integrated by a common value chain) of a given industry, state-owned and private research and educational institutes, different public organizations responsible for economic development, and service companies providing different services (eg. logistical services). The members of the cluster are connected with each other via one or more of the followings:

- common suppliers;
- common technologies;
- common customers and distribution channels;
- common market of labor.

In the supplier networks operating in a network-like way - such as supplier cluster of a given industry – the logistics has an outstanding role in case of any cooperation between the elements of the system. In spite of that fact, the ample literature dealing with industry/regional clusters does not really consider the importance of designing and operation of the logistical system of a cluster. Much of literature related to regional economic development deals with the factors needed for the establishment of clusters, or analyses the activity of the clusters by means of statistical indicators of regional development (Lengyel, & Grósz, 2003), (Economic Development Administration, USA, 1997), (Porter, 1998), other authors investigates the types of the logistical services should be provided by a cluster by industries (Maier, & Bergman, 2000), (Ravn, & Petersen, 2005), (Guyani, 2001), (Hansen, 2001). Other works deal with production networks established on the base of industry clusters and virtual logistical networks derived from small and medium sized enterprises (SMEs) (Cselényi, & Illés, 2004), (Cselényi, Illés, & Kerepeszki, 2004), (Wiendhal, & Lutz).

Automotive industry is a typical field of cluster initiatives, where a large number of spatially isolated companies can be found in the supply chain of the Original Equipment Manufacturers (OEMs: car manufacturers) despite of the efforts to reduce the number of suppliers. Beside Tier-1 (first level) suppliers producing parts and subbassemblies on a high level with the help of their advanced intern and extern logistic system, there are Tier-2 (second level) suppliers with relatively low level of production capacities and limited logisitcal resources. For theese companies a regional supplier cluster can give the chance of being a supplier or preserve their acquired status by the integration of the capacities and capabilities of the cluster members. The efforts to maximize the prodictivity of the OEMs (eg. with the help of advanced methods of production management such as the widely spread Toyota Production System), and to minimize the production costs (eg. with Just in Time or Just in Sequence supply) leads to the outsanding role of logistics in the automotive supply chain. For this reason one of the main tasks of the supplier clusters in the automotive industry is to elaborate an effective logistical control system connecting the cluster members, which shoul be continously overviewed an redesigned with the consideration of the changing structure of demand and environment. Within the frame of this paper we want to introduce some elements of the research work performed related to elaborating the logistical control system of the Carpathian Supplier Cluster.

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## 2. Introduction of the Carpathian Supplier Cluster

Nowadays, emerging of a new business centre can be witnessed in the region of Eastern & Central Europe which is driven by the automotive industry (Figure 1.). The majority of the OEMs have established manufacturing capacities int he region owing to geographical location of the countries of the region; availability, quality, and costs of labor; and developing business environment.

Figure 2. Car Assembly Plants in Eastern & Central Europe
(source: CEE Opportunities for OEM Suppliers, 2006. Deloitte Central Europe Holdings Ltd.)

Recognising the increased demand for supplier capacities and the challenges derive from the integrating nature of the automotive industry different concerned economic actors of the three-border region of Hungary, Slovakia and Ukraine led by the Regional Foundation for Enterprise-development at Zemplén have established the Carpathian Supplier Cluster. This cluster initiative can be considered as a cooperation of the independent companies, public organizations responsible for economic development, and educational and research institutes of the region, where the cooperating members use relatively high scale of products and services of the other members, require the same infrastructure and knowledge-base and interested in same types of innovation.

The Carpathian Supplier Cluster aims to help:

•companies which are already suppliers of the big multinational companies, or able to become a supplier of them to settle down in the region;

•the three-border region of Hungary, Slovakia and Ukraine and the Zemplén-Euroregion to get integrated into the above mentioned business centre of the region;

•the elaborating of a new cooperative network of production and trading copanies and logistics providers of the region;

• új new supplier-buyer relations;
• the cluster members to become a supplier,
• the continous improvement of the capabilities of suppliers;
• foreign companies to settle down in the three-border region or Zemplén-Euroregion.

Some of among the parallel sub-projects related to the cluster have finished so far: the assesment of the first group of the possible supplier members of the cluster has been completed, a web site (www.karpatokklaszter.hu) have been created to provide information from the cluster project, and the members. The Regional University Knowledge Center of Mechatronics and Logistics of University of Miskolc was charged with elaborating the logistical controlling system of the cluster one of the determinant tasks of the cluster project. The overall objective of the sub-project is to elaborate cluster structure operating like a Virtual Enterprise (VE) which is able to make decisions related to the flow of materials and resources based on the flow of information between the actors of the model. Mathematical and data models and typical management strategies should have been elaborated during the research poject.

Figure 2. shows the structure and information- and materials-flow (denoted by continous and broken line) relations of a logistical cluster of automotive supplier.

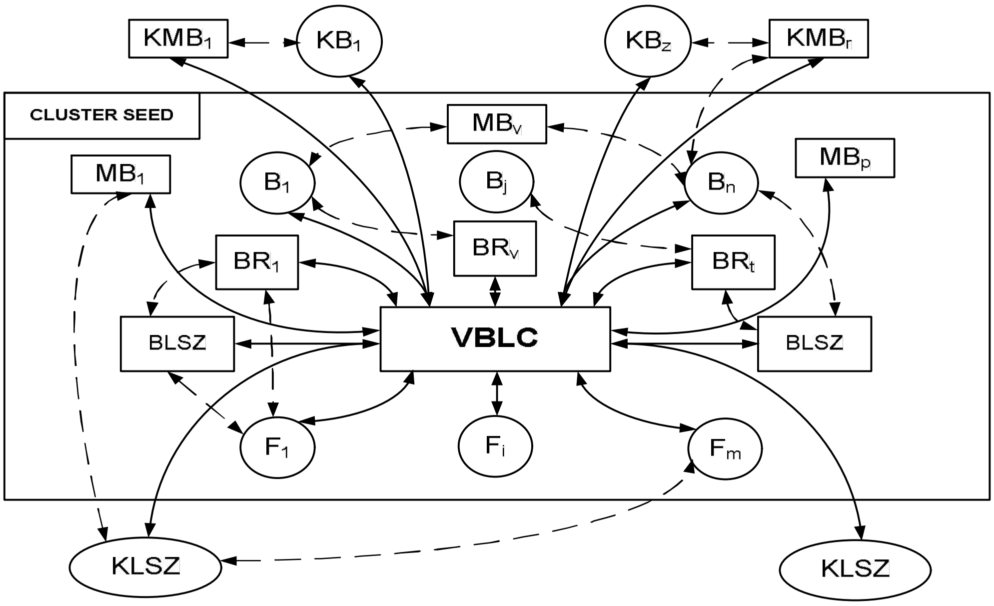


Figure 3. Structure of the logistical cluster of automotive suppliers
(continous line:information flow, broken line: materials flow)

The main object of the cluster is the Virtual Business and Logistical Center (VBLC), which is the decision making entity of the model. Further obejcts of the model are cluster members which can be divided to: Tier1 suppliers ($B_j$), buyers ($F_i$, mainly OEMs, Tier1 suppliers), Tier2 suppliers ($MB_v$), shared warehouses for suppliers ($BR_t$), logistic service providers ($BLSZ_k$). Model elements from outside the cluster are external Tier1 suppliers ($KB_z$), external Tier2 suppliers ($KMB_r$), and external logistic service providers ($KLSZ_q$).

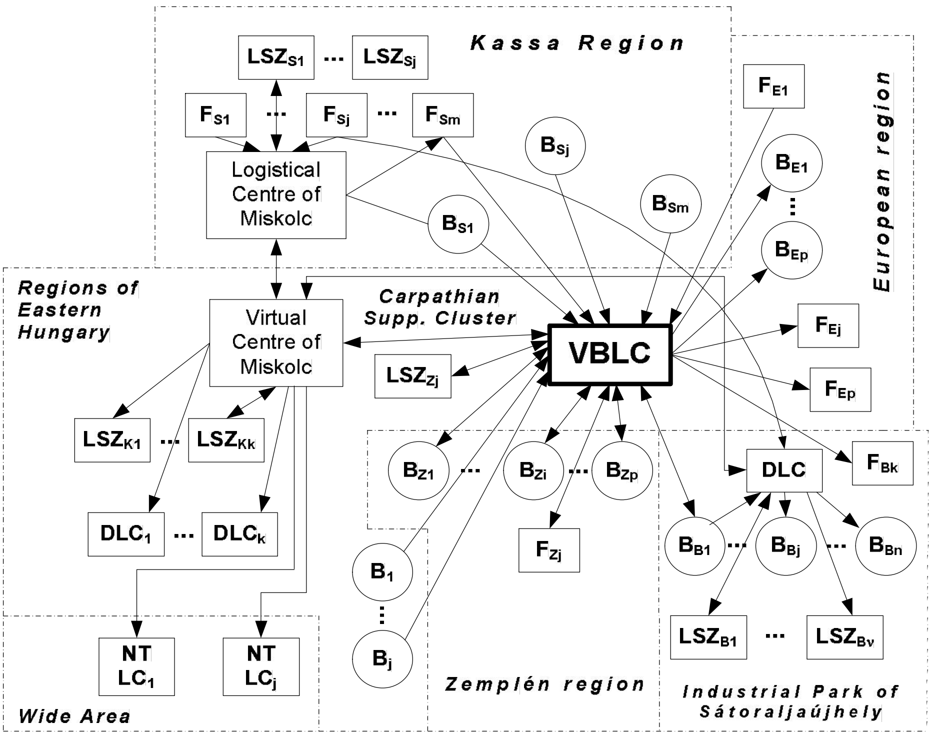


Figure 4.
Joining possibilities of the Carpathian Supplier Cluster to regional, national and international logistical networks

Figure 3. shows the possibilities of Carpathian Supplier Cluster joining to other regions and logisitical networks. The operation of Virtual Business and Logistical Center of the cluster could especially help the suppliers ($B_{Bj}$, $B_{Zi}$), buyers ($F_{Bk}$, $F_{Zj}$,), and logistic providers ($LSZ_{Bv}$) of the Industrial Park of Sátoraljaújhely and Zemplén Region. The logistical service companies and logistical decentres (industrial parks, multimodal nodes) linked to the Nort-Hungarian Logistical Centre can also take part in performing the tasks occured in the cluster. At international level Kassa Region could get an outstanding role. The logistic providers ($LSZ_{Sj}$), suppliers ($LSZ_{Sj}$), and buyers ($B_{Sj}$) can be found there should join the cluster because of the short geographical distance and active economic relations, or

can perform tasks when occasion arises. Finally, buyers ($F_{Ep}$) and suppliers ($B_{Ep}$) from the sorrounding European countries will hopefully join the cluster.

## 3. Tasks of the logistical cluster of automotive suppliers

The following logistical tasks have to be perfomed in a supllier cluster:

- assigning suppliers of parts and subassemblies (which are mainly SMEs) to the buyers (which are mainly Tier1, and Tier2 suppliers of OEMs);
- assigning providers of logistical and non logistical services to suppliers and buyers, and scheduling of theese services;
- providing logistical and non logistical services to the cluster members, which can be:
    - logistical service (e.g. warehousing, order picking, packing etc.);
    - non-logistical service going with significant information- and materials-flow (e.g. maintenance, waste management etc.);
- logistical tasks related to cluster management (e.g organizing logistical trainings, R&D programs, logistical benchmarking projects; continous supplier improvement activity).

This enumeration of the tasks cannot be considered complete, the cluster should provide other – buiness – services such as financial services, business consulting services, organization of labour etc.)

### 3.1 Assigning suppliers to the buyers

The most important task of the supplier cluster is to assign the suppliers to the buyers. There are many possible variants of suppliers-buyers assignment depending on the decision variables, time horizont, constraints etc. We can consider for example *strategic level assignment* (decisions on the assignment for three months or one year) and *operative level assignment* (decision on the assignment for a day or week). The conceptual variants of the strategic assigning of supplier and buyer members of the cluster should be the followings:

- *Variant* A: the set of the supplier members of the cluster and their supply are considered given, and the task is to find the appropirate buyer to each supplier which needs the produced parts and subbassemblies manufactured by the given supplier;
- *VariantB*: the set of buyers and their needs are considered given, and the task is to find the appropirate supplier to each buyer which can satisfy the needs of the given buyer;
- *Variant C*: the sets of suppliers and buyers and their supply and demand are considered given, and the task is to find the optimal supplier-buyer assignment.

Theese variants differs from each other in the formulation of the mathematical model related to the assignment problem. By using the introduced variants, a subset of suppliers can be assigned to every buyers considering different factors (e.g. distance, capacity constraints). At operative level the VBLC choose one supplier from the selected subset of suppliers determined at strategic level, which is allowed to fulfill the given order of the buyer.

The VBLC should determine the optimal assignment considering the following conditions:

- the needs of the buyer(s) should be satisfied by the selected supplier at minimal cost level;
- the selected supplier must provide the required quality level;
- the selected aupplier should fulfill the orders with maximal reliability;
- the lead time of a given order-fulfillment should be minimal;
- the selected supplier should perform the supplies with the required frequency;
- a given supplier should supply as much types of parts and subbassemblies as possible to a buyer;
- selection of a supplier from outside the cluster is possible only if there is not any cluster member which could satisfy the needs of the given buyer(s).

## 4. Supplier audit structure for evaluating the possible cluster members

In order to determine the strategic assignment of suppliers-buyers mentioned in the previous section there is a need for an expansive assessment of the possible suppliers, which was realized through detailed supplier audits based on inspections and interviews. Every audit structure have specialities characteristic to the given company, the structures differ in priorities, weighting of the different categories, the applied scoring scale. The structure of the supplier audit (Table 1.) related to the cluster project was elaborated considering results of interviews carried out at determinant companies of the region.

Table 8. Structure of a supplier audit – An overview

| Weight | Criteria | Weight | Sub-Criteria | Details |
|---|---|---|---|---|
| *0,2* | *Structural potential* | *0,1* | *Organizational structure* | Organizational structure |
| | | *0,1* | *Enterprise strategy* | Enterprise strategy |
| | | *0,3* | *Management* | Management style<br>Managerial skills<br>Information policy<br>Development program |
| | | *0,1* | *Human resource* | Specialized knowledge<br>Programs for further-education |
| | | *0,4* | *Economic indicators* | Direct/indirect labor<br>Sales figures<br>Investments<br>Balance-sheet figures |
| *0,2* | *Quality potential* | *0,4* | *Certifications* | ISO/TS 16949, ISO 9001-2000 |
| | | *0,4* | *Process &quality management* | Actions for quality assuarance<br>Process control<br>Quality inspection |
| | | *0,2* | *Quality awareness* | Quality awareness |
| *0,2* | *Logistical potential* | *0,1* | *Location-environment* | Risk management |
| | | *0,3* | *Materials-handling* | Warehousing-materials flow<br>Process improvement |
| | | *0,4* | *Contract management* | Order-tracking<br>Material requirements planning<br>Integrated data processing<br>New logistical conception |
| | | *0,2* | *Capacity planning* | Maintenance planning, |
| *0,2* | *Technical potential* | *0,3* | *Development* | Product and material competence<br>Competence on process-improvement<br>R&D infrastructure<br>Communication & cooperation |
| | | *0,25* | *Machinery* | Machinery |
| | | *0,25* | *Production managements* | Production organization<br>Flexibility of production<br>Suppliers |
| | | *0,2* | *Occupational & environmental safety* | Environmental management: ISO14001<br>Applied environmental protection<br>Fire-protection<br>Data protection |
| *0,2* | *Cost and price potential* | *0,6* | *Cost structure* | Direct and overhead costs, effectiveness, cost reduction |
| | | *0,4* | *Cost planning, accounting, controlling* | Accounting - controlling system |

As the fields of the audit and the priorities show that the aim of assessment is to establish – at least mid-term – business relations.

## 4.1 Potential Star method

The Potential Star (PotStar, PotStern) method can be a useful reource to aggregate and compare the qualitative results derive from the supplier audit. The Potential Star method is able to represent the potential of the suppliers in a quantitative way. The essence of the method is mapping the activity and/or features of an entity (a company, a town etc.) into hierarchical (activity) levels by a model. In this model the features (e.g. company functions) are divided to main branches (categories), and the main branches are divided to sub-branches. After analyzing the features at every level the model represents the overall evaluation of the sub-categories at the main activity level as a single figure without dimension (e.g. as a rating on a five-graded [from -2 to +2, or from 0 to 5], ten-graded or a hundred-graded scale). After it these figures are represented on the axles of a polar coordinate system with many axles (where the axles represent the analyzed categories or branches, and the figures represent the rating of the categories) and after linking the represented points of the polar coordinate system we can get the polygon, so-called Potential Star. The area of the Potential Star is in direct proportion to the potencial of a given supplier expressed as percentages (the area of the ideal Potential Star refers to 100%). Using Potential Star method the possible suppliers can be compared at the level od the resulting supplier potential, or at the levels of sub-categories.

Table 2. shows a possible definition of main activity levels (categories) which results the overall supplier potential, while Figure 4. shows the detailed structure of factors related to the category of "logistical readiness".

Table 9. The main categories for evaluating the supplier potential

| ID | Main activity levels (categories) |
|---|---|
| P1. | Product and/or Service Structure |
| P2. | Technology & Processes |
| P3. | Quality Management |
| P4. | Information Technology Infrastructure |
| P5. | Logistical Readiness |
| P6. | Flexibility |
| P7. | Finnancing & Controlling |
| P8. | Human Resource Management |

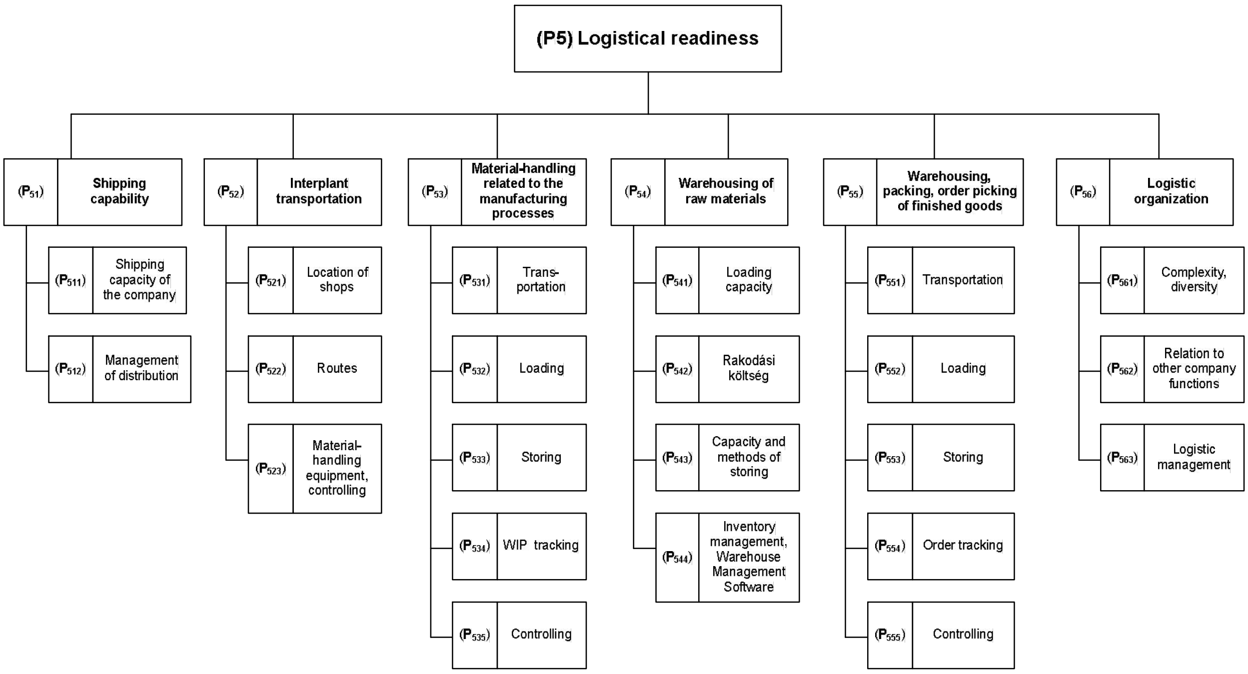


Figure 5. Factors of logistical readiness

Figure 5. shows an "external" potential star representing the overall supplier potential of a given supplier and the ideal potential star with maximal area. The supplier potential expressed as percentages can be calculated as:

$$P_{ie} = \frac{A_i}{A_0} \quad (1)$$

where:

$P_{ie}$: overall potential of supplier $i$, [%];

$A_i$: area of the external potential star related to supplier $i$;

$A_0$: area of the ideal potential star.

Figure 6. shows an internal potential star related to a given sub-category (e.g. logistical readiness).

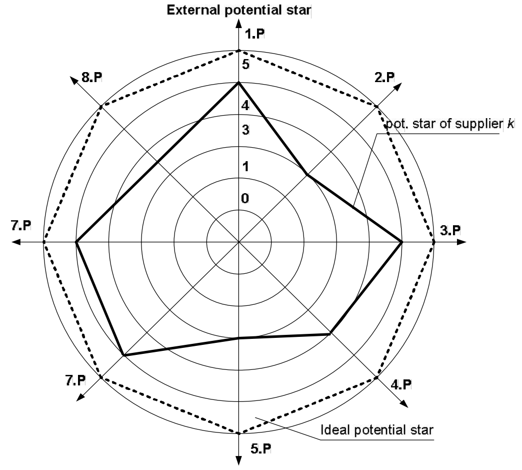


Figure 6. Overall supplier potential (external potential star)

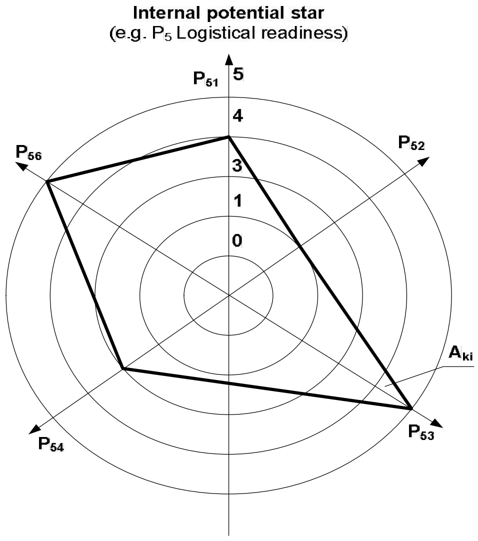


Figure 7. Potential star of logistical readiness (internal potential star)

## 5. Acknowledegements

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# SUPPLIER RELATIONSHIP MANAGEMENT (CUSTOMER RELATIONSHIP MANAGEMENT IN SUPPLY CHAIN)

Süleyman BARUTÇU[1]

## Abstract

*In the collaboration era, Supplier Relationship Management is an important approach to increase relationship, communication, collaboration and coordination in supply chain activities, because there is widespread interest for relationship-based concepts in literatures. Supplier Relationship Management helps suppliers build profitable supplier relationships among supply chain members. This study; (1) explores the role of Supplier Relationship Management approach to increase overall company performance and achieve harmonious, productive working relationships with suppliers within the supply chain, (2) analyzes the linking points of Supply Chain Management and Customer Relationship Management in Supplier Relationship Management, (3) explains Supplier and Customer Relationship Management in Enterprise Resource Planning. Therefore, the importance and role of these three concepts for companies are analyzed. It is concluded that a better relationship and collaboration emerged among companies in supply chain results in important benefits at the supply chain efficiency level. Supply Chain Management, Customer Relationship Management and Supplier Relationship Management are very important in order to establish better relationship, decrease production, marketing and logistics risks, increase performance and profitable of companies and gain competitive advantage in highly competitive markets.*

Keywords: Customer Relationship Management, Supply Chain Management, Supplier Relationship Management

## 1. Introduction

Increasing competitive pressures and market globalization are forcing companies to develop and use new concepts that can quickly respond to suppliers' or customers' needs. In this competition, relationship and relationship quality in supply chain are very important concepts for companies. Relationship exists between companies and their suppliers, manufactures, distributors, retailers and end-customers. Relationship must be managed from initial purchase of raw materials and components to the delivery of products to final customers or end-customers. In another word, a strong supplier-manufacturer-customer (distributor, wholesaler, and retailer) relationship is one of the key success factors because higher relationship quality, better information flows, less uncertainty etc. are very important for profitable companies. Therefore, relationship with suppliers, supply chain relationship quality and relationship management called in Supplier Relationship Management have a large and direct impact on overall performance of the supply chain.

There are two main management concepts in the Supplier Relationship Management; Supply Chain Management (SCM) and Customer Relationship Management (CRM). A strong Supplier Relationship Management built by CRM is a critical component of SCM. The objective Supplier Relationship Management is to increase relationships with suppliers to improve the overall performance of the supply chain.

In this study, (1) Supply Chain Management, Customer Relationship Management and Supplier Relationship Management concepts, (2) the importance of relationship and relationship quality to improve business performance, (3) the importance and benefits of Supplier Relationship Management, (4) the role of Supplier and Customer Relationship Management in Enterprise Resource Planning and (5) example of Supplier Relationship Management software for supply chain are analyzed.

## 2. Supply Chain and Supply Chain Management

In the highly competitive business environment, companies no longer competes business to business but supply chain to supply chain (Monczka & Morgan, 1996) and suppliers are no longer simply supplying and they are critical players in the success of the companies. If a supplier fails to develop and deliver competitive features, company is no longer competitive. If the supplier doesn't allocate adequate supply, company can not manufacture and take revenue for their products (Horne 2005). Therefore, suppliers can directly impact the financial performance and profitability of companies, as they influence product development costs, inventory levels, manufacturing schedules and the timeliness of delivery of goods and services. A straightforward example of where supplier relationships are critical to the companies is in manufacturing process. If materials, parts or services can not be supplied to meet

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manufacturing deadlines, companies get in to trouble and have difficulty in manufacturing products and services (www.ameinfo.com).

Companies need to compete on the basis of product innovation, higher quality, and faster response times, all of which must be delivered, in most cases simultaneously and always at the lowest costs attainable. Those competitive dimensions can not be delivered without an effectively managed supply chain (Presutti, 2003). Most of the companies have learnt and understood that the efficiency of their own businesses is heavily depended on their suppliers and supply chain partners. In order to optimize their performance, supply chain functions must operate in a coordinated manner. Therefore, supply chain is very important to improve their effectiveness in performing activities (Bradford et al., 2004). As the role of the supplier has expanded, managers should understand that the success of their companies depends in part on the companies in supply chain. Hence, some supply chain-based concepts has emerged like Supply Chain, SCM, Strategic Supplier Alliances and Supplier Relationship Management.

Supply Chain is a network of material and information that flows from suppliers, manufacturers, distributors, retailers to final customers. Ganeshan & Harrison (1995) define that a supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. However, the term SCM implies a shared business process that synchronizes product, information and cash flow across several independent companies (Greig, 2005). A SCM system is the coordination of production, inventory, location, transportation, and information among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served (Hugos, 2003). The Global Supply Chain Forum defines SCM as the integration of key business processes from end-customer through original supplier that provides materials, products, services, and information that add value for customers and other stakeholders (Lambert et al., 1998).

Business is characterized as evolving away from its traditional focus on single exchange transactions and toward an emphasis on creating and maintaining buyer-seller relationships. These strategic relationships generate managed supply chains. Materials and information must simultaneously flow both up and down the supply chain to leverage strategic positioning and to improve operating efficiency (Meier et al. 2004). In effective SCM strategy, there are three critical flows; (1) material and product flows, (2) information flows and (3) relationship management. The product flow includes the movement of material and products from suppliers to manufactures and customers. The information flow involves transmitting all information among supply chain members in order to meet suppliers' and customers' wants. The relationship management flow involves establishing good relationship and managing relationship among supply chain for better material, product and information flow.

The integration of business processes in supply chain requires considerable relationship among supply chain members and considerable management attention. However, relationship and relationship quality in supply chain are very important and relationship in supplier–buyer integration has received considerable attention. The SCM business processes will be integrated with key supply chain members. This integration is supported by the linking of information systems. Managers need to choose the appropriate level of integration for particular relationships in the supply chain and the appropriate degree of information sharing (García-Dastugue & Lambert, 2003).

An example of a supply chain process is shown in Figure 1. In this example, material and product flow occurs from the left side to the right side of in supply chain (suppliers-manufacture-customers), information flow and relationship management can be happened in all side and all partners in supply chain and SCM process.

As seen in Figure 1, the SCM forum members identified eight key business processes that are implemented within the supply chain. Two of them are relationship-based applications and methods; CRM and Supplier Relationship Management (Croxton et al. 2001: García-Dastugue & Lambert, 2003). CRM provides the structure for how relationships with customers are developed and maintained between the company and its customers. Supplier Relationship Management provides the structure for how relationships with suppliers are developed and maintained and it will be a significant component in SCM process.

Supplier Relationship Management is a comprehensive approach to managing a company's interactions with the other companies that supply the products and services it uses. The goal of Supplier Relationship Management is to streamline and make more effective the processes between a company and its suppliers just as CRM. (searchsap.techtarget.com). Supplier Relationship Management can be simply defined as CRM for suppliers. Supplier Relationship Management involves the management of preferred suppliers and finding new ones whilst reducing costs, making procurement predictable and repeatable, pooling buyer experience and extracting the benefits of supplier partnerships, while CRM focused on leveraging and exploiting the interaction with the customer to maximize customer satisfaction, ensure return business, and ultimately enhance customer profitability. It becomes crucial for manufacturers to integrate the demand of customers to their preferred suppliers as well as sourcing new ones in a real time base during the new product development cycle in order to remain competitive in business (Choy et al. 2003). The detailed information about CRM and Supplier Relationship Management are below.

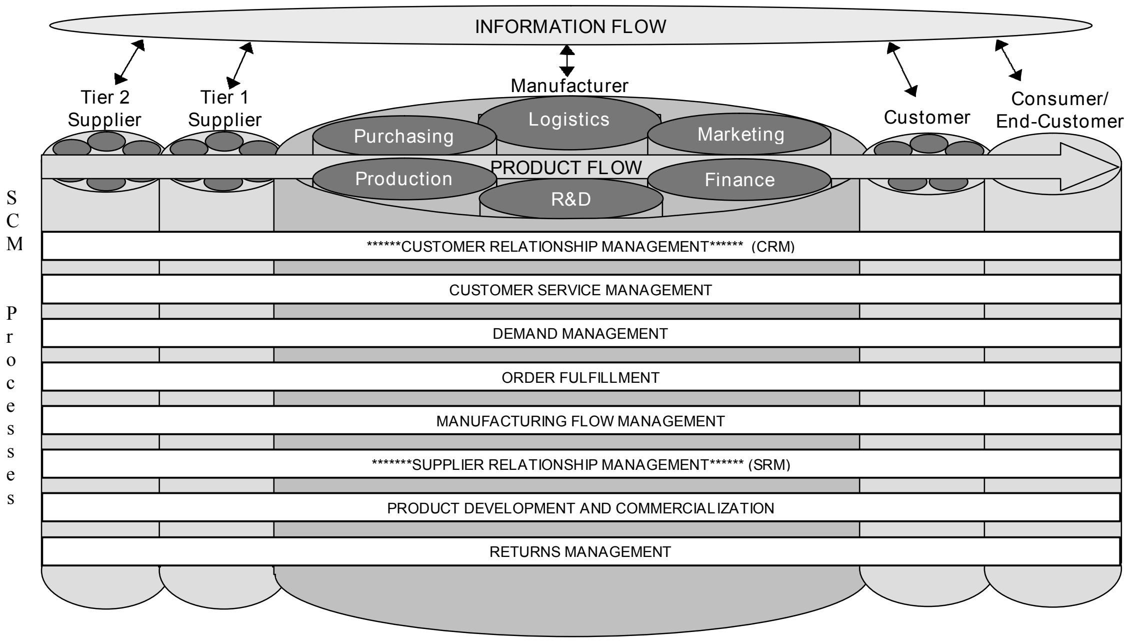


Figure 1. Supply Chain Management: Integrating and Managing Business Processes across the Supply Chain. Source: Adapted from Douglas et al. (1998, p.2) in Garcia-Dastugue & Lambert (2003, p.252)

## 3. Costumer Relationship Management

In today's hyper-competitive world, there is a major change in the way companies organize themselves as companies switch from product-based to customer-based structures. A key driver of this change is the advent of CRM. Companies looking to implement successful CRM strategies need to focus on a common view of the customer using integrated information systems and contact center implementations that allow the customer to communicate via any desired communication channel.

The original focus of CRM was to forge closer and deeper relationships with customers, ‘being willing and able to change your behavior toward an individual customer based on what the customer tells you and what else you know about the customer' (Peppers et al., 1999). CRM provides a lens that can be used to focus the alignment of the company (people, processes, information systems) and the market (individual customers). Each company needs to align its production of product qualities and attributes valued by the target market. With the exception of niche suppliers, most organizations will offer and market a range of products that represent different company and market alignments (Lloyd, 2005).

CRM is a process or methodology used to learn more about customers' needs and behaviors in order to develop stronger relationships with them. The more useful way to think about CRM is as a process that will help to bring together lots of pieces of information about customers, sales, marketing effectiveness, responsiveness and market trends. CRM helps businesses use technology and human resources to gain insight into the behavior of customers and the value of those customers (crmtutorial.com). CRM allows the formation of individualized relationships with customers, with the aim of improving customer satisfaction and maximizing profits, identifying the most profitable customers and providing them with the highest level of service (Choy et al. 2003). Moreover, CRM is a process by which a company maximizes customer information in an effort to increase loyalty and retain customers’ business over their lifetimes. The primary goals of CRM are to (1) build long term and profitable relationships with chosen customers, (2) get closer to those customers at every point of contact, and (3) maximize the company’s share of the customer’s wallet (Shaw, 1999). The benefits of CRM modeling are developing a richer, clearer understanding of customers and their needs and wants. CRM enables to company (1) to better product/service design and delivery, (2) identification novel cross-selling opportunities (3) greater customer loyalty, (4) improved customer retention/churn management (Lloyd, 2005).

Choy et al. (2002) simply stated that CRM is about finding, getting, and retaining customers. It is at the core of any customer-focused business strategy and includes the people, processes, and technology questions associated with marketing, sales, and service. Couldwell (1998) explained the key characteristics of CRM are: (1) a customer relationship perspective aimed at the long-term retention of selected customers, (2) gathering and integrating information on customers, (3) use of dedicated software to analyze this information (often in real time), (4) segmentation by expected customer lifetime value, (5) micro-segmentation of markets according to customers' needs and wants, (6) customer value delivery through service tailored to micro-segments, facilitated by detailed, integrated customer profiles.

CRM allows the formation of individualized relationships with customers, with the aim of improving customer satisfaction and maximizing profits, identifying the most profitable customers and providing them the highest level of service. In summary, CRM is focused on leveraging and exploiting the interaction with the customer to maximize customer satisfaction, ensure return business, and ultimately enhance customer profitability. As the trend toward use of technology to drive competitive advantage has taken root, visionary manufacturers are starting to take advantage of a new competitive opportunity called Supplier Relationship Management (Choy et al. 2002).

## 4. Supplier Relationship Management

In a highly competitive marketplace, companies are searching for further opportunities to reduce costs and improve operational efficiencies. Supplier Relationship Management represents an evolutionary extension of supply chain management, driven by the need for companies to better understand their suppliers' long-term financial and operational contribution to the top and bottom lines. Supplier Relationship Management is the next step in managing the supply chain more effectively (www.ameinfo.com). The intensive global competition among manufacturers to coordinate and respond quickly to the industry value chain from suppliers to customers has made Supplier Relationship Management important in the new business era. In such circumstances the decision making in each business plays a key role in the cost reduction, and supplier selection is one of the important functions in the Supplier Relationship Management (Choy et al. 2004).

The nature of supply chain relationships has undergone some dramatic changes. Companies have been encouraged to develop close partnerships with suppliers and customers alike. Supplier Relationship Management is a term that has appeared in recent years. Because of the importance of supplier relationship, there was Supplier Relationship Management Conference on March 8-9, 2006, at the Grand Hyatt Atlanta, USA so as to explore the range of tools, concepts, and opportunities within Supplier Relationship Management. According to Gulledge (2002), Supplier Relationship Management takes SCM to the next level, allowing supply chain partners to act as a single business entity in a virtually linked supply chain. Herrmann & Hodgson, (2001) defined Supplier Relationship Management as a process involved in managing preferred suppliers and finding new ones whilst reducing costs, making procurement predictable and repeatable, pooling buyer experience and extracting the benefits of supplier partnerships. Croxton et al. (2001) explained how Supplier Relationship Management can help improve relationship with suppliers in a number of areas including; customer service, communications, product development, quality control, service monitoring in supply chain activities.

Supplier Relationship Management as a new category of supply chain applications contributes to the supplier selection and thus increases the competitive advantage of the manufacturer through three primary mechanisms: (1) support of improved business processes across the supply chain, (2) a next-generation architecture that can handle multi-enterprise processes, and (3) facilitation of rapid product cycles and new product introduction. Together, these mechanisms can drive competitive advantage through substantial reductions in the true cost of parts and materials, increased flexibility to respond to changes in customer demand, and faster cycle times which can enhance customer satisfaction and increase market share (Choy et al. 2003b).

Supplier Relationship Management is the utilization of the latest technologies to build networks of collaborative relationships that bring joint benefits to large companies and their suppliers. the focus in Supplier Relationship Management is on joint benefits with suppliers (Gulledge, 2002). In virtually every industry, the role of the supplier has radically expanded over the past decade. Today there are cases where almost every aspect of product development and operations has been outsourced to a new breed of suppliers. Suppliers have gone from simply being invited to the design team meetings to becoming the design team. The role of the supplier has also been changed by the need for assured supply (Horne 2005).

The use of Supplier Relationship Management is to provide effective relationship between (1) purchasing operations and suppliers (2) logistics and transportation providers (3) manufacturing companies and wholesalers or retailers who sell their products and (4) customer service and support.

### 4.1. Supplier and Customer Relationship Management in Enterprise Resource Planning

Enterprise Resource Planning (ERP), when successfully implemented, links all areas of a company including order management, manufacturing, human resources, financial systems and distribution with external suppliers and customers into a tightly integrated system with shared data and visibility (Chen, 2001). The information captured and managed within ERP applications can play a vital role in planning product schedules through the integration of ERP with Supplier Relationship Management and CRM.

Most companies that successfully adapted Supplier Relationship Management systems have also taken the plunge into ERPs and SCM as well (www.epiqtech.com). Another word, Implementation of CRM and ERP successfully, companies need Supplier Relationship Management in order to develop better relationship and retain suppliers.

As seen in Figure 2, ERP systems promise to integrate all functional areas of the business with suppliers and customers. In fact, there is an interesting and satisfying symmetry between the role of CRM and the role of Supplier Relationship Management in the manufacturing environment as shown in Figure 2, which shows a company operations architecture linking customers with the supply bases. As companies recognize the value of managing their supply base as a competitive weapon, Supplier Relationship Management becomes the single most important technology investment they can make to ensure that supply chain transformation they are driving is successful (Choy et al. 2002).

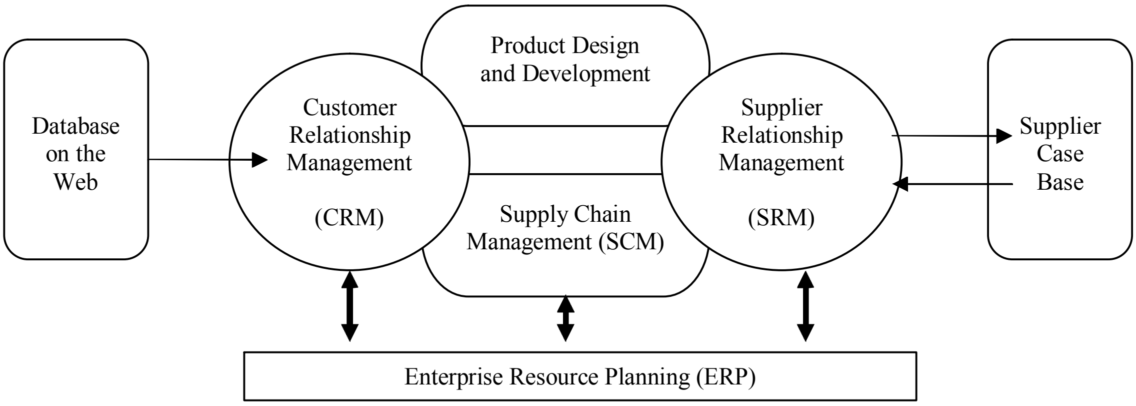


Figure 2. Basic Management Tools in Enterprise Resource Planning Source: Choy et al. 2002, p.284

The Supplier Relationship Management automates processes in the business-to-business supply chain that previously have been done manually. Supplier Relationship Management applications add functionality within a company's ERP system to help companies work with suppliers when purchasing items such as operational supplies. When a manufacturer does business with multiple suppliers in several different countries, the job of integrating supplier data with a company's ERP system can be very tedious. That's where Supplier Relationship Management comes into play (Westervelt 2004). Supplier Relationship Management improves the flow of products and materials and supply information throughout the supply chain by four kind of activities; (1) indirect and (2) direct procurement, (3) sourcing, and (4) trading exchange. By integrating CRM with Supplier Relationship Management properly through the process of product design and development, and the application of supply chain management under the same platform of an ERP system, Supplier Relationship Management solutions can provide significant competitive advantage by delivering value in three important areas. They are: (1) the dramatic cost savings, (2) the increasing flexibility and responsiveness to customer requirements, and (3) substantially faster cycle times. Together these benefits can lead to meaningful faster time to market share in the course of the product life cycle based on the customer demand with a maximum degree of customization (Choy et al. 2002: Choy et al. 2004).

4.2. The Importance and Benefits of Supplier Relationship Management

Supplier Relationship Management extended from SCM is a key successful managerial tool. Manufacturers can not have direct control over the capability and performance of theirs hundreds suppliers from different geographic locations. However, the evaluation of its suppliers' capabilities to provide raw materials and component parts is an important issue to manufacturers (Choy et al. 2004). All successful companies should build strong relationships with their suppliers. Companies are not isolated entities that simply purchase goods and services from individuals who happen to be able to supply them at that particular time. Another element of these supplier relationships is advanced planning. Manufactures do not just communicate with suppliers when a procurement need arises; they also contact them in order to discuss their future needs and to determine how best to satisfy those needs by working together. Overall, customers (manufactures, wholesaler and retailer) are both better served when they come together to form strong, mutually beneficial, and secure business relationships for non-commodity type goods and services. When these relationships exist, they can drive the growth and profitability of both organization and prevent purchasing and execution problems (www.epiqtech.com).

By applying Supplier Relationship Management system in a company (Honeywell), the main goals of CRM and Supplier Relationship Management, which are to build long term and profitable relationship with chosen customers and to maximize the value of a manufacturers' supply base by increasing flexibility and responsiveness to customer requirements and substantially faster cycle times, are achieved (Choy et al. 2004).

Supplier Relationship Management includes both business practices and software and is part of the information flow component of SCM. Supplier Relationship Management practices create a common frame of reference to enable effective communication between an manufactures and suppliers who may use quite different business practices and terminology.

Supplier Relationship Management contributes to the supplier selection and thus increases the competitive advantage of the manufacturer through three primary mechanisms: (1) support of improved business processes across the supply chain, (2) a next-generation architecture that can handle multi-enterprise processes and (3) facilitation of rapid product cycles and new product introduction. Together, these mechanisms can drive competitive advantage through substantial reductions in the true cost of parts and materials, increased flexibility to respond to changes in customer demand, and faster cycle times which can enhance customer satisfaction and increase market share (Choy et al. 2004).

There are some significant benefits to Supplier Relationship Management. It provides the ability to strategically manage all aspects of the supplier relationship to reduce the cost and risk associated with the kind of outsourcing practices seen today. Supplier Relationship Management tools help companies create and sustain their sourcing strategy (Horne 2005). Establishing a dependable and long-term focus on relationships gives firms the ability to monitor, improve or eliminate poor performing suppliers. A supply chain's long-term focus along with close communication with customers and suppliers is critical to financial success (Tan et al., 1998). Any time a supplier falls short on delivery or does not get a critical subsystem developed in time for a new product's launch, the top line suffers. This makes Supplier Relationship Management the best investment a company can make in design and procurement. It is the only system that can simultaneously reduce cost and risk (Horne 2005).

Supplier Relationship Management contributes to competitive advantage through three primary mechanisms: (1) support of improved business processes across the supply chain, (2) a next-generation architecture that can handle multi-companies processes, and (3) facilitation of rapid product cycles and new product introduction (Herrmann & Hodgson, 2001). Moreover, Supplier Relationship Management represents an opportunity to improve the accuracy and speed of buyer-supplier transactions, while improving collaborative working practices to the benefit of both parties, driving continuous improvement and lowering total cost of communication (www.ameinfo.com).

Customers also benefit when product offers are tailored to them individually or in micro-segments and can lead to greater loyalty. Companies have to restructure their manufacturing processes with the objective of achieving mass customization by implementing successful SCM and Supplier Relationship Management systems.

### 4.3. Supplier Relationship Management Software

Business software industry has been growing. CRM has become very important in the competitive business environment since late 1990s and is now a multimillion-dollar industry (Choy et al. 2003b). The market for CRM software is experiencing explosive growth. In the US market, the CRM software market is expected to more than double from US$20 billion in 2001 to US$46 billion by 2003 (Rigby et. al, 2002). In recent years, companies have invested in Supply Chain Management software to automate procurement processes, improve delivery times and reduce the cost of doing business. Now, market trends, such as increased global competition, shorter product lifecycles and a move to outsource business processes, require companies to improve collaboration with their supplier base and to examine methods of further reducing the costs associated with supplier relationships (www.ameinfo.com). Supplier relationships have become just as critical as customer relationships, but they are often far more complex. The nature of the cross-functional, cross-divisional, cross-company workflows involved in Supplier Relationship Management requires a new architecture built from the ground up and focused on it (Horne 2005). In this environment, improving supply chain execution and leveraging the supply base has become more critical than ever in achieving competitive advantage. A new category of supply chain software applications is evolving, called Supplier Relationship Management which can dramatically improve supply chain performance and empower a new level of supply-base management (Herrmann and Hodgson, 2001). For example, with the mySAP Supplier Relationship Management (mySAP SRM) software designed to achieve sustainable savings, value-generating supplier relationships, and faster business innovation integrates strategic practices for supplier qualification, negotiation, and contract management more tightly and cost-effectively with other company functions and their suppliers' processes. Using this software, managers of companies can (1) simplify and automate procurement, (2) evaluate, enable, and engage your suppliers more effectively and (3) develop supplier relationships that deliver value. As a result, the benefits of this software are lower costs, increased profits, and a better-run business (www.sap.com). Therefore, companies in supply chain should use Supplier Relationship Management software in order to develop better relationship with suppliers or customers.

## 5. Conclusion

Supplier Relationship Management may not have had a strong following a few years ago, but today more businesses are moving toward the implementation of this system. Supplier Relationship Management is emerging as an essential element of the SCM infrastructure. The integration among supply chain supported by Supplier Relationship Management approach will be one of the main competitive advantages in competitive environment.

Supplier Relationship Management applications attempt to focus on the supplier first so as to build a mutually beneficial relationship. It helps managers to develop and implement an integrated business strategy focused on maximizing supplier value, loyalty, revenue, and profitability. Companies recognize the need to understand, anticipate, and respond to the needs, behaviors and preferences of not only their customers but also suppliers. Building customer-supplier relationships, implementing information and communication technology and managing materials, products, information, relationship flows are important strategic success factors that need to be focused in developing successful Supplier Relationship Management system. Supplier Relationship Management can only be successful if companies in supply chain are fully committed to meeting the objectives of the relationship and the free flowing of information across the supply chain. It is concluded that companies should develop strong and long-term relationship with suppliers and other partners for mutual benefits.

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# SUPPLY CHAIN MANAGEMENT PRACTICES IN TURKISH AUTOMOTIVE INDUSTRY: AN EMPIRICAL INVESTIGATION OF SUPPLIER SELECTION

Ibrahim Gurler[1]

## Abstract

*Supplier selection in supply chain management becomes more important due to the competition between supply chains rather than companies. Increasingly, firms are allocating more resources to their core competencies and encouraging the outsourcing of non-core activities, which increases their reliance and dependence on supplier selection. Managing the supply chain is an important but complex issue for automotive manufacturers. This increases the importance of effective supplier selection in automotive industry. In this paper, in order to investigate the supplier selection in supply chain management a questionnaire is applied to companies of Turkish Automotive Industry which is being affected from the increasing competition. For this reason a questionnaire is sent to 170 companies and data is collected from 49 companies. A factor analysis is applied to the findings of questionnaire to explore the supplier selection criteria of Turkish Automotive Industry Companies. According to factor analysis 9 factors are obtained from 26 variables that indicate the supplier selection criteria of Turkish Automotive Industry.*

*Keywords: Supply Chain Management, Supplier Selection, Supplier Selection Criteria, Factor Analysis,* Turkish Automotive Industry

## 1. Introduction

Across industries, firms increasingly assign greater responsibility to suppliers in order to produce innovative, high–quality products at a competitive cost. Increasingly demanding customers, globalization, accelerated competition, technological advances in the communication of information, decreased governmental regulation worldwide manufacturing firms toward adoption of the supply chain management (SCM) philosophy.

The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain.

Supply chain management is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage (Robert, Ernest, 1999:2). The great benefit of supply chain management is that when all of the channel members – including suppliers, manufacturers, distributors, and customers – behave as if they are part of the same company, they can enhance performance significantly across the board (William, 1997:17)

Greater dependence on suppliers increases the need to effectively manage suppliers. Three dimensions underlie supplier management: (1) effective supplier selection; (2) innovative supplier development strategies; and (3) meaningful supplier performance assessment mechanisms (Vijay, Keah, 2002:11).

Supply chain management can be define as the task of integrating organizational units along a supply chain and coordinating materials, information and financial flows in order to fulfill (ultimate) customer demands with the aim of improving competitiveness of supply chain as a whole (Hartmut, Christoph, 2001:9).

This definition is described with the figure of “The House of Supply Chain Management”. The House of Supply Chain Management (see figure 1) illustrates the many facets of SCM. Forming a supply chain requires the choice of suitable partners for a mid-term partnership; one of the pillars of the House of Supply Chain Management shows this choice.

The choice of partners starts with analyzing the activities associated with generating a product or service for a certain market segment. Successful supply chain approaches are built on strategic alliances with the best suppliers. Selection criteria should not be based solely on costs, but on the future potential of a partner to support the competitiveness of the supply chain. A suitable organizational culture and a commitment to contribute to the aims of the supply chain will be of great importance. A possible partner may bring in specialized know – how regarding a production process or know – how of products and its development (Hartmut, et al., 2001).

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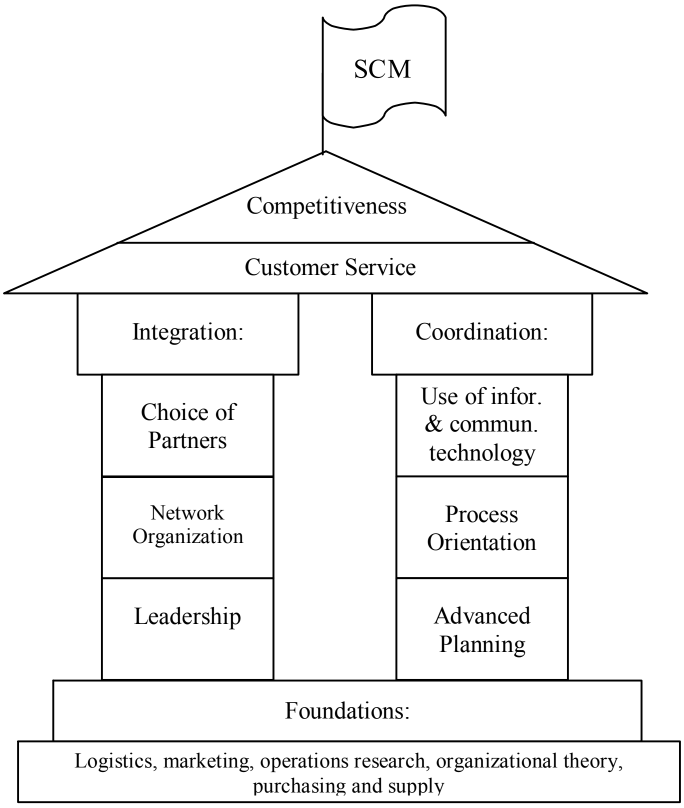


Figure 1.House of SCM (Hartmut, Christoph, 2000:10)

In adopting a supply chain management philosophy, firms must establish management practices that permit them to act or behave consistently with the philosophy. Previous research has suggested various activities necessary to implement an SCM philosophy successfully at table 1.1 (John, 2001:10).

| Table 1.Supply Chain Management Activities | |
|---|---|
| 1. | Integrated behavior |
| 2. | Mutually sharing information |
| 3. | Mutually sharing channel risks and rewards |
| 4. | Cooperation |
| 5. | The same goal and the same focus of serving customers |
| 6. | Integration of processes |
| 7. | Partners to build and maintain long – term relationships |

The concept of supplier management has grown to meet the changing needs of today's marketplace. As is illustrated in Table 2, traditional approaches to supplier sourcing, the procurement management process, an buyer/seller relationship values have undergone significant modification and accented the need for close-working business alliances.

| Table 2. Traditional Purchasing Versus Supplier Partnering (David, 2000:239) | |
|---|---|
| Traditional Approach | Supplier Partnerships |
| Primary emphasis on price | Multiple selection criteria |
| Short – term contracts | Long – term contracts |
| Evaluation by bid | Evaluation by commitment to partnership |
| Many suppliers | Fewer selected suppliers |
| Improvement benefits shared based on relative power | Improvement benefits shared equally |
| Minimal involvement in design issues | Close involvement in design issues |
| Improvement at discrete time intervals | Continuous improvement |
| Problems are supplier's responsibility to correct | Problems jointly solved |
| Information proprietary | Information shared |
| Clear definition of business responsibilities | "Virtual" organizations |

The relationship between buyer and seller must be open and honest; there must be commitment to using available resources to achieve common objectives; there must be an equal share in the risks and the rewards; and it must be a long-term proposition meant to weather the bad as well as the good times. Finally, partnership means redefining the usual ways purchasers and vendors think about product quality and reliability, delivery, price, responsiveness, lead time, location, technical capabilities, research and development investment plans, and financial and business stability. Choosing the right partners is critical to the success of the SCM implementation. If the wrong partner is selected, an incredible amount of energy and resources can be expended in a very short time with no real payback. (David, 2000:344).

Because of the pressure of globalization in the last two decades outsourcing activities has become an important strategic decision so that supplier selection is a prime concern. In fact, the selection problem is more crucial for the automotive manufacturers. The issue of the selection of supplies is essentially a problem of selecting the most suitable suppliers for different parts or component. The objective is selecting the ideal combination of suppliers, given the criteria that are important for the purchasing decision under a number of secondary conditions (Zeger, Filip, 1999). One of the automotive manufacturer company is a successful as its ability to co-ordinate the efforts of its key suppliers as steel, glass, plastic, and sophisticated electronic systems are transformed into an automobile that is intended to compete in world markets against the US, the Japanese, the European and the others manufacturers (Spekman, John, & Niklas, 1998: 53).

Supplier selection process is a multi-criteria problem, which includes both qualitative and quantitative factors. In order to select the best supplier in the automotive industry it is necessary to make a trade off between tangible and intangible factors some of which may conflict.

Traditionally, the selections of suppliers are often based on the price criterion. The cheapest supplier is usually selected without taking into consideration additional costs this supplier may introduce in the value chain of the purchasing organization. Thus, the costs related to unreliable delivery, limited quality of goods supplied, and poor communication are not involved in the selection process (Zeger, et al., 1999)

Supplier decisions are one of the most important aspects that firms must incorporate into their strategic processes. With the increasing importance of the purchasing function, supplier management decisions have become more strategic. As organizations become more dependent on suppliers, the direct and indirect consequences of poor decision making become critical (Marvin, Gioconda, & Carlo, 2003: 492).

Selecting the most appropriate suppliers is considered an important strategic management decision that impact all areas of an organization. Because this reason, this study describes the extent to which factors are using as supplier selection criteria in the Turkish automotive industry by using a survey. It presents a factor analysis that describes which factors are using by the Turkish automotive manufacturer companies as supplier selection criteria.

## 2. Literature Review

During recent years, supply chain management and the supplier (vendor) selection process have received considerable attention in the business management literature. There are several factors that complicate the supplier decision (Soukup, 1987). These include: (1) a rapid increase in value of purchased items as a percentage of total revenue for manufacturing firms; (2) an increased rate of technological change accompanied by short product life cycles; and (3) an expansion of outsourcing.

Dickson (1966), in one of the early works on supplier selection, identified over 20 supplier attributes which managers trade off when choosing a supplier. Since then, a considerable number of conceptual and empirical articles on supplier selection have appeared. An exhaustive review was done by Weber et al (1991). In these articles quality, cost and delivery performance history highlighted as the three most important criteria in supplier selection. According to this review of 74 articles discussing supplier selection criteria, quality was perceived to be most important, followed by delivery performance and cost.

Discussions with academics and practitioners alike indicate that some still consider unit price the criterion that carries the most weight in the selection and evaluation of suppliers (Micheal & Chong, 2001). According to another view; suppliers must be selected n the basis of how well they met a variety of specific requirements, and not solely on price. Different organizations have different requirements (Vaidyanathan, Rajesh, & Benton, 1999: 53).

Suppliers directly impact, either positively or negatively, the cost, quality, technology, delivery, flexibility, and profits of the firms that incorporate the supplies' outputs into their final product (Daniel & Thomas, 2002). If capable suppliers exist and are selected, a company may reap competitive advantage from its supply chain. Supply chain can provide a sustainable competitive advantage by enabling the manufacturer to please customers by improving product offerings and service while simultaneously reducing cost.

Supplier selection strategy is the strategy adopted by the manufacturer, to evaluate and select suppliers, which fulfills the requirements of the manufacturer. To build more effective relationship with suppliers, organizations are using supplier selection criteria to strengthen the selection process (Nelson, Muhammad, Loo, Mat, 2005:333).

The supplier selection strategy in terms of technology, quality, cost and delivery performance are important strategies in overcoming the "upstream" uncertainties, such as supplier defaults on delivery and performance, high cost production, and quality rejects; as well as "downstream" uncertainties due to demand volatility and changes in product mix, price, and competition action, which requires flexibility in the manufacturing processes (Nelson, et al., 2005:334).

## 3. Methodology

The population for this study consists of manufacturing firms in the automotive industry in Turkey listed in the member lists of “Association of Automotive Parts & Components Manufacturers” and “Automotive Manufacturers Association”. A questionnaire instrument was developed to collect data for this study. A copy this questionnaire was sent each of the 170 companies listed in the sampling frame, out of which 58 copies were collected back. However, only 49 copies were usable.

The design of the questionnaire is derived from the issues and questions raised in the literature. The questions were taken from the past questionnaires with few modifications made to the model requirements (Daniel et al., 2002; Michael et al., 2001; Nelson et al., 2005; Vijay et al., 2002; Robert et al., 1998, Chan et al., 2004). Based on these sources 28 criteria used to select suppliers were identified (see table 3).

Respondents were asked to indicate the importance their firms assigned to these supplier selection criterions in the supplier selection process. A five-point Likert scale, which ranged from 1 (Low Importance) to 5 (High Importance), was used to assess importance.

Table 3. Findings about Supplier Selection Variables

| Variables | 1 | 2 | 3 | 4 | 5 | N | M. | S.D. |
|---|---|---|---|---|---|---|---|---|
| Company size | 2 (4.1) | 5 (10.2) | 27 (55.1) | 11 (22.4) | 4 (8.2) | 49 | 3.20 | 0.889 |
| Ability to meet with contract conditions | - | 2 (4.1) | 4 (8.2) | 24 (49.0) | 19 (38.8) | 49 | 4.22 | 0.771 |
| Scope of resources | - | - | 9 (18.4) | 27 (55.1) | 13 (26.5) | 49 | 4.08 | 0.672 |
| Technical expertise level | - | - | 3 (6.1) | 21 (42.9) | 25 (51.0) | 49 | 4.45 | 0.614 |
| Industry knowledge | - | 1 (2.0) | 6 (12.2) | 24 (49.0) | 18 (36.7) | 49 | 4.20 | 0.735 |
| Commitment to quality | - | - | - | 11 (22.4) | 38 (77.6) | 49 | 4.78 | 0.422 |
| Open site evaluation | - | 3 (6.1) | 4 (8.2) | 23 (46.9) | 19 (38.8) | 49 | 4.18 | 0.834 |
| Having enough information about your business | - | 1 (2.0) | 13 (26.5) | 19 (38.8) | 16 (32.7) | 49 | 4.02 | 0.829 |
| References / reputation of supplier | - | 1 (2.0) | 12 (24.5) | 18 (36.7) | 18 (36.7) | 49 | 4.08 | 0.838 |
| Ability to meet delivery due dates | - | - | 1 (2.0) | 10 (20.4) | 38 (77.6) | 49 | 4.76 | 0.480 |
| Price of materials, parts, and services | - | - | 5 (10.2) | 13 (26.5) | 31 (63.3) | 49 | 4.53 | 0.680 |
| Financial stability and staying power | - | 1 (2.0) | 11 (22.4) | 24 (49.0) | 13 (26.5) | 49 | 4.00 | 0.764 |
| Supplier’s effort in eliminating waste | 1 (2.0) | 1 (2.0) | 15 (30.6) | 26 (53.1) | 6 (12.2) | 49 | 3.71 | 0.791 |
| Ability to have honest and frequent communications with suppliers | - | - | 4 (8.2) | 20 (40.8) | 25 (51.0) | 49 | 4.43 | 0.645 |
| Flexible contract terms and conditions | - | 2 (4.1) | 12 (24.5) | 23 (46.9) | 12 (24.5) | 49 | 3.92 | 0.812 |
| Geographical compatibility / proximity | - | 2 (4.1) | 12 (24.5) | 26 (53.1) | 9 (18.4) | 49 | 3.86 | 0.764 |
| Cultural match between companies | 2 (4.1) | 6 (12.2) | 23 (46.9) | 15 (30.6) | 3 (6.1) | 49 | 3.22 | 0.896 |
| Past and current relationship with supplier | - | 3 (6.1) | 18 (36.7) | 18 (36.7) | 10 (20.4) | 49 | 3.71 | 0.866 |
| Suppliers’ effort in promoting JIT principles | - | - | 2 (4.1) | 19 (38.8) | 28 (57.1) | 49 | 4.53 | 0.581 |
| Supplier has strategic importance to your firm | - | 1 (2.0) | 9 (18.4) | 29 (59.2) | 10 (20.4) | 49 | 3.98 | 0.692 |
| Suppliers’ willingness to share confidential information | 2 (4.1) | 5 (10.2) | 19 (38.8) | 15 (30.6) | 8 (16.3) | 49 | 3.45 | 1.022 |
| Percentage of suppliers’ work commonly subcontracted | 3 (6.1) | 1 (2.0) | 27 (55.1) | 16 (32.7) | 2 (4.1) | 49 | 3.27 | 0.836 |
| Supplier’s order entry and invoicing systems, including EDI | 3 (6.1) | 8 (16.3) | 16 (32.7) | 17 (34.7) | 5 (10.2) | 49 | 3.27 | 1.056 |
| Your annual orders as a percentage of their overall business | 2 (4.1) | 5 (10.2) | 21 (42.9) | 15 (30.6) | 6 (12.2) | 49 | 3.37 | 0.972 |
| Provide your company extra advantage at competition | - | 3 (6.1) | 8 (16.3) | 27 (55.1) | 11 (22.4) | 49 | 3.94 | 0.801 |
| Willingness to integrate supply chain management relationship | 1 (2.0) | 5 (10.2) | 16 (32.7) | 20 (40.8) | 7 (14.3) | 49 | 3.55 | 0.937 |
| Commitment to continuous improvement in product and process | - | 1 (2.0) | 7 (14.3) | 21 (42.9) | 20 (40.8) | 49 | 4.22 | 0.771 |
| Reserve capacity or the ability to respond to unexpected demand | - | 1 (2.0) | 4 (8.2) | 23 (46.9) | 21 (42.9) | 49 | 4.31 | 0.713 |

The questionnaire was pre-tested for content validity by 10 purchasing and materials management. Where necessary questions were reworded to improve validity and clarity. Pretest questionnaires were not used in the subsequent analyses. The revised instrument was sent to general managers of the companies. It was assumed that respondents were familiar with their organizations' supplier management activities and could make reasonable judgments regarding suppliers' performances.

The values in parenthesis at table 3 are percent values and the others are frequency values. "N" is response value, "M" is median, "S.D" is standard deviation.

## 4. Results

### 4.1. Demographic and Descriptive Statistics

Responses came from approximately 17 percent from automotive manufacturer companies and the rest 83 percent came from automotive parts and components manufacturer companies. 80 percent of these companies are manufacturing automotive or automotive parts with in 20 years or more. Companies varied from ten to 3000 employees with a median of 250, and 88 percent are operating at international markets with a big amount of exportation. Questionnaires are responded by general manager with 17 percent, purchasing manager with 15 percent, logistics manager with 11 percent and associative general manager with 11 percent.

The sixth numbered variable "Commitment to quality" is the most important criteria within the 4.78 median according to responses. Another important supplier selection criteria is "Ability to meet delivery due dates" ($10^{th}$ variable) within the median 4.76. The other important supplier selection variables are $4^{th}$, $11^{th}$, $14^{th}$, $19^{th}$ and $28^{th}$. The less important variables are first variable "Company Size" and $17^{th}$ variable "Cultural match between companies".

### 4.2. Analysis

Prior to assessing the impact of supplier selection reliability and factor analyses were conducted by the help of SPSS 11.0. In order to ensure to reliability of the measures, the multiple statements dealing with supplier selection variables were assessed for reliability using Cronbach's α. The reliability α of supplier selection factors is found 0.8334 which shows that the sample have a higher reliability. The minimum generally acceptable value for Cronbach's α is 0.70. The cronbach's α values of supplier selection factors are shown at table 4. $16^{th}$ and $28^{th}$ variables were omitted from analyses because of their negative effect on the reliability of survey.

Factor analysis was carried out to reduce each scale to smaller number of underlying factors. Principal components analysis was used to extract factors (eigen-values > 1) and Varimax rotation used to obtain a more interpretable factor matrix. With few exceptions, variables had factor loadings of at least 0.50. The 26 remaining supplier selection criteria were reduced to nine underlying factors (table 4). The nine factors accounted for 71 percent of total variance in the data.

Table 4. factor Analysis of Supplier Selection

| | Variable. Nu. | α | Mean | Stan. Dev. | Factor Loadings |
|---|---|---|---|---|---|
| Factor Groups of Supplier Selection | | 0.8334 | | | |
| Factor I: Adequacy of Corporate | | 0.7170 | | | |
| Technical expertise level | 4 | | 4.4490 | 0.6145 | 0.714 |
| References / reputation of supplier | 9 | | 4.0816 | 0.8376 | 0.696 |
| Financial stability and staying power | 12 | | 4.0000 | 0.7638 | 0.528 |
| Ability to meet delivery due dates | 10 | | 4.7551 | 0.4800 | 0.528 |
| Ability to have honest and frequent communications with suppliers | 14 | | 4.4286 | 0.6455 | 0.505 |
| | Total Variance | | | | 20.993 |
| Factor II: Information Sharing and Service Adequacy | | 0.6099 | | | |
| Suppliers' willingness to share confidential information | 21 | | 3.4490 | 1.0219 | 0.775 |
| Price of materials, parts, and services | 11 | | 4.5306 | 0.6801 | 0.686 |
| Flexible contract terms and conditions | 15 | | 3.7143 | 0.7906 | 0.596 |
| Scope of resources | 3 | | 4.0816 | 0.6720 | 0.467 |
| | Total Variance | | | | 8.977 |
| Factor III: The capacity and systems that suppliers have | | 0.6898 | | | |
| Company size | 1 | | 3.2041 | 0.8893 | 0.859 |
| Supplier's order entry and invoicing systems, including EDI | 23 | | 3.2653 | 1.0562 | 0.708 |
| Percentage of suppliers' work commonly subcontracted | 22 | | 3.2653 | 0.8360 | 0.598 |
| | Total Variance | | | | 8.236 |
| Factor IV: Supplier Integration | | 0.5985 | | | |
| Suppliers' effort in promoting JIT principles | 19 | | 4.5306 | 0.5810 | 0.855 |
| Supplier has strategic importance to your firm | 20 | | 3.9796 | 0.6919 | 0.536 |
| Commitment to continuous improvement in product and process | 27 | | 4.2245 | 0.7710 | 0.480 |
| Provide your company extra advantage at competition | 25 | | 3.9388 | 0.8013 | 0.449 |

| | | | | | |
|---|---|---|---|---|---|
| | Total Variance | | | | 6.479 |
| Factor V: Relationship Between Companies | | 0.5215 | | | |
| Cultural match between companies | 17 | | 3.2245 | 0.8959 | 0.809 |
| Past and current relationship with supplier | 18 | | 3.7143 | 0.8660 | 0.678 |
| | Total Variance | | | | 6.301 |
| Factor VI: To Obey The Agreements | | 0.6820 | | | |
| Ability to meet with contract conditions | 2 | | 3.7143 | 0.6250 | 0.771 |
| Supplier's effort in eliminating waste | 13 | | 4.2245 | 0.5944 | 0.583 |
| | Total Variance | | | | 5.550 |
| Factor VII: Supply Chain Relationship | | 0.5127 | | | |
| Willingness to integrate supply chain management relationship | 26 | | 3.5510 | 0.9368 | 0.882 |
| Your annual orders as a percentage of their overall busin. | 24 | | 3.3673 | 0.9724 | 0.477 |
| | Total Variance | | | | 5.205 |
| Factor VIII: Audit | | 0.4721 | | | |
| Open site evaluation | 7 | | 4.1837 | 0.8335 | 0.766 |
| Industry knowledge | 5 | | 4.2041 | 0.7354 | 0.579 |
| | Total Variance | | | | 4.696 |
| Factor IX: Quality Level | | 0.4022 | | | |
| Commitment to quality | 6 | | 4.7755 | 0.4216 | 0.696 |
| Having enough information about your business | 8 | | 4.0204 | 0.8289 | 0.577 |
| | Total Variance | | | | 4.463 |

## 5. Conclusions

A number of conclusions can be drawn from this study. This study demonstrates the importance supplier selection factors in automotive industry. It is apparent from these findings that in Turkish automotive industry the most important supplier selection factor is adequacy of corporate. These factor consist of Technical expertise level, References / reputation of supplier, Financial stability and staying power, Ability to meet delivery due dates, Ability to have honest and frequent communications with suppliers. With the increasing competition in markets companies willingness to have strategic partner than a supplier in their supply chains. This factor shows us that Turkish automotive companies want to make a long term relationship with their suppliers by developing closer ties, share confidential information. Also supplier must serve the buyer's long term needs by obeying the delivery agreements with higher technical production level.

Selecting the most appropriate suppliers is considered an important strategic management decision that impact all areas of an organization because of this automotive companies gives more important technical expertise level, financial stability and honest communication. Companies give less importance to quality and price level because they want to build strategic alliances with the best suppliers. If the selected partner has a future potential than the quality and price level can be easily improved by the supplier development program.

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# LEAD TIME FACTORS OF MAINTEINANCE LOGISTICS

Béla Illés[1]

## Abstract

*Logistics processes are important elements of the maintenance activities. Few articles can be found in the literature relating to maintenance logistics processes. The service activity is significant during the quality analysis of the products. The aim of this paper is the determination and mathematical description of elements of maintenance logistics processes relating to the lead time. Logistics activities of the maintenance process are considered as process oriented activities. Reasons of the importance of the papers are the followings:*

- *technological time of maintenance activity is only a few percentage of the total lead time relating to the process from ordering to finishing of maintenance, the additional more than 90% is the time of logistics activities,*
- *world wide maintenance supply chains are operating in the globalized world, in which logistics times have main role,*
- *time components are dominant during the achievement of economical activities.*

*Key words: logistics, maintenance logistics, process of maintenance, time factor, optimization*

## 1. Introduction

The shaping of the process of the maintenance logistics and the applied logistical strategies are basically determine the lead time of the maintenance activity by which the satisfaction is substantially influenced of the given products customers.

It was investigated whether which time parameters are determinable for the lead time.

The basic condition of the start of the maintenance activity is the existence of the followings at the object under the activity:

- the necessary type of materials in suitable quality and quality,
- the necessary type of constituents in suitable quantity and quality,
- the necessary type of facilities in suitable quantity and quality,
- the necessary services to the maintenance and the staff.

The task of the maintenance logistics is to provide the above mentioned conditions.

## 2. Time Factors

In case of the time parameters of the maintenance logistics two main factors are considered as can be seen in (1).

$$t_a = t_M + t_H \qquad (1)$$

where

$t_M$ lead time of the order process of the necessities,

$t_H$ time of demand of delivery, that is the total time of the logistical activities connected to the maintenance object

The ordering process of the necessities (materials, constituents, facilities, service, staff) can be seen in Figure 1.

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## 3. Process Of Order Of The Maintenance Necessities

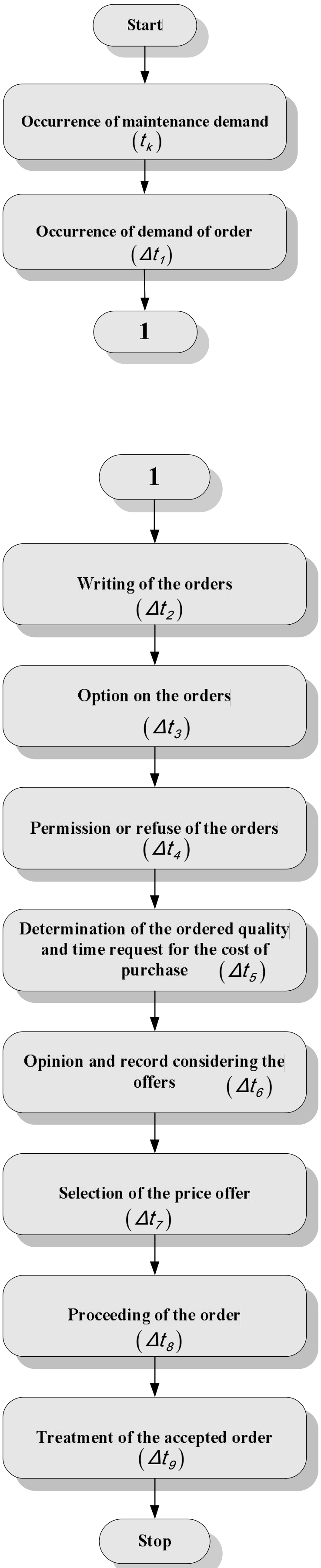


Figure 1. The process of the order of the maintenance necessities

$$t_{MA_{i_a j_a}} = \sum_{k_a=1}^{n_a} \Delta t_{i_a j_a k_a} \qquad (2)$$

where:

$i_a$ is the identifier of the transporter,

$j_a$ is the identifier of the material which should be purchased,

$k_a$ is the identifier of the time increment of the process of ordering,

$n_a$ the maximum number of the time increment has been considered, which means the number of activity elements of the process of the ordering.

for the constituents of the maintenance process

$$t_{MR_{i_r j_r}} = \sum_{k_r=1}^{n_r} \Delta t_{i_r j_r k_r} \qquad (3)$$

where:

$i_r$ is the identifier of the transporter,

$j_r$ is the identifier of the constituent to be purchased,

$k_r$ is the identifier of the time increment at the ordering process,

$n_r$ the maximum number of the time increment has been considered, which means the number of activity elements of the process of the ordering.

for the maintenance facilities:

$$t_{ME_{i_e j_e}} = \sum_{k_e=1}^{n_e} \Delta t_{i_e j_e k_e} \qquad (4)$$

where:

$i_e$ is the identifier of the transporter,

$j_e$ is the identifier of the constituent to be purchased,

$k_e$ is the identifier of the time increment of the ordering,

$n_e$ the maximum number of the time increment has been considered which means the number of activity elements of the process of the ordering.

for the maintenance service:

$$t_{MS_{i_s j_s}} = \sum_{k_s=1}^{n_s} \Delta t_{i_s j_s k_s} \qquad (5)$$

where:

$i_s$ is the identifier of the given service,

$j_s$ is the identifier of the service to be purchased,

$k_s$ is the identifier of the time increment of the ordering process,

$n_s$ is the maximum number of the time increment has been considered which means the number of activity elements of the process of the ordering.

By using (2), (3), (4) and (5) the lead time can be given for the materials, constituents, facilities and services which are necessary for the ordering of maintenance. It is expedient to write the followings:

$$t_{MA_{i_a j_a}} = \sum_{k_a=1}^{n_a} \Delta t_{i_a j_a k_a} = \min \qquad (6)$$

$$t_{MR_{i_r j_r}} = \sum_{k_r=1}^{n_r} \Delta t_{i_r j_r k_r} = \min \qquad (7)$$

$$t_{ME_{i_e j_e}} = \sum_{k_e=1}^{n_e} \Delta t_{i_e j_e k_e} = \min \qquad (8)$$

$$t_{MS_{i_s j_s}} = \sum_{k_s=1}^{n_s} \Delta t_{i_s j_s k_s} = \min \qquad (9)$$

## 4. Logistical Features Of Demand Of Delivery Necessary For Maintenance

In the followings the time factors to be connected with the demand of delivery of the necessities will be investigated. The time factors are belonging to the place where the necessity should be satisfied and to the object being under the maintenance. These factors can be:

- times for logistical activities,
- waiting times for the necessary facilities and equipments.

Logistical type of activities in field of maintenance logistics can be the next:

- different kind of storage activities, activities in connection with stores (transmission in and out),
- activities in connection with demolition or making of unit packages,
- commission,
- transportation,
- packing,
- classification
    - removable constituent
    - constituent for recycling
    - pieces for putting as waste

The time necessity for the demand of delivery of maintenance will be given in Figure 2. taking the logistical type activities into regard.

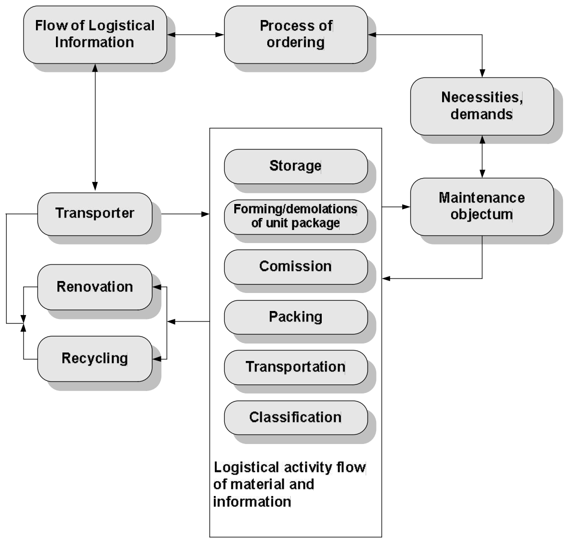


Figure 2. Logistical features of demand of delivery necessary for maintenance

In the system of the demand of delivery for the maintenance activity all the time new material and facility transportation is taken into regard, because for example in case of material the necessary oil or glum can't be renovated and also the facilities are considered not to have to be renovated due to the maintenance demand.

The satisfactions for the constituents can be carried out from the point of the logistics is three different ways:

transportation of the new constituents from the transportation in store or transportation of a renovated constituent has been in the store,

the constituent has to be manufactured before the transportation,

the given constituent has to be removed from the original place and then after reparation should be put back.

If the transportation is proceeded from the transportation in storage, (new or renovated constituent) then the time for demand of delivery is:

in case of parallel activity

$$t_{HR1} = \max_{i_r} \left\{ t_{HR1_{i_r}} \right\} \qquad (10/a)$$

in case of serial activity

$$t_{HR1} = \sum_{i_r} t_{HR1_{i_r}} \qquad (10/b)$$

$$t_{HA1i_r} = t_{T_{i_r}} + t_{E_{i_r}} + t_{K_{i_r}} + t_{R_{i_r}} + t_{S_{i_r}} \quad (11)$$

where:

| | |
|---|---|
| $t_{HR1}$ | time of demand of delivery for given maintenance task in case of demand of delivery from store, |
| $t_{HR1_{i_r}}$ | time of demand of delivery of a transported constituent for the transporter $i_r$ in case of given maintenance activity, |
| $t_{T_{i_r}}$ | the storage time necessity in case of supply between the transporter $i_r$ and the maintenance object, |
| $t_{E_{i_r}}$ | the time necessity for forming and demolition of unit package in case of supply between the transporter $i_r$ and the object under maintenance, |
| $t_{K_{i_r}}$ | time necessity for commission in case of supply between the transporter $i_r$ and the object under maintenance, |
| $t_{R_{i_r}}$ | the time necessity of storage in case of supply between the transporter $i_r$ and the object under maintenance, |
| $t_{S_{i_r}}$ | the time necessity in case of supply between the transporter $i_r$ and the object under maintenance. |

$$t_{T_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_t=1}^{n_{\kappa_r}(i_r,j_r)} t_{T_{i_r,j_r,\kappa_t}} \quad (12)$$

$i_r = 1, 2 \ldots n_{i_r}$

where:

| | |
|---|---|
| $t_{T_{i_r,j_r,\kappa_t}}$ | the storage time in the sore $\kappa_t$ for the constituent $j_r$ and transporter $i_r$ during the supplying process, |
| $n_{\kappa_r}(i_r,j_r)$ | the number of stores for the constituent $j_r$ and transporter $i_r$ during the process of supply, |
| $n_{j_r}(i_r)$ | the number of transported constituents in case of transporter $i_r$, |
| $n_{i_r}$ | number of the transporters being involved. |

$$t_{E_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_e=1}^{n_{\kappa_e}(i_r,j_r)} t_{E_{i_r,j_r,\kappa_e}} \quad (13)$$

where:

| | |
|---|---|
| $t_{E_{i_r,j_r,\kappa_e}}$ | the time for the construction and demolition of the unit packages $\kappa_e$ at the constituent $\kappa_e$ and transporter $i_r$ -during the process of supply, |
| $n_{\kappa_e}(i_r, j_r)$ | the number of construction and demolition of unit packages in case of transporter $i_r$ and constituent $j_r$ during the process supply. |

$$t_{K_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_k=1}^{n_{\kappa_k}(i_r,j_r)} t_{K_{i_r,j_r,\kappa_k}} \quad (14)$$

where:

| | |
|---|---|
| $t_{K_{i_r,j_r,\kappa_k}}$ | the time for commission $\kappa_k$ in case of the transporter $i_r$ and constituent $j_r$ during the process supply, |
| $n_{\kappa_k}(i_r, j_r)$ | the number of commission in case of the transporter $i_r$ and constituent $j_r$. |

$$t_{R_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_r=1}^{n_{\kappa_k}(i_r,j_r)} t_{R_{i_r,j_r,\kappa_r}} \quad (15)$$

where:

| | |
|---|---|
| $t_{K_{i_r,j_r,\kappa_r}}$ | the time for storage $\kappa_r$ in case of constituent $j_r$ and transporter $i_r$ -in case of the process of the supply, |
| $n_{\kappa_r}(i_r, j_r)$ | the number of storage in case of the constituent $j_r$ and transporter $i_r$. |

$$t_{S_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_s=1}^{n_{\kappa_s}(i_r,j_r)} t_{S_{i_r,j_r,\kappa_s}} \quad (16)$$

where:

| | |
|---|---|
| $t_{S_{i_r,j_r,\kappa_s}}$ | the transportation time $\kappa_s$ in case of the constituent $j_r$ and transporter $i_r$ in the process of supply, |
| $n_{\kappa_s}(i_r, j_r)$ | the number of transportations in case of constituent $j_r$ and transporter $i_r$. |

Summarizing the content of (10), (11), (12), (13), (14), (15), (16):

$$t_{HR1} = \max_{i_r} \left\{ \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_t=1}^{n_{\kappa_t}(i_r,j_r)} t_{T_{i_r,j_r,\kappa_t}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_e=1}^{n_{\kappa_e}(i_r,j_r)} t_{E_{i_r,j_r,\kappa_e}} + \right.$$

$$+ \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_k=1}^{n_{\kappa_k}(i_r,j_r)} t_{K_{i_r,j_r,\kappa_t}} + \quad (17)$$

$$\left. + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_r=1}^{n_{\kappa_r}(i_r,j_r)} t_{R_{i_r,j_r,\kappa_r}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_s=1}^{n_{\kappa_s}(i_r,j_r)} t_{S_{i_r,j_r,\kappa_s}} \right\}$$

It can be prescribed as an object function that (17) should be minimal:

$$t_{HR1} = \max_{i_r} \left\{ \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_t=1}^{n_{\kappa_t}(i_r,j_r)} t_{T_{i_r,j_r,\kappa_t}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_e=1}^{n_{\kappa_e}(i_r,j_r)} t_{E_{i_r,j_r,\kappa_e}} + \right.$$

$$+ \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_k=1}^{n_{\kappa_k}(i_r,j_r)} t_{K_{i_r,j_r,\kappa_t}} + \quad (18)$$

$$\left. + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_r=1}^{n_{\kappa_r}(i_r,j_r)} t_{R_{i_r,j_r,\kappa_r}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_s=1}^{n_{\kappa_s}(i_r,j_r)} t_{S_{i_r,j_r,\kappa_s}} \right\} = \min$$

On base of (18) it can be concluded, that the value of the object function in case of supply of the constituents for the maintenance from a transportation in storage is depend on the

- number of the transporters being involved,
- number of the constituents being transported,
- and on
  - the number of the storages $\left(n_{i_r}\right)$,
  - the number of the compositions and demolitions of unit packages $\left(n_{j_r}\right)$,
  - the number of applied commissions $\left(n_{\kappa_t}\right)$,
  - the number of applied storages $\left(n_{\kappa_e}\right)$,
  - the number of transportations $\left(n_{\kappa_k}\right)$,
  - per transporters and constituents $\left(n_{\kappa_r}\right)$.
- the time demand of given logistical activities in case of given transporters and constituents.

- The real time necessity of the logistical activities are added by two parts:
- the real technological time of the logistical activity,
- the waiting times for facilities, equipments, which are necessary for the given logistical activities and perhaps also the waiting time for the maintenance object.

All of the elements in (11) can be written as

$$t_{\alpha_{i_r,j_r}} = t'_{\alpha_{i_r,j_r}} + t''_{\alpha_{i_r,j_r}} \qquad (19)$$

where:

$t_{\alpha_{i_r,j_r}}$ at given maintenance activity the real time for the logistical activity $\alpha$ in case of the product $j_r$ at the transporter $i_r$,

$t'_{\alpha_{i_r,j_r}}$ at given maintenance activity the technological time for the logistical activity $\alpha$ in case of the product $j_r$ at the transporter $i_r$,

$t''_{\alpha_{i_r,j_r}}$ at given maintenance activity the waiting time for the logistical activity $\alpha$ in case of the product $j_r$ it the transporter $i_r$.

Bellowing to the information of (18) the followings can be started:

$$t_{\alpha_{i_r,j_r}} = t'_{\alpha_{i_r,j_r}} + t''_{\alpha_{i_r,j_r}} = \min \qquad (20)$$

or

$$t''_{\alpha_{i_r,j_r}} \to 0 \qquad (21)$$

$$t'_{\alpha_{i_r,j_r}} = \min \qquad (22)$$

If the assurance of the necessary constituent bellowing to a given maintenance activity a carried out by renovation of the dissembled constituent at an external place, then for the determination of the time of the demanded of delivery the followings should be taken in to consideration:

the time necessity of the logistical activity being proceeded between the object under maintenance and the renovation place $\left(t_B\left(i_r, j_r\right)\right)$,

the real time of the renovation

In this case the time for the demand of delivering:

$$t_{HR2} = t_{HR1} + t_B\left(i_r j_r\right) + t_F\left(i_r j_r\right) \quad (23)$$

If the maintenance activity is proceeded by the re-manufacturing of the necessary constituent the total manufacturing time should be taken into consideration $\left(t_G\left(i_r, j_r\right)\right)$:

$$t_{HR3} = t_{HR1} + t_G\left(i_r j_r\right) \qquad (24)$$

The materials, facilities the necessary times of demands of deliveries can be written in a similar way by using (18); (23) and (24).

By using (1) let us denote the necessary times for carrying out the maintenance activity:

$t_{a_A} = t_{MA} + t_{HA}$; for materials, (25)

$t_{a_R} = t_{MR} + t_{HR}$; for constituents, (26)

$t_{a_E} = t_{ME} + t_{HE}$; for facilities, (27)

$t_{a_s}$ - is the time for demand of delivery .

Let us denote the time when it turns out the maintenance has to be proceeded by $t_k$.

So the possible start of the maintenance activity at the object is

$$t_{IND} = t_k + \max\left\{t_{a_A}; t_{a_R}; t_{a_E}; t_{a_S}\right\} \qquad (29)$$

where:

$t_k$ - is the time of occurence of the demand

of the maintenance.

## 5. Conclusion

The paper introduced the logistics process of maintenance. The possible and required tasks of the process were determined. The time consumption of activities was defined by mathematical formulas. Parameters were defined which have influence on time consumptions used in formulas. The study defined the possible objective functions relating to mathematical formulas. The complexity of the tasks can be seen in the complex list of parameters. Analysis was completed on time horizon. The defined formulas can provide the mathematical description of maintenance logistics activity.

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# AGGREGATE PRODUCTION PLANNING WITHIN A SPANNING TREE SUPPLY CHAIN NODE WITH POSSIBLISTIC DEMAND AND WORKFORCE


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## Abstract

Aggregate production planning is a medium term capacity planning that determines minimum cost workforce and production plans to meet customer demand. In a supply chain an assembly or manufacturing node or stage can be situated within a spanning tree network. More than one supplier and customer can be located upstream and downstream of the stage. In these paper we try to build the aggregate production planning of a manufacturing factory which is located in such a supply chain. The demands of customers and worker numbers are possibilistic related with seasonal change.



*Keywords: Aggregate Production Planning, Possibilistic Linear Programming, Supply Chain*


## 1. Introduction

Aggregate production planning is concerned with the determination of production, inventory, and work force levels to meet fluctuating demand requirements over a planning horizon that ranges from six months to one year. Typically the planning horizon incorporates the next seasonal peak in demand. The planning horizon is often divided into periods. For example, a one-year planning horizon may be composed of six one-month periods plus two three-month periods. Normally, the physical resources of the firm are assumed to be fixed during the planning horizon of interest and the planning effort is oriented toward the best utilization of those resources, given the external demand requirements.

Generally, during the production horizon, demand is not uniform and it is not easy to execute the production plan. Aggregate planning can be a significant challenge when there is varying demand pattern such as seasonality that results in a varying production plan. When demand is seasonal or fluctuates significantly over the planning period, production must be planned more carefully lest shortages and/or high inventory levels result (Evans, 1997)

Traditional mathematical programming techniques clearly cannot solve all fuzzy programming problems. Buckley (1988) formulated a mathematical programming problem in which all parameters may be fuzzy variables specified by their possibility distribution. Lai and Hwang (1992b) developed an auxiliary multiobjective linear programming (MOLP) model for solving a possibilistic linear programming with imprecise objective and constraint coefficients.

## 2. Different Supply Chain Network Types

### 2.1 Serial Line

If it is considered N stage in a supply chain, stage i is the immediate upstream supplier for stage i+1, for i=1,2,…, N-1. Hence, stage 1 is raw material stage and has no supplier; and stage N is the finished goods inventory stage, from which customer demand is served. Each represents a major processing function in the supply chain. A typical stage might represent the procurement of a raw material or the manufacturing of a subassembly or the shipment of the finished product from a regional warehouse to the customer's distribution center. Each stage is a potential location for holding a safety-stock inventory of the item processed at the stage.


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A schematic of a typical supply chain is shown in Figure 1:

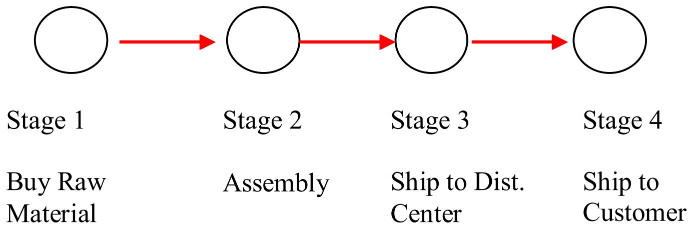


Figure 1.Serial supply chain

2.2 Assembly Network

A supply chain that can be modeled as an assembly network is one in which each stage can receive inputs from several adjacent suppliers but can directly supply only one downstream stage. In network terms, an assembly network is a graph where each node can have multiple incoming arcs but only one outgoing arc. An example of a typical supply chain is shown in Figure 2:

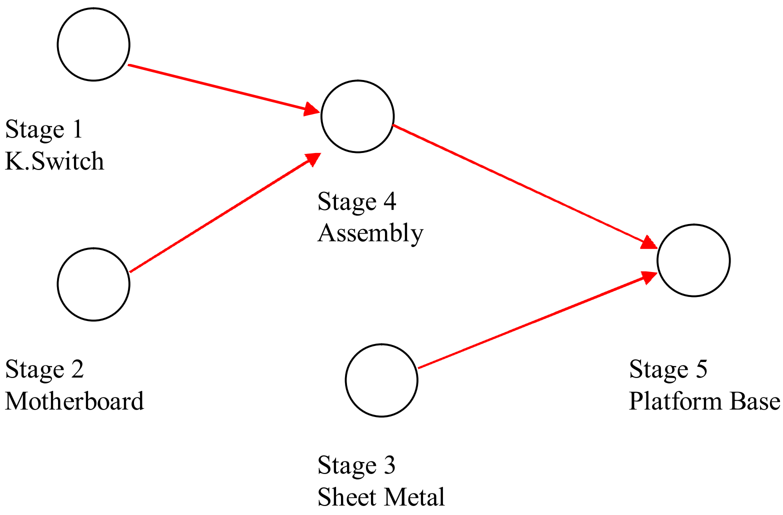


Figure 2. Assembly network supply chain

2.3 Distribution Network

A supply chain that can be modeled as a distribution network is one in which each stage can have only one supplier and one or more customers. In network terms, a distribution network is a graph where each node can have multiple outgoing arcs but only one incoming arc. An example of a distribution network is shown in Figure 3:

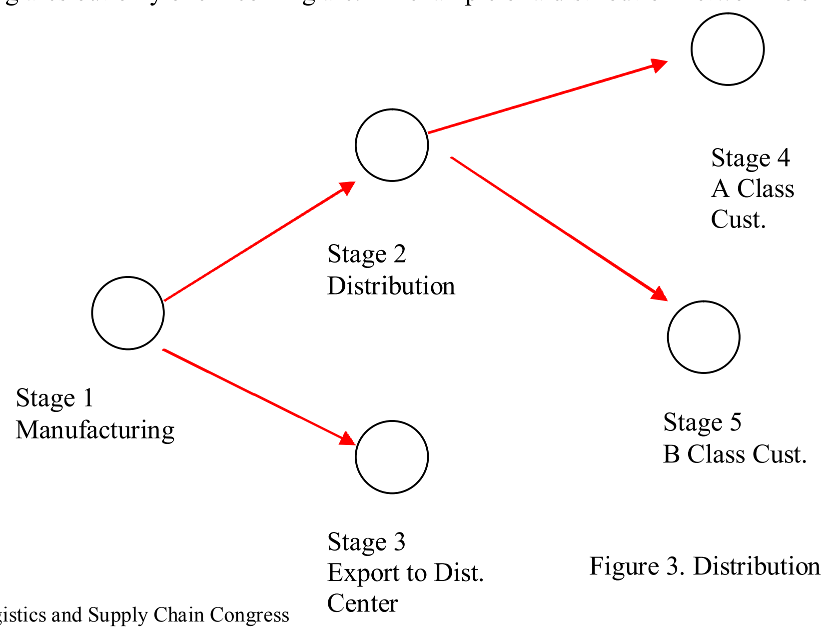


Figure 3. Distribution network supply chain

2.4 Spanning Tree Network

A spanning tree is connected graph that contains N nodes and N-1 arcs. Assembly networks and distribution network are both special cases of spanning trees. Spanning trees allow the flexibility to capture numerous kinds of a real world supply chains. In particular, they can model networks where a common component goes into different final assemblies that each have different distribution channels. An example of a typical supply chain is shown in Figure 4:

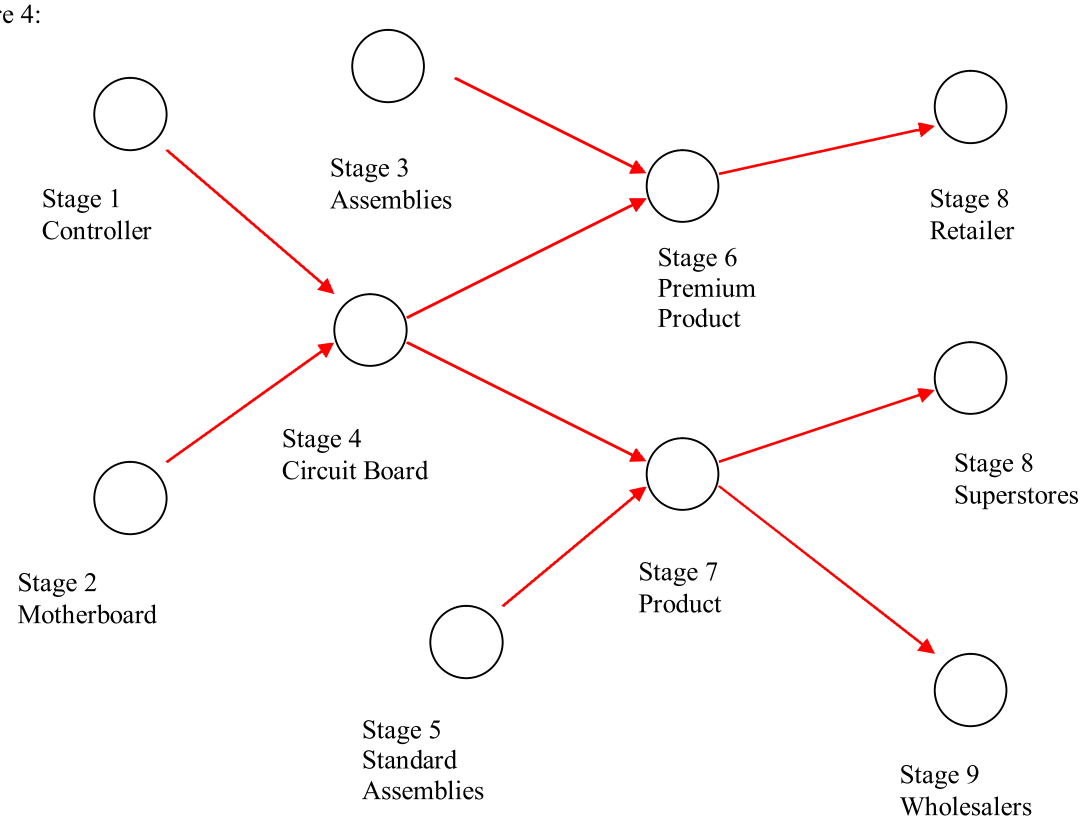


Figure 4. Spanning Tree network supply chain

## 3. Possibilistic APP Depending on Uncertainty & Assumptions

In real-world APP problems, input data or related parameters, such as market demand, available resources and capacity, and relevant operating cost, frequently are imprecise/ fuzzy owing to some information being incomplete or unobtainable. Generally, the environment coefficients and related parameters are uncertain in a medium time horizon. Therefore, the forecast demand, related operating costs and labor and machine capacity are imprecise over the planning horizon. With imprecise parameters, defining the APP problem with crisp numbers is inconvenient (Wang, 2005).

In these paper, we investigated the situation of an assembly or manufacture node (stage 7). As indicated in Fig.4 for instance stage 7 is situated in a middle node which process the inputs from stage 4 and stage 5 and send its output (product) to its downstream stages; stage 8 and stage 9. During the APP, all environmental data can be imprecise but this condition will need hard / complex linear programming knowledge and long computer time. Because of this, the planner must choose his/her possibilistic parameters. For instance (for stage 7) total demand requested by its downstream (stage 8 and stage 9) can be imprecise during all months. Analogously, workforce in stage 7, related by seasonal workforce changing, can be imprecise. We assumed that the left side of stage 7 data is precise; upstream stages (stage 4 and 5) are always provide %100 service and fulfillment requested by stage 7. This state is resumed in Figure 5, imprecise data will be demonstrated with ~ coefficients :

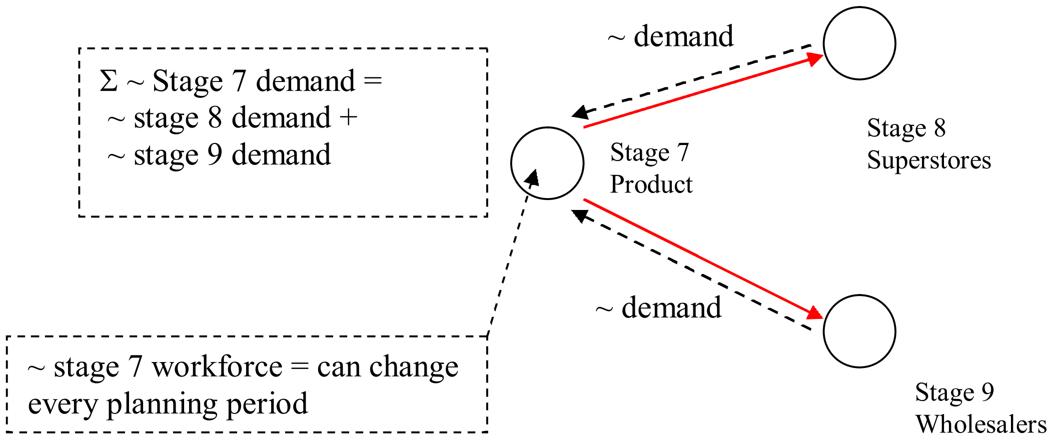


Figure 5. Imprecise coefficients ( factors) in stage 7.

## 4. Possibilistic Linear Programming and Model Development

The purpose of possibilistic aggregate production planning linear programming is to minimize the most possible value of the imprecise cost. In a possibilistic linear programming imprecise coefficients can be stated as

$$\text{Min } \tilde{z} = \sum_{i=1}^{n} \tilde{c}_i x_i \tag{1}$$

$$\text{s.t. } x \in X = \{x \mid Ax \le b, x \ge 0\}$$

where $\tilde{c}_i = (c_i^p, c_i^m, c_i^o)$, all I, are imprecise cost components and have triangular possibility distributions as in Figure 6. $c_i^m$ is the most possible value, $c_i^p$ (the most pessimistic value), and $c_i^o$ (the most optimistic value) are the least possible values.

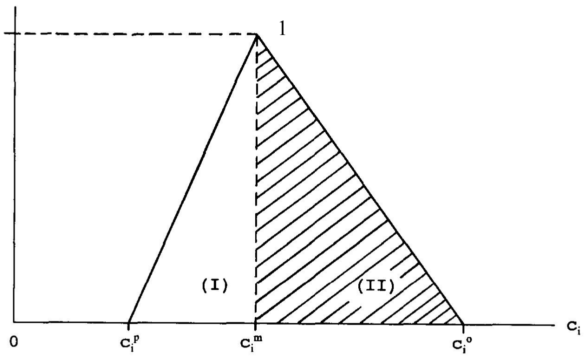


Figure 6. The triangular possibility distribution of $\tilde{c}_i$ (Lai&Hwang, 1992)

Related to triangular imprecise cost coefficients and demand data, the APP model is formulated as below. The simple precise model of single product model was given by Chung & Krajewski, 1984:

$$\text{Min } \tilde{z} = \sum_{t=1}^{m} (\tilde{C}_H \tilde{H}_t + \tilde{C}_F \tilde{F}_t + \tilde{C}_R X_t + \tilde{C}_O O_t + \tilde{C}_I I_t + \tilde{C}_U U_t) \tag{2}$$

subject to:

Inventory constraint:

$$I_{t-1} + X_t + O_t - I_t = \tilde{D}_t \tag{3}$$

$$I_t = B_t$$

Regular time production constraint

$$X_t - A_{1t} \tilde{W}_t + U_t = 0 \tag{4}$$

Overtime production constraint

$$O_t - A_{2t}\widetilde{W}_t + U_t = 0 \qquad (5)$$

Work force level change constraint:

$$\widetilde{W}_t - W_{t-1} - \widetilde{H}_t + \widetilde{F}_t = 0 \qquad (6)$$

Initializing constraints:

$$W_0 = A_3 \qquad (7)$$
$$I_0 = A_4 \qquad (8)$$
$$W_m = A_5 \qquad (9)$$

where

$\widetilde{C}_H = (\widetilde{C}_H^{\,p}, \widetilde{C}_H^{\,m}, \widetilde{C}_H^{\,o})$ = The cost of hiring an employee.

$\widetilde{C}_F = (\widetilde{C}_F^{\,p}, \widetilde{C}_F^{\,m}, \widetilde{C}_F^{\,o})$ = The cost of firing an employee.

$\widetilde{C}_R = (\widetilde{C}_R^{\,p}, \widetilde{C}_R^{\,m}, \widetilde{C}_R^{\,o})$ = The cost per labor-hour of regular time production.

$\widetilde{C}_O = (\widetilde{C}_O^{\,p}, \widetilde{C}_O^{\,m}, \widetilde{C}_O^{\,o})$ = The cost per labor-hour of overtime production.

$\widetilde{C}_I = (\widetilde{C}_I^{\,p}, \widetilde{C}_I^{\,m}, \widetilde{C}_I^{\,o})$ = The cost per month of carrying one labor-hour of hour.

$\widetilde{C}_U = (\widetilde{C}_U^{\,p}, \widetilde{C}_U^{\,m}, \widetilde{C}_U^{\,o})$ = The cost per labor-hour of idle regular time production.

$\widetilde{H}_t = (\widetilde{H}_t^{\,p}, \widetilde{H}_t^{\,m}, \widetilde{H}_t^{\,o})$ = The number of employees hired in month t.

$\widetilde{F}_t = (\widetilde{F}_t^{\,p}, \widetilde{F}_t^{\,m}, \widetilde{F}_t^{\,o})$ = The number of employees fired in month t.

$X_t$ = The regular time production hours scheduled in month t.

$O_t$ = The overtime production hours scheduled in month t.

$I_t$ = The hours stored in inventory at the end of month t.

$U_t$ = The number of idle time regular production hours in month t.

$\widetilde{D}_t = (\widetilde{D}_t^{\,p}, \widetilde{D}_t^{\,m}, \widetilde{D}_t^{\,o})$ = The hours of production to be sold in month t.

$B_t$ = The minimum number of hours to be stored in inventory in month t.

$A_{1t}$ = The maximum number of regular time hours to be worked per employee per month.

$\widetilde{W}_t = (\widetilde{W}_t^{\,p}, \widetilde{W}_t^{\,m}, \widetilde{W}_t^{\,o})$ =The number of people employed in month t.

$A_{2t}$ = The maximum number of overtime hours to be worked per employee per month.

$S_t$ = The number of unused overtime hours per month per employee.

$A_3$ = The initial employment level.

$A_4$ = The initial inventory level.

$A_5$ = The desired number of employees in month m (the last month in planning horizon).

$m$ = The number of months in planning horizon.

4.1. Solving Steps

1- This problem can be solve with aid of MOLP(multiobjective linear programming)(Lai &Hwang, 1992). First its required to write 3 crisp objective function and crisp constraint sets.

2- The main objective function is a minimization problem and this is why the objective of 3 crisp function and constraint sets should be presented as follow:

$$\text{Min } z_1 = z^m$$
$$= \sum_{t=1}^{m} (\widetilde{C}_H^m \widetilde{H}_t^m + \widetilde{C}_F^m \widetilde{F}_t^m + \widetilde{C}_R^m X_t + \widetilde{C}_O^m O_t + \widetilde{C}_I^m I_t + \widetilde{C}_U^m U_t) \qquad (10)$$

s.t. Equation (3) to (9)

---

$$\text{Min } z_2 = (z^m - z^p)$$

$$=\sum_{t=1}^{m}(\widetilde{C}_H^m-\widetilde{C}_H^p)(\widetilde{H}_t^m-\widetilde{H}_t^p)+(\widetilde{C}_F^m-\widetilde{C}_F^p)(\widetilde{F}_t^m-\widetilde{F}_t^p)+(\widetilde{C}_R^m-\widetilde{C}_R^p)X_t+(\widetilde{C}_O^m-\widetilde{C}_O^p)O_t+(\widetilde{C}_I^m-\widetilde{C}_I^p)I_t+(\widetilde{C}_U^m-\widetilde{C}_U^p)U_t) \quad (11)$$

s.t. Equation (3) to (9)

---

Max $z_3 = (z^o - z^m)$

$$=\sum_{t=1}^{m}(\widetilde{C}_H^o-\widetilde{C}_H^m)(\widetilde{H}_t^o-\widetilde{H}_t^m)+(\widetilde{C}_F^o-\widetilde{C}_F^m)(\widetilde{F}_t^o-\widetilde{F}_t^m)+(\widetilde{C}_R^o-\widetilde{C}_R^m)X_t+(\widetilde{C}_O^o-\widetilde{C}_O^m)O_t+(\widetilde{C}_I^o-\widetilde{C}_I^m)I_t+(\widetilde{C}_U^o-\widetilde{C}_U^m)U_t) \quad (12)$$

s.t. Equation (3) to (9)

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3- The constraint sets (Equation (3) to (9) ) have also imprecise coefficients ( $\widetilde{D}, \widetilde{W}$) . For converting them to crisp numbers w1, w2, w3 weights can be used (Lai and Hwang,1992) ; w1, w3 $= \frac{1}{6}$, w2 $= \frac{4}{6}$ .

Using Zimmerman fuzzy programming method with normalization process, Positive Ideal Solutions (PIS) and Negative Ideal Solutions should be calculated. These are

$$z_1^{PIS} = \min z_1, \qquad z_1^{NIS} = \max z_1 \quad (13)$$

$$z_2^{PIS} = \max z_2, \qquad z_2^{NIS} = \min z_2 \quad (14)$$

$$z_3^{PIS} = \min z_1, \qquad z_3^{PIS} = \max z_1 \quad (15)$$

4- For the final solving step, linear membership function of these three objective function can be computed as:

$$\mu z_1 \neq \begin{cases} 1, & z_1 < z_1^{PIS}, \\ \dfrac{z_1^{NIS} - z_1}{z_1^{NIS} - z_1^{PIS}}, & z_1^{PIS} \le z_1 \le z_1^{NIS}, \\ 0, & z_1 > z_1^{NIS}, \end{cases} \quad (16)$$

$$\mu z_2 \neq \begin{cases} 1, & z_2 > z_1^{PIS}, \\ \dfrac{z_2 - z_2^{NIS}}{z_2^{PIS} - z_2^{NIS}}, & z_2^{NIS} \le z_2 \le z_2^{PIS}, \\ 0, & z_1 > z_1^{NIS}, \end{cases} \quad (17)$$

$$\mu z_3 \neq \begin{cases} 1, & z_3 < z_3^{PIS}, \\ \dfrac{z_3^{NIS} - z_3}{z_3^{NIS} - z_3^{PIS}}, & z_3^{PIS} \le z_3 \le z_3^{NIS}, \\ 0, & z_3 > z_3^{NIS}, \end{cases} \quad (18)$$

5- In the final step to complete equivalent single-goal LP model by using decision maker satisfaction degree coefficient (L) can be formulated as follows:

$$
\begin{aligned}
&\text{Max } L \\
&\text{s.t} \\
&L \le \mu(z_i), i = 1,2,3 \\
&I_{t-1} + X_t + O_t - I_t = D_t \\
&I_t = B_t \\
&X_t - A_{1t} W_t + U_t = 0 \\
&O_t - A_{2t} W_t + U_t = 0 \\
&W_t - W_{t-1} - H_t + F_t = 0 \\
&W_0 = A_3 \\
&I_0 = A_4 \\
&W_m = A_5 \\
&0 \le L \le 1, \\
&X_t, O_t, I_t, D_t, A_t, W_t, U_t, B_t, H_t, F_t \ge 0
\end{aligned}
\qquad (19)
$$

After the computational result, L is showing the common satisfaction degree of three objective functions (Eq 10, 11,12). If L=1, the result will satisfy the decision maker(DM)/planner at higher level. Lower than 0,5 is generally unacceptable area in the literature. For better L, DM can modify imprecise data and related model parameters until a satisfactory solution is found.

## 5.Conclusion

Transferring the PLP to an auxiliary crisp MOLP problem, PLP problem can be easily solved and different satisfaction level solutions can be seen by decision maker interactively. This facilitates the decision making process, enables a DM to interactively modify the imprecise data and related model parameters.

Possibilistic linear programming approach outputs more wide ranging decision information than other models. The solution has the nature of maximizing the possibility of lower cost, minimizing the most possible cost and minimizing the possibility of higher cost. Thus PLP is a very efficient technique to solve problems with imprecise nature in the world.

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# APPROXIMATIVE REASONING APPROACH TO OPERATORS WORKLOAD ESTIMATION

Čičević Svetlana [1], Dimitrijević Branka [2]


## Abstract

*Better knowledge about reliable indicators – parameters of various levels of operators workload, would help to confident prediction of their performances, concerning upon numerous influencing and intervening factors. In such a way, conditions leading to mistakes or failures could be predicted and eliminated, which directly increases the systems safety, resulting in optimal human resources management, i.e. protecting their mental and physical health. As human voice carries significant information about the state of a speaker, acoustic analysis of operators speech samples was conducted. Some acoustic parameters were derived. Among them, the first three formants of speech were chosen for further analysis. Aapproximate reasoning, bi-univocal uniform correspondence of homogeneous elements and correlative transformation, upon the first three formant frequencies was performed.*


*Keywords: Workload, Formant structure of speech, Aapproximate reasoning*

## 1. Introduction

Even highly reliable technical systems and technological processes are subject to failures the initial cause of which does not lie in them. If the causes resulting from the impact of the environment on the considered system are left out, the most frequent factor of the system unreliability is human error. Man is the immediate cause of 20% - 90% of all system failures (60% − 70% in land transport, ≅ 75% in air transport, ≅ 70% in industry, in the army from 74% during the period of peace up to 90% during war). This fact has led to a sharp increase of interest in studying human reliability for the purpose of eliminating, i.e. reducing human errors in production systems. In the aspect of working activities and the quality of performed work, functional condition is considered as a sum of features of those functions and qualities which directly or indirectly influences fulfilling the required tasks.

### 1.1. Concept and definition of operators workload

The term 'workload' has been used to describe elements of interactions that occur between an operator and assigned tasks (Gopher and Donchin, 1986, Parasuraman et al., 1993, Wickens and Holland, 2000). Further, workload is described as a measure of the *cost* of accomplishing those assigned tasks for the human; costs include fatigue, stress, and the depletion of attention and cognitive resources resulting in the inability to accomplish additional tasks and often concomitant performance decrements.

In various complex socio-technical systems, as for instance in the field of logistics, human agents are faced with a variety of threats that impose periods of high and low workload. In the same manner, an early workload assessment of air traffic controllers identified the need for workload prediction to assist planning and staffing of air traffic control rooms. High levels of workload degrade the operator's concentration, information processing and decision making, leading to increased errors which might have catastrophic effects. However, low workload can also be pathological since it causes boredom and can result in a deterioration of performance. The number of operators needed for each shift is largely defined by the expected peaks of workload during the shift. Time line analyses can be performed on the identified scenarios to estimate peak workloads and find points at which several simultaneous operator tasks may be needed. Therefore, to guarantee the best level of performance efficiency avoiding excessive mental stress and fatigue, particular attention has to be paid to arranging duty periods.

Analytical techniques simulate aspects of human behavior and performance to estimate workload using a variety of mathematical models based on information theory, manual control and queuing theory; simulations and task analysis using fuzzy logic and discrete event simulation (Wetteland et al. 2000) to model workload in task sequences.

Research in mental workload can be said to explore three areas: 1) prediction of performance, 2) the assessment of workload imposed by the system on the operator, and 3) the assessment of workload that is experienced by the human.

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The fact that behavior is multidimensional needs to be considered when choosing a particular measure, and even then, the relationship between objective and subjective data is unclear. Useful measures of mental workload should meet the following criteria (properties):

*Sensitivity*: A criteria referring to how well a measure detects changes in the mental workload (e.g., task difficulty and/or resource demand). The measure should distinguish task situations that intuitively seem to require differing levels of mental workload (Sanders and McCormick, 1993). Oftentimes, the degree of sensitivity of a given measure depends on that workload level experienced by the operator.

*Diagnosticity*: This criterion indicates not only when workload varies but also the *cause* of that variation. For example, by varying only one aspect of the task at a time, elucidation of which particular aspect is responsible for the non-optimal workload level may be fostered.

*Reliability*: The measure should offer a reasonable estimate of workload with a 'bandwidth' such that any important, transient changes can be observed. The reliability criterion is concerned with whether the measure is *stable and consistent* over an extendable time. This is a question of being able to replicate workload measures in similar environs: if they can be replicated, they are considered reliable.

*Obtrusiveness*: Sometimes called 'acceptability', this criterion indicates a measure that does not interfere with, contaminate, or disrupt performance of the primary task. In short, the measure should be acceptable to the person being measured.

*Validity*: There are many types of validity with respect to workload, but a general definition of validity is that the measure measures what it is supposed to measure.

*Implementation Requirements*: When designing measures or selecting methods of measuring, one must consider the implementation requirements of the measure set. The general issues to be considered include ease of data collection, robustness of the measurement instruments, and overall data quality control. These issues apply to design and maintenance of laboratory measurement systems and instruments as well as to simulator studies and field exercises.

Brenner, Doherty, and Shipp (1994) suggested that speech would be a valuable assessment index of workload because of its unobtrusive nature. Modern speech analyzing software could enable the goal of obtaining an easily-computed set of task load measures for prediction of operators workload.

### 1.2. Speech measures in workload estimation

In the field of speech analysis, workload and fatigue as its consequence, has been found to alter the normal behavior of the human speech production and the resulting speech feature characteristics. Workload changes the normal speech production process, resulting in irregular vocal fold movement, vocal tract articulator perturbation, variation in airflow from the lungs, changes in sub glottal air pressure, and other vocal system modifications. The area of speech analysis has drawn many researchers into investigating the vocal and acoustical changes caused by the functionally altered state of the speaker.

A body of research has given rise to the suggestion that voice is an indicator of the psychological and physical state of an individual (Brenner and Cash, 1991; Williams and Stevens, 1969; Ruiz et al., 1990; Brenner et al., 1994; Kuroda et al., 1976). The potential of using voice as an indicator of the physical and emotional state of an individual is great. An advantage of using voice as an indicator of the condition of an individual is its unobtrusive nature.

The manner in which workload will lead to changes in speech can be considered from two perspectives (Baber and Noyes, 1996). A mechanical perspective would assume that workload would induce measurable physical changes in the speech production apparatus, e.g., muscle tension could increase resulting in changes to speech level and fundamental frequency. Other mechanisms might include changes to the dimensions of the vocal tract, resulting in changes of formant frequencies.

Simonov and Frolov (1973) found that analysis of formant structure could be used to differentiate emotional from physiological stress and predict the direction (i.e. positive or negative) of emotional stress. Further evidence points to a change in the precision of the first two formants under cognitive or emotional stress, with the direction of change depending on the coping strategy adopted by the speaker (Tolkmitt & Scherer, 1986).

The formants are one of the quantitative characteristics of the vocal tract. In the frequency domain, the location of vocal tract resonances depends upon the shape and the physical dimensions of the vocal tract. Since the resonances tend to ''form'' the overall spectrum, speech scientists refer to them as formants. Each formant is characterized by its center frequency, amplitude and its bandwidth. It has been found that subjects during stress or under depression do not articulate voiced sounds with the same effort as in the neutral emotional state (Tolkmitt and Scherer, 1986). During the emotional states of happiness and anger, the second formant (F2) is confuse with the first formant (F1) and F1 interfere with the pitch frequency. Stressed or colored by anger speech may be expressed with a low articulation effort, a fact which causes formant peak smoothing and spectral flatness as well as energy shifting from low to high frequencies in the power spectrum. House and Stevens (1956) found that as coupling to the nasal cavity is introduced, the first formant amplitude reduces and its bandwidth and frequency increase. Fant (1960) reviewed the acoustic characteristics of nasalization pointed out in literature until then, and from his own observations confirmed the reduction in the amplitude of the first formant due to an increase in its bandwidth, and the rise in the first formant frequency. In nasalized speech, which occur in the state of fatigue an increase in F1 and F2 bandwidths, an increase or decrease in the intensity of harmonics, and an increase or decrease in F1, F2 and F3 frequency. Fujimura and Lindqvist (1971) observed a movement in the frequency of the first formant toward higher frequencies. In Jitica, et al. paper (2002), the analysis was directed towards the study of the dynamics of acoustic parameter values.

### 1.3.Working time and operators functional condition

A huge amount of literature considers the effects of prolonged working time on development of human operators fatigue. But, in some kinds of professions which include short working time intervals with high mental and low to moderate physical workload, operators performances show specific pattern of changes. At the end of working interval fatigue occurs, but in the course of the duty some disturbances of operators functional condition take place, which could be designated as instability. In such kind of state the possibility of human errors is very high leading to unsafe operations with catastrophic consequences. This problem was not treated in the literature, in more details. It is necessary to find out a measure or combination of measures which could predict when such performances deterioration will occur, in order to make better staff scheduling model. The solution could be in shortening of working intervals or eliminating operators whose performances are not at optimal level, which protect their physical and mental health and contribute to the system safety.

*The scope*: The purpose of this research was to examine voice recordings taken over operators short working cycles in order to determine the effects of workload and fatigue on simple voice characteristics. This research raises the fundamental questions of whether it is possible to compensate for the production of speech under workload, i.e., whether it might be possible to produce algorithms which track the graceful degradation of utterance consistency in speakers under workload.

The main goal of this paper is operators functional condition estimation on the basis of formant structure of speech by implementing of approximate reasoning.

Remaining part of the paper is organized as follows. Section 2 describes our approach to approximate reasoning. In the Section 3 Fuzzy model concept for workload estimation, only from formants central frequencies as input variables is shown. In the Section 4 some computational results based on real sample were analyzed, and Section 5 gives conclusion remarks.

## 2. Implementation of fuzzy systems in workload estimation

The question is how does speech production change when people are working? If it is possible to demonstrate significant effects of workload on speech production, then additional care needs to be taken in the implementation of ASR in cockpits and in other domains where workload is likely to be high. In this paper attention is given to the nature of workload, its effect on speech production and the impact workload can have on the performance of operators.

The natural vocal signal never repeats itself, even in the case of constantly uttered vowels. The variability is easily noted by monitoring: the zero crossing rate, the pitch, the shape of time domain signal, time domain envelope, variation of the central frequencies and of the bandwidths of formants etc. Statistical tests for nonstationarity can also be used to the same end. Speech signal may be regarded as a concatenation of nonlinear regimes, i.e. a mixture of nonlinear and nonstationary processes. Thus, the theory of fuzzy-sets could be introduced to the field of human reliability assessment.

Fuzzy logic first advanced in the mathematical literature by Zadeh (1965), was developed to handle situations such as these, where states or events do not fall strictly into the ‘yes/no’ categorizations known in fuzzy logic parlance as crisp sets.

Fuzzy logic is a mathematical model that allows computers and analytical processes to account for the vagueness (fuzziness) in concepts; fuzzy logic is designed to reflect one of the ways that humans think. Fuzzy logic control was derived to combine the structure of conventional automatic control with the knowledge base of humans or experts. Knowledge is retained in a rule base. Even when a process is complicated and modeling the process is too difficult or too costly, a fuzzy logic controller can be employed. Using only the knowledge of an experienced process operator, a fuzzy logic controller can be derived. The fuzzy sets are created by the control system designer to aid in the reasoning about control actions given conditions expressed in terms of fuzzy sets.

In the field of speech research, fuzzy logic was implemented for improving the algorithms for feature extraction, in ASR and speaker verification as well as in speech synthesis.

### 2.1. Changes of formant structure under the influence of workload

According to theoretical and experimental knowledge (laboratory and in-field studies) speech changes patterns during workload show some similarities, but also, some differences as compared to those in states of situational or emotional stress and excitation, although the last might be considered as inherent part, as well as the natural consequece of operators load. Formant structure also show different directional changes after working interval of various duration.

With respect to the results of field study conducted by the author of this paper, after short working cycles, F1 demonstrate shifts towards lower frequencies, spectral range is narrower and the amplitude decreases. Central frequency and bandwidth of the second and third formant increase, while their amplitudes fall. In sum, F1 decreases while F2 and F3 raise, BW1 narrows, BW2 and BW3 widen, as far as A1, A2 and A3 diminish.

After two hours of work F1 and A1 raise and BW1 decreases. Central frequency of the second formant decreases, BW2 enlarges and A2 increases. F3 and BW3 show decreasements while A3 raises. Briefly, F1 increase, F2 and F3 decrease, BW1 and BW3 become narrow, while BW2 seems to be wider, and the amplitudes of all three formants increase. Generally, after short working interval amplitudes decrease, while after two hours of work all three amplitudes show growth.

The increasement of formant central frequencies and amplitudes together with narrowing of their bandwith, means excitation of an individual being exposed to stress, higher activation level and muscle tension, which take place after two hours on duty. If formant frequencies values show decrements and their bandwidth become wider, simultaneous with amplitude decrement, this implies lower muscle tension, as in the case of depresion. However, concering those changes in the light of working abilities, such changes indicate lower level of fatigue developing after short working intervals.

2.2. Framework for designing workload estimation fuzzy system

On the basis of above described relationship between formant structure and experienced workload, and in with the respect of the in field study conducted by one of the authors of this paper, 9 formant features turned out to be important for operators workload estimation (Čičević, 2005).

It is necessary to remark, that, even though, the fundamental frequency of speech (F0) is one of the most important and prominently utilized parameter in research practice, in this work, the attempt was made to emphasize the formant structure of speech which is more authentic, complex and to certain degree, less explored. Numerous and various F0 characteristics could be successfully introduced to the suggested concept and certainly will be one of the further steps in our research.

Considering nine formant features proposed in this study, which were designated as input variables, two global concepts in the development of fuzzy system were established.

The first approach, considered more detailed in this paper, include the two phase fuzzy system (controller), based on three categories of rules, which, in the first phase, would be aggregated through three output variables describing operators functional condition (FC), founded on the partial values of three basic formant features. This kind of two phased fuzzy system is depicted in Figure 1. The second phase of the proposed fuzzy system have to imply repeated aggregation of obtained partial output variables values into one singular variable describing the overall operators functional condition.

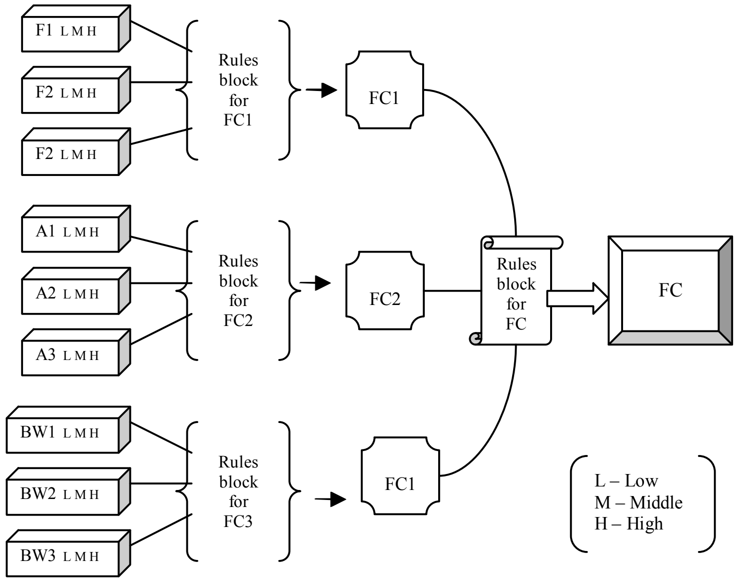


Figure 1. The two phased fuzzy system

Concerning the number of input variables, fuzzy system conceptualized in the manner of linguistic variables containing only three classes of values (for example, low-middle-high) obviously claims for formulating of 3 groups with 27 rules ($3^3$) in the first phase, and another group containing 27 rules, in the second phase. Therefore, the entire set of rules in fuzzy system will be 108. However, the total amount of rules in the system was reduced in the course of model development as will be shown later in the text.

According to above mentioned, the model of fuzzy system proposed in this paper, include three fuzzy systems for each variable: Low, Middle and High, which is shown in Figure 2 where example of the input variable F1 is depicted.

For the first variable F1, for Low set Z – Type with parameters :150 and 500 was used, for Middle the Bell– Type with parameters :200, 350 and 700 and for High the S – Type with parameters :200 and 800,

For F2, for Low set Z – Type with parameters : 500 and 1300, for Middle the Bell– Type with parameters : 800, 1400 and 2100, and for High the S – Type with parameters :1200 and 2300 and

For F3, for Low set Z – Type with parameters : 1500 and 3000, for Middle the Bell– Type with parameters : 1500, 2200 and 3000, and for High the S – Type with parameters :1900 and 4000.

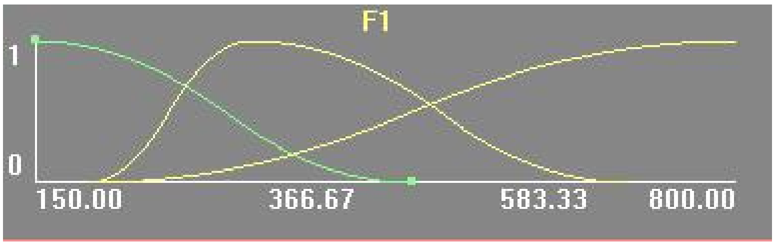


Figure 2. Example of the membership functions for variable *F*1.

Each of the output variables is defined in the same way.

For the output variable for Optimal condition Z – Type set with parameters :15 and 50 was used, for Unstable, Bell type with parameters :15, 50 and 90, and for Fatigue, S – Type with parameters :50 and 85.

An example of the output variable is represented in Figure 3.

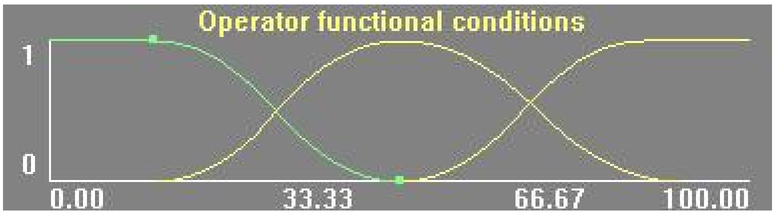


Figure 3. Example of the output variable .

Set of the rules used in the second phase for aggregation of the functional condition of the operator are :

IF F1 is Low AND F2 is Low AND F3 is Low THEN Operator functional conditions is Fatigue
IF F1 is Low AND F2 is High AND F3 is Low THEN Operator functional conditions is Unstable
IF F1 is Middle AND F2 is Middle AND F3 is Middle THEN Operator functional conditions is Optimal
IF F1 is High AND F2 is Low AND F3 is Low THEN Operator functional conditions is Fatigue
IF F1 is High AND F2 is High AND F3 is High THEN Operator functional conditions is Unstable
IF F1 is High AND F2 is Middle AND F3 is Low THEN Operator functional conditions is Optimal

IF BW1 is Low AND BW2 is High AND BW3 is Low THEN Operator functional conditions is Fatigue
IF BW1 is Low AND BW2 is Low AND BW3 is Low THEN Operator functional conditions is Fatigue
IF BW1 is Low AND BW2 is Middle AND BW3 is High THEN Operator functional conditions is Optimal
IF BW1 is Middle AND BW2 is Middle AND BW3 is High THEN Operator functional conditions is Unstable
IF BW1 is High AND BW2 is Low AND BW3 is Middle THEN Operator functional conditions is Optimal

IF A1 is Low AND A2 is Low AND A3 is Low THEN Operator functional conditions is Unstable
IF A1 is Middle AND A2 is High AND A3 is High THEN Operator functional conditions is Optimal
IF A1 is High AND A2 is Middle AND A3 is Middle THEN Operator functional conditions is Fatigue
IF A1 is High AND A2 is Middle AND A3 is Low THEN Operator functional conditions is Optimal

The second approach could be based on the generation of one-phased system, in which total amount of rules will be $3^9 = 19683$ fuzzy sentences. In this case the form of fuzzy sentence will be as follows :

IF F1 is ... AND F2 is ...AND F3 is ... AND BW1 is … AND BW2 is … AND BW3 is …AND A1 is … AND A2 is … AND A3 is … THEN FC is …

However, this approach overcome the purpose of this paper.

3. Illustrative fuzzy model for workload estimation based on formant structure

In our work, we computed acoustic correlates including those providing prosodic information of the speech signal. The chosen features comprised utterance-level statistics corresponding to formant structure, which suppose to be, according to many research findings, in correlation with psychophysiological state and workload of the operator. Thus, an attempt was made to investigate the contribution of formant features to various levels of operators functional condition by development of fuzzy model.

The ability of previously described fuzzy system to reveal for operators workload estimation, was tested by treating only the initial segment within the first phase of the model, as well as, the accuracy of the basic postulates of the whole system.

Based on previously explained approach fuzzy system presented in Figure 1 was analyzed. Formants: first, second and third formant frequencies (F1, F2, F3), their amplitudes (A1, A2, A3) and bandwidths (BW1, BW2, BW3). The main formant features – central frequency, spectral bandwidth and amplitude correspond to three fuzzy systems. Ranges for the input variables are respectively :

F1: Minimum value : 150 Hz, Maximum value : 800 Hz
F2: Minimum value : 500 Hz, Maximum value : 2300 Hz
F3 : Minimum value : 1500 Hz, Maximum value : 4000 Hz

BW1: Minimum value : 100 Hz, Maximum value : 1000 Hz
BW2: Minimum value : 130 Hz, Maximum value : 900 Hz
BW3 : Minimum value : 120 Hz, Maximum value : 900 Hz

A1: Minimum value : 80 dB, Maximum value : 117 dB
A2: Minimum value : 72 dB, Maximum value : 101 dB
A3 : Minimum value : 64 dB, Maximum value : 91 dB

The set of implemented rules was presented in Section 2. Min Max Mamdani inference system was used with central of gravity defuzzufier. The model was tested on 40 values recorded in real situation from speech samples of air traffic controllers working at Belgrade airport. The results were analyzed by "Un-fuzzy 1.2 software" developed at Universidad Nacional de Colombia 1998.

## 4. Computational experience

Real time data for operators who spent on duty between 0 and two hours, together with assessments given by experienced expert in this field are shown in Table 1. Knowledge about working interval durations, as well as recorded values for amplitude and bandwidth of the first three formants were included in expertise. The results show that average error expressed in average deviation from expert estimations is 63.4%. Obviously, results obtained by applying mentioned illustrative model show relatively large error, but they are encouraging having in mind the fact that only six rules were used, and only F1 values are considered. Hence, further research needs to analyze more complex fuzzy system as it is shown in the Fig. 1, and more thoroughly tuning of parameters, rules, inference systems, as well as variables shapes themselves.

## 5. Discussion and conclusions

The possibility of approximate reasoning approach upon formant structure of speech for operators functional condition estimation was tested in this study. In spite the fact that fuzzy logic enlarge its application in numerous fields from arranging time tables of various types, predicting genetic traits, temperature control, anti-block braking systems, predicting travel time, medical diagnosis, etc., although there are some investigations concerned with job activities scheduling and utilization of speech parameters in ASR and speech synthesis, there are no research considering direct effects of operators workload on formant structure of speech, and the possibility of implementing fuzzy system which could link them. In this paper, two general approaches to fuzzy system development were proposed, founded on two- ore one-phased controller. One segment of the introduced two-phased fuzzy system, where estimations of operators functional condition were gathered on the basis of first three formant frequencies, was developed and tested on numerical example acquired from real data.

The application of the model yielded results which could encourage us for further research. The next step has to be the two-phase model elaboration and additional rules introduction which, probably will the benefit to accuracy. To the certain degree, some constraints come form the point of view of phonetic science. Speech content, analysed in this study was one segment of the word containing four syllables, hence, formant structure of this segment is liable to coarticulation, ie. contextual overlaping of formant characteristics of vocals and consonants. It is necessary to examine more vocal-consonant combinations. Furthermore, improved algorithms for formant features extraction probably could give us better results. However, it has been shown that there are certain similarities for real, as well as for estimated values, in some subjects, in the state of rest (working 0 h) and those working two hours. Physiological explanation may be taken into account, we assume that, some irregularities in operators physiological functions take place after 1h 30 min, when fine homeostasis is disturbed. Thus, operators performances are not optimal and the probability of making errors increases. After two hours of work operators are fatigued, with lower level of performances - some habituation to the situation arises, their reactions are stable and they are much reliable, than those working shorter.

Thus, some other formant features, like for example, spectral tilt (the amplitude difference between formants as well as inter formant distances has to be included into the set of rules.

Table 1. Results of model application

| subject | time | F1(Hz) | F2(Hz) | F3(Hz) | expert | model | % |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 549 | 1356 | 2077 | 30 | 19.587 | 50 |
| 2 | 0 | 721 | 1324 | 2551 | 60 | 26.648 | 122.2 |
| 3 | 0 | 409 | 1195 | 2357 | 28 | 21.210 | 33.3 |
| 4 | 0 | 430 | 1410 | 2260 | 30 | 21.417 | 42.857 |
| 5 | 0 | 355 | 1410 | 2476 | 15 | 22.433 | 31.818 |
| 6 | 0 | 290 | 1291 | 2164 | 12 | 19.379 | 36.842 |
| 7 | 0 | 430 | 1313 | 2260 | 23 | 18.651 | 21.05 |
| 8 | 0 | 409 | 1302 | 2433 | 22 | 18.766 | 15.789 |
| 9 | 0 | 355 | 2056 | 2551 | 10 | 51.478 | 80.392 |
| 10 | 0 | 312 | 1475 | 2002 | 20 | 24.178 | 16.66 |
| 11 | 0 | 419 | 1367 | 2336 | 31 | 19.893 | 55 |
| 12 | 0 | 290 | 1367 | 2465 | 15 | 21.570 | 31.818 |
| 13 | 0 | 775 | 1388 | 2476 | 80 | 29.045 | 175.86 |
| 14 | 0 | 441 | 1302 | 2465 | 30 | 19.041 | 57.894 |
| 15 | 1h30m | 441 | 1356 | 2013 | 35 | 19.977 | 75 |
| 16 | 1h | 409 | 1259 | 2024 | 32 | 17.963 | 77.77 |
| 17 | 1h | 312 | 1453 | 2325 | 10 | 23.104 | 56.521 |
| 18 | 1h | 398 | 1238 | 2497 | 28 | 19.371 | 47.368 |
| 19 | 1h | 333 | 1378 | 2487 | 2 | 21.457 | 90.476 |
| 20 | 1h | 409 | 1313 | 2400 | 30 | 18.763 | 57.894 |
| 21 | 1h | 355 | 1959 | 2551 | 70 | 46.459 | 52.173 |
| 22 | 1h10m | 366 | 1345 | 2185 | 3 | 18.947 | 84.21 |
| 23 | 1h10m | 527 | 1324 | 2228 | 55 | 21.329 | 161.904 |
| 24 | 1h | 312 | 1421 | 2067 | 3 | 21.963 | 86.363 |
| 25 | 1h | 366 | 1313 | 2487 | 17 | 19.520 | 15 |
| 26 | 1h30m | 344 | 1905 | 3854 | 75 | 52.107 | 44.230 |
| 27 | 2h | 344 | 1324 | 2088 | 2 | 18.612 | 89.473 |
| 28 | 2h | 419 | 1378 | 2497 | 35 | 21.599 | 59.09 |
| 29 | 2h | 247 | 1421 | 2379 | 0 | 33.182 | 100 |
| 30 | 2h | 258 | 1442 | 1991 | 5 | 30.796 | 83.87 |
| 31 | 2h | 312 | 1442 | 1733 | 10 | 33.506 | 70.588 |
| 32 | 2h | 236 | 958 | 1453 | 90 | 78.710 | 13.924 |
| 33 | 2h | 376 | 1410 | 2153 | 20 | 20.797 | 4.761 |
| 34 | 2h | 398 | 1302 | 2508 | 40 | 19.486 | 110.526 |
| 35 | 2h | 492 | 1496 | 2422 | 60 | 25.806 | 130.769 |
| 36 | 2h | 366 | 1313 | 2454 | 17 | 19.193 | 10.526 |
| 37 | 2h | 484 | 1324 | 2142 | 33 | 20.038 | 65 |
| 38 | 2h | 441 | 1367 | 2411 | 30 | 20.280 | 50 |
| 39 | 2h | 732 | 1453 | 2616 | 70 | 39.506 | 75 |
| 40 | 2h | 419 | 1367 | 1948 | 32 | 21.106 | 52.380 |

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# A MULTI-FACET PLANNING MODEL BASED ON GENETIC ALGORITHM FOR A VEHICLE ROUTING PROBLEM

Min Qiu[1], Lixi Zhang[2]

## Abstract

*Excel is a user-friendly package for data manipulation and can handle complex data relationships. However, it has a limited capacity to deal with non-linear combinatorial optimization problems. The advent of Evolver, a proprietary "Add-Ins" package to Excel, has changed this.*

*The paper presents a genetic algorithm (GA) model for the multi-facet planning for delivery vehicles using "milk runs"; vehicles carry a full or partial truckload from a warehouse to deliver to multiple customers. Planning decisions allocate customer orders to vehicles, work out a sequence for each vehicle to deliver multiple orders and determine its departure time. The objective is to minimise the total distance travelled. The constraints are: the vehicle type needs to match that of goods ordered by customers; the allocation of orders to each vehicle cannot exceed the corresponding load capacity; and the vehicle arrival at each customer shall be within a preferred time period. The model also considers the grid structure of roads linking the warehouse and customers, and the congestion during different periods of a day.*

*The model sets up various parts of the process by utilizing built-in functions in Excel and uses Evoler to search for the optimal solution.*

Keywords: Vehicle routing problem, Vehicle allocation, Type of goods, Time windows, Roads, Congestion, Genetic Algorithm, Excel

## 1. Introduction

In a system of vehicle delivery using "milk runs", vehicles carry a full or partial truck load from a warehouse to deliver to multiple customers. Planning decisions allocate customer orders to individual vehicles, work out a route for each vehicle and determine the departure time. The objective is to minimise the total travel distance. Meanwhile, the vehicle type needs to match that of goods ordered by customers, the allocation of orders to each vehicle cannot exceed the corresponding load capacity, and its arrival time at each customer location shall be within a preferred time period. Vehicles travel along the shortest road paths linking customers and take account of different average travel speeds in various time periods in a day.

This is a combinatorial optimization problem with mixed nature of decisions variables, on which some tailor-made search methods have been developed. These methods are based on varieties of algorithms, such as an adaptive insertion-based heuristic (Currie and Salhi, 2003), heuristic algorithms based on the column generation method and the simulated annealing algorithm (Kim et al., 2002), evolution strategies (Homberger and Gehring, 1999), and a mathematical approach (Min et al., 1992). One of the commonality of these different methods is that they probably operate on some sort tailor-made computer programs.

Excel is probably one of the most widely used packages in the business world for data manipulation and presentation. One of its significant features is that it can handle complex relationships between data items through built-in functions. By incorporating its programming language VBA (Visual Basic for Applications) and add-in programs, Excel can be used as a search tool that is powerful enough to deal with complex combinatorial optimization problems.

The paper reports a multi-facet planning model for the delivery vehicle routing problem. The model is based on Excel to build most relationships between variables and to calculate the objective function. VBA is used to build a user defined function specific to the problem and to search for the shortest paths between customers on a road network. A third-party "Add-In" software to Excel, Evolver, is used as a search tool for the optimal solution.

## 2. Specification of the Problem

This is a mixed combinatorial optimisation problem for minimising the total travel distance ($L$) by vehicles, with three sets of decision variables:

- Grouping subsets of customers by vehicles,
- Finding the sequences of customers to be delivered by vehicles, and
- Determining the vehicle departure times from the warehouse.

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### 2.1 Allocation of Customer Orders to Vehicles

The essence of allocating customer orders to individual vehicles is to group a subset of customers or null customers into the corresponding vehicles. Null customers being grouped into a vehicle means it does not deliver any customer order and stays at the warehouse.

In this study, orders are classified as ordinary and chilled goods, and two types of vehicles are needed respectively. When orders are allocated to vehicles, the type of orders needs to be matched by that of vehicles, and one kind of order, either ordinary or chilled, from a customer is not allowed to allocate to more than one vehicle.

A critical issue when allocating orders is that no vehicle is to be overloaded. Let $N$ denote the number of delivery vehicles, $C_i$ and $m_i$ the subset and number of customers respectively whose orders are to be delivered by vehicle $i$, $G_i$ the load capacity of vehicle $i$ ($i$ = 1, 2, …., $N$), and $O_{C_{ij}}$ the order size of customer $C_{ij}$, which is customer $j$ to be delivered by vehicle $i$, $C_{ij} \in C_i$ ($j$ = 1, 2, …, $m_i$ and $i$ = 1, 2, …, $N$), then the vehicle capacity constraint is defined as the following:

$$\sum_{j=1}^{m_i} O_{C_{ij}} \le G_i \quad (j = 1, 2, \ldots, m_i \text{ and } i = 1, 2, \ldots, N). \qquad (1)$$

### 2.2 Vehicle Routing

Planning a route for a vehicle $i$ to visit each customer in the subset $C_i$ is to equivalently shuffle the sequence of visiting the customers to deliver their orders.

Let $R_{iq}$ denote the code of the customer which is the $q$th client to be delivered by vehicle $i$, where $R_{iq} \in C_i$ ($q$ = 1, 2, …, $m_i$ and $i$ = 1, 2, …, $N$). Then, a sequence in which vehicle $i$ visits each customer is a permutation of the codes of those whose orders are to be delivered by vehicle $i$.

For example, if the orders of five customers: Customer 1, 2, 3, 4 and 5, are to be delivered by vehicle 1, the corresponding customer subset is $C_1 = \{1 \quad 2 \quad 3 \quad 4 \quad 5\}$ and a delivery sequence: $1 \to 3 \to 5 \to 2 \to 4$ is expressed by the set $\{1 \quad 3 \quad 5 \quad 2 \quad 4\}$, where $R_{11} = 1$, $R_{12} = 3$, $R_{13} = 5$, $R_{14} = 2$ and $R_{15} = 4$.

### 2.3 Determining Departure Times

One important factor that determines the time for vehicle $i$ to depart the warehouse is the preferred time windows of customers whose orders are to be delivered by the vehicle. The term "preferred" means that the time window is an ideal period for the customer to receive the order but may not be absolutely satisfied, a small deviation from the time window being probably acceptable in reality.

Other issues associated with determining the departure time are the vehicle travel route, average travel speeds during different periods in a day and unloading time at each stop.

Let $D_i$ the departure time of vehicle $i$ from the warehouse,

$s_{R_{iq}}$ the start of the preferred time window of customer $R_{iq}$, which is the $q$th one to be delivered by vehicle $i$, $R_{iq} \in C_i$ ($q$ = 1, 2, …, $m_i$ and $i$ = 1, 2, …, $N$),

$e_{R_{iq}}$ the end of the preferred time window of customer $R_{iq}$, which is the $q$th one to be delivered by vehicle $i$, $R_{iq} \in C_i$ ($q$ = 1, 2, …, $m_i$ and $i$ = 1, 2, …, $N$),

$L_{R_{i1}}$ the travel distance along the shortest path from the warehouse to the customer which is the 1st one to be delivered by vehicle $i$ ($i$ = 1, 2, …, $N$),

$L_{R_{iq}}$ the travel distance along the shortest path between the customers which are the ($q$ – 1)th and $q$th clients to be delivered by vehicle $i$ ($i$ = 1, 2, …, $N$), and

$L_{R_{i\,m_i+1}}$ the travel distance between the customer, which the last one to be delivered by vehicle $i$, and the warehouse ($i$ = 1, 2, …, $N$).

For customer $R_{iq}$, the time required to unload the order $U_{R_{iq}}$ is assumed in proportion to the order size, that is $U_{R_{iq}} = \alpha \cdot O_{R_{iq}}$, where $\alpha$ is the time required for unloading one order unit.

Let $T_{R_{i1}}$ denote the arrival time of vehicle $i$ at the first customer, i.e. customer $R_{i1}$, then $T_{R_{i1}} = D_i + L_{R_{i1}} / v$, where it is assumed that all vehicles travel at an average speed of $v$, which varies with traffic congestion during different periods in a day. Similarly, let $T_{R_{iq}}$ the arrival time of vehicle $i$ at customer $R_{iq}$, then $T_{R_{iq}} = T_{R_{iq-1}} + U_{R_{iq-1}} + L_{R_{iq}} / v$.

Based on the above equations, the preferred time window for each customer can be expressed by the following inequality:

$$s_{R_{iq}} \le T_{R_{iq}} \le e_{R_{iq}} \quad (q = 1, 2, \ldots, m_i \text{ and } i = 1, 2, \ldots, N). \qquad (2)$$

### 2.4 The Objective Function

In this study, the objective is formulated to minimise the total distance travelled by all vehicles, with respect to three sets of decision variables: allocating customer orders to vehicles ($C_{ij}$), the route to deliver customer orders ($R_{iq}$) and the departure time from the warehouse ($D_i$), which is expressed as the following:

Minimise: $L=\sum_{i=1}^{N}\sum_{q=1}^{m_i+1} L_{R_{iq}}$ with respect to: $C_{ij}$, $R_{iq}$ and $D_i$ (3)

Subject to: $\sum_{j=1}^{m_i} O_{C_{ij}} \le G_i$ ($j$ = 1, 2, …, $m_i$ and $i$ = 1, 2, …, $N$) (1)

$s_{R_{iq}} \le T_{R_{iq}} \le e_{R_{iq}}$ ($q$ = 1, 2, …, $m_i$ and $i$ = 1, 2, …, $N$) (2)

## 3. A Genetic Algorithm

An Excel-based genetic algorithm (GA) is developed to search for the optimal to the problem. GA was invented by Holland (1975) to mimic some processes observed in natural evolution, which take place on chromosome, organic devices for encoding the structure of living things. A living being is created partly through a process of decoding information encoded on chromosomes. In natural selection processes, chromosomes that carry better structures of living beings have more chance of reproducing offspring, and the mutations and recombinations of the biological parent's chromosomes may create quite different chromosomes for biological offspring (Davis, 1991).

GA is a procedure implemented on the computer to mimic the above natural evolutionary process, and has been used as a class of methods for search and optimisation, especially for combinatorial optimisation problems. Like any GA applications, the genetic algorithm used in the study consists of three parts:

a process of calculating the objective function for each solution,

a mechanism for searching the optimal solution, based on the value of the objective function, and

methods of imposing constraints.

### 3.1 Calculating the Objective Function

In general, the calculation of objective function is domain specific and sometimes involves very complicated processes (Qiu, 2000; Taplin et al., 2005). This requires a platform that, on the one hand, enables complex calculation to derive the value of the function, given a set of the values of decision variables, and on the other hand, to output the calculation result to the mechanism for search the optimal solution.

The study uses an Excel spreadsheet to set up a process for calculating the objective function value, exploiting its easy-to-use yet powerful capability in handling complexity in calculation, which is mainly due to the logic relationships between various steps in the process. In addition, VBA is used to build a user defined function to calculate the arrival time of a delivery vehicle at a customer, taking account of departure time from the upstream customer, the shortest travel distance between the customers and the speed profile during a day. VBA is also used to develop a program to search for the shortest path between two consecutive customers. The execution of the VAB codes is incorporated into the spreadsheet as part of the process of calculating the objective function.

The calculation result can be read by the Excel "Add-in" GA package, Evolver, which is used to search for the optimal solution. To a large extent, the process is a "black box" for Evolver, and what matters to Evolver is the value of the objective function. The relationships between the Excel worksheet, VBA codes and Evolver are shown in the following diagram.

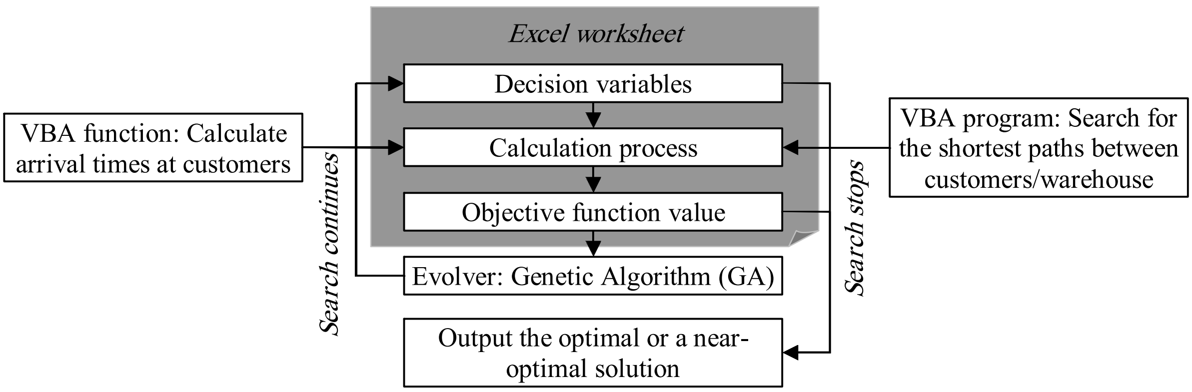


Figure 1. Excel-based GA model for the vehicle routing problem

### 3.2 Searching for the Optimal Solution

As shown in Figure 1, Evolver is used to search for the optimal solution. As indicated by Figure 2, the package has three sets of interfaces with the Excel worksheet for calculating the objective function:

- Objective function: it is in Excel cell $AG$93, and the address is input in the Reference Edit Control in Group Box Control "For the cell";
- Decision variables: the cell addresses of decision variables are recorded in Group Box Control "By Adjusting the Cells"; and
- Constraints: some constraints are input into Group Box Control "Subject to the Constraints".

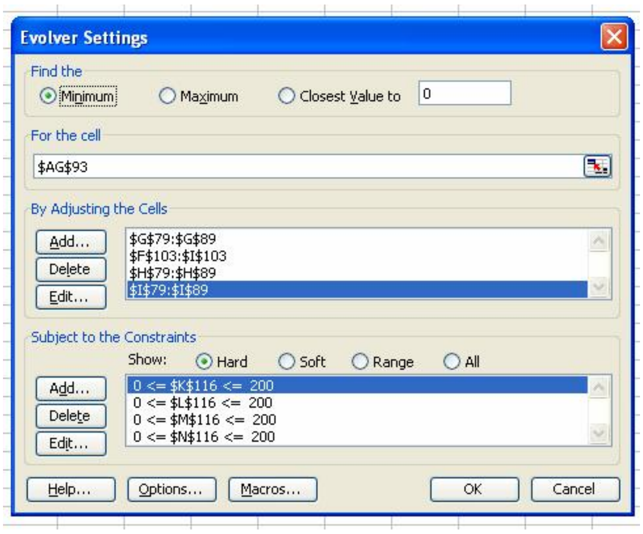

Figure 2. The settings of Excel "Add-in" genetic algorithm package: Evolver

A feature of Evolver is that it can accommodate a variety of decision variables, with each having their own rates of crossover and mutation, which are two of the three main operators of searching for the optimal solution, the third being reproduction operator. This feature makes it possible to formulate an optimisation problem with a mixed different nature of decision variables.

In this study, three sets of decision variables are used.

- Vehicle delivery routes: the sequences of visiting customers are coded by a string of ordered integers (shown in cells $G$79:$G$89 in Figure 2), with the integer representing the customer code and the order being the sequence. The "order" solving method in Evolver is used to shuffle the existing values in the cells around, which is a combinatorial optimisation process.
- Allocating customer orders to vehicles: in this study, four vehicles used to deliver customer orders are coded by two strings of independent integers with a range of 1 to 4 (shown in cells $H$79:$H$89 and $I$79:$I$89 in Figure 2), the integer representing the code of the vehicle to which the corresponding customer order is allocated. The "recipe" solving method with "Integer Values Only" is used and is equivalent to an integer programming process. The match between the types of customer orders and vehicles are controlled through an Excel built logic function.
- Departure time: the departure time from the warehouse is coded as four independent real numbers with a range of 7 to 17 (shown in cells $F$103:$I$103 in Figure 2). The "recipe" solving method is used and is equivalent to an ordinary programming process.

### 3.3 Imposing Constraints

In general, the methods imposing constraints in genetic algorithms can be classified as pro-choice and pro-life approaches (Michalewicz, 1995). Pro-choice approaches do not allow the presence of infeasible solutions by removing infeasible ones from the calculation and then generating feasible replacements. They may work well for optimising problems in which the feasible search space is convex and constitutes a substantial part of the whole space (Michalewicz, 1995). On the other hand, these methods are not suitable in some situations. For example, a problem may be so highly constrained that finding a feasible solution is as difficult as finding the optimum (Goldberg, 1989: 85). Another case is that the optimal solution needs to evolve from infeasible solutions iteration by iteration (Michalewicz, 1995).

One of the pro-life approaches allows the presence of infeasible solutions by penalising them to reflect the violation of constraints, which transforms a constrained optimisation process into an unconstrained problem (Qiu, 2000).

Preliminary trials in this study reveal that it is reasonably easy to satisfy the constraint of vehicle load capacity but extremely difficult to comply with the constraint of the preferred time windows. Therefore, the former constraint is imposed by the pro-choice approach through the "Evolver Setting" dialog box as shown in Figure 2, and the latter constraint is imposed by penalising the objective function on the spreadsheet as the following:

$$L' = L + \sum_{i=1}^{N} \sum_{q=1}^{m_i} 0.1 \cdot \left[ \exp\left( \frac{d_{R_{iq}}}{0.1} \right) - 1 \right], \qquad (4)$$

where $L'$ is the penalised objective function, $L$ the objective function without penalties by Eq. (3), $d_{R_{iq}}$ the deviation from the time window at the customer $R_{iq}$, which is the $q$th client to be delivered by vehicle $i$.

The choice of the specific function form for the penalty is due to that fact it imposes a small penalty to minor violation of the preferred time window but a heavy one to a significant deviation.

## 4. Computational Results and Discussion

This study uses a case to test the multi-facet planning model. There are 11 customers (Customer 2 to 12) scattered in an area served by a road network as shown in the following diagram.

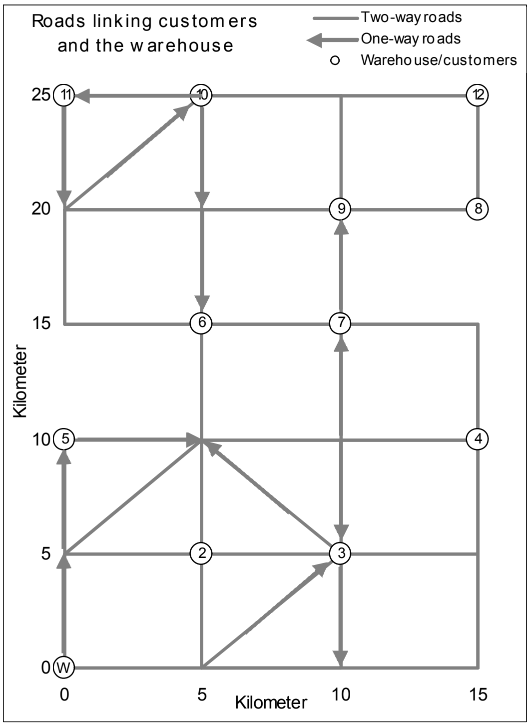


Figure 3. Roads linking the warehouse/customers

As shown in Figure 3, the network contains one-way and two-way roads. The travel speeds by vehicles on the roads are assumed to vary to reflect traffic congestion during different periods of a working day. The warehouse and customers are connected through the network and it is assumed that vehicles travel along the shortest path between two consecutive stops.

Three scenarios have been run to test the model:

- Scenario 1 has wide and non-staggered time windows, which is used as a base case for comparing with other two scenarios;
- Scenario 2 has the same time windows as Scenario 1, but a total order size of the chilled goods smaller than that in Scenario 1, which is used to test whether or not the model is sensitive to the total order size by changing the number of vehicles used for delivering orders; and
- Scenario 3 has narrower and staggered time windows, which is used to explore the impact of restrict time windows on vehicle scheduling and on the total travel distance.

The input information on order sizes by individual customers and the corresponding time windows are summarised in Table 1. Table 2 shows the optimal or near optimal solutions to the three test scenarios.

Table 1. Order sizes and time windows in the three test scenarios

| Customer | Scenario 1 | | | | Scenario 2 | | | | Scenario 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Order size | | Time window | | Order size | | Time window | | Order size | | Time window | |
| | Ordinary | Chilled | | | Ordinary | Chilled | | | Ordinary | Chilled | | |
| 2 | 50 | 0 | 08:00 | 17:00 | 50 | 0 | 08:00 | 17:00 | 50 | 0 | 08:00 | 12:00 |
| 3 | 20 | 50 | 08:00 | 17:00 | 20 | 30 | 08:00 | 17:00 | 20 | 50 | 12:00 | 17:00 |
| 4 | 50 | 0 | 08:00 | 17:00 | 50 | 0 | 08:00 | 17:00 | 50 | 0 | 08:00 | 12:00 |
| 5 | 20 | 50 | 08:00 | 17:00 | 20 | 30 | 08:00 | 17:00 | 20 | 50 | 12:00 | 17:00 |
| 6 | 20 | 0 | 08:00 | 17:00 | 20 | 0 | 08:00 | 17:00 | 20 | 0 | 08:00 | 12:00 |
| 7 | 50 | 20 | 08:00 | 17:00 | 50 | 20 | 08:00 | 17:00 | 50 | 20 | 12:00 | 17:00 |
| 8 | 60 | 0 | 08:00 | 17:00 | 60 | 0 | 08:00 | 17:00 | 60 | 0 | 08:00 | 12:00 |
| 9 | 50 | 20 | 08:00 | 17:00 | 50 | 20 | 08:00 | 17:00 | 50 | 20 | 12:00 | 17:00 |
| 10 | 20 | 30 | 08:00 | 17:00 | 20 | 30 | 08:00 | 17:00 | 20 | 30 | 08:00 | 12:00 |
| 11 | 0 | 70 | 08:00 | 17:00 | 0 | 20 | 08:00 | 17:00 | 0 | 70 | 12:00 | 17:00 |
| 12 | 40 | 0 | 08:00 | 17:00 | 40 | 0 | 08:00 | 17:00 | 40 | 0 | 08:00 | 17:00 |
| Total Order | 380 | 240 | | | 380 | 150 | | | 380 | 240 | | |

Table 2. Solutions to the three test scenarios

<table>
<tr><td colspan="2">Scenario</td><td colspan="4">1</td><td colspan="4">2</td><td colspan="4">3</td></tr>
<tr><td rowspan="2">Vehicle</td><td>Type</td><td colspan="2">Ordinary</td><td colspan="2">Chilled</td><td colspan="2">Ordinary</td><td colspan="2">Chilled</td><td colspan="2">Ordinary</td><td colspan="2">Chilled</td></tr>
<tr><td>No.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td colspan="2">Depart. time</td><td>09:20</td><td>10:44</td><td>11:25</td><td>09:07</td><td>8:54</td><td>10:30</td><td>9:54</td><td>n.a.</td><td>11:16</td><td>7:40</td><td>12:17</td><td>10:52</td></tr>
<tr><td rowspan="2">Vehicle load</td><td>Capacity</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td><td>200</td></tr>
<tr><td>Actual</td><td>190</td><td>190</td><td>190</td><td>50</td><td>190</td><td>190</td><td>150</td><td>0</td><td>190</td><td>190</td><td>160</td><td>80</td></tr>
<tr><td rowspan="2">Travel distance (km)</td><td>By vehicle</td><td>89</td><td>60</td><td>80</td><td>27</td><td>89</td><td>80</td><td>90</td><td>0</td><td>117</td><td>87</td><td>80</td><td>74</td></tr>
<tr><td>Total</td><td colspan="4">256<br>(Obj. fun. with penalty = 256)</td><td colspan="4">259<br>(Obj. fun. with penalty = 259)</td><td colspan="4">358<br>(Obj. fun. with penalty = 358)</td></tr>
<tr><td colspan="2">Delivery route & arrival time (Customer code|hh:mm)</td><td>6|10:20<br>9|10:52<br>8|11:36<br>12|12:22<br>10|13:06<br>11|13:28</td><td>5|11:04<br>7|11:46<br>4|12:36<br>3|13:26<br>2|13:48</td><td>5|11:45<br>7|12:45<br>9|13:07<br>10|13:39<br>11|14:07</td><td>3|10:06</td><td>8|10:46<br>12|11:32<br>10|12:16<br>11|12:38<br>6|13:08<br>2|13:40</td><td>5|10:50<br>7|11:32<br>9|12:12<br>4|13:32<br>3|14:22</td><td>5|10:18<br>7|11:16<br>9|11:28<br>10|12:00<br>11|12:28<br>3|13:40</td><td>n.a.</td><td>4|12:00<br>3|12:50<br>5|13:32<br>7|14:14<br>9|14:54<br>11|15:54</td><td>2|08:00<br>6|09:30<br>10|10:28<br>12|11:00<br>8|11:34</td><td>5|12:37<br>7|13:37<br>9|13:59<br>11|14:41</td><td>10|12:00<br>3|13:08</td></tr>
</table>

4.1 Scenario 1 – Wide and Non-Staggered Time Windows

Five runs have been carried out with different initial solution points and three of them converge to a solution that has the lowest objective function value of 256, which is likely the optimum or at least a near-optimal solution.

It can be seen from Table 2 that the objective function values with and without penalties are the same, with all the time windows being satisfied. Moreover, because of the wide time windows in Scenario 1, the objective function value can be preserved with some different departure times as long as all arrival times are within the time windows and the values of the other decision variables are maintained.

In the following diagram, a dash arrow line represents a trip between two consecutive stops by the delivery vehicle.

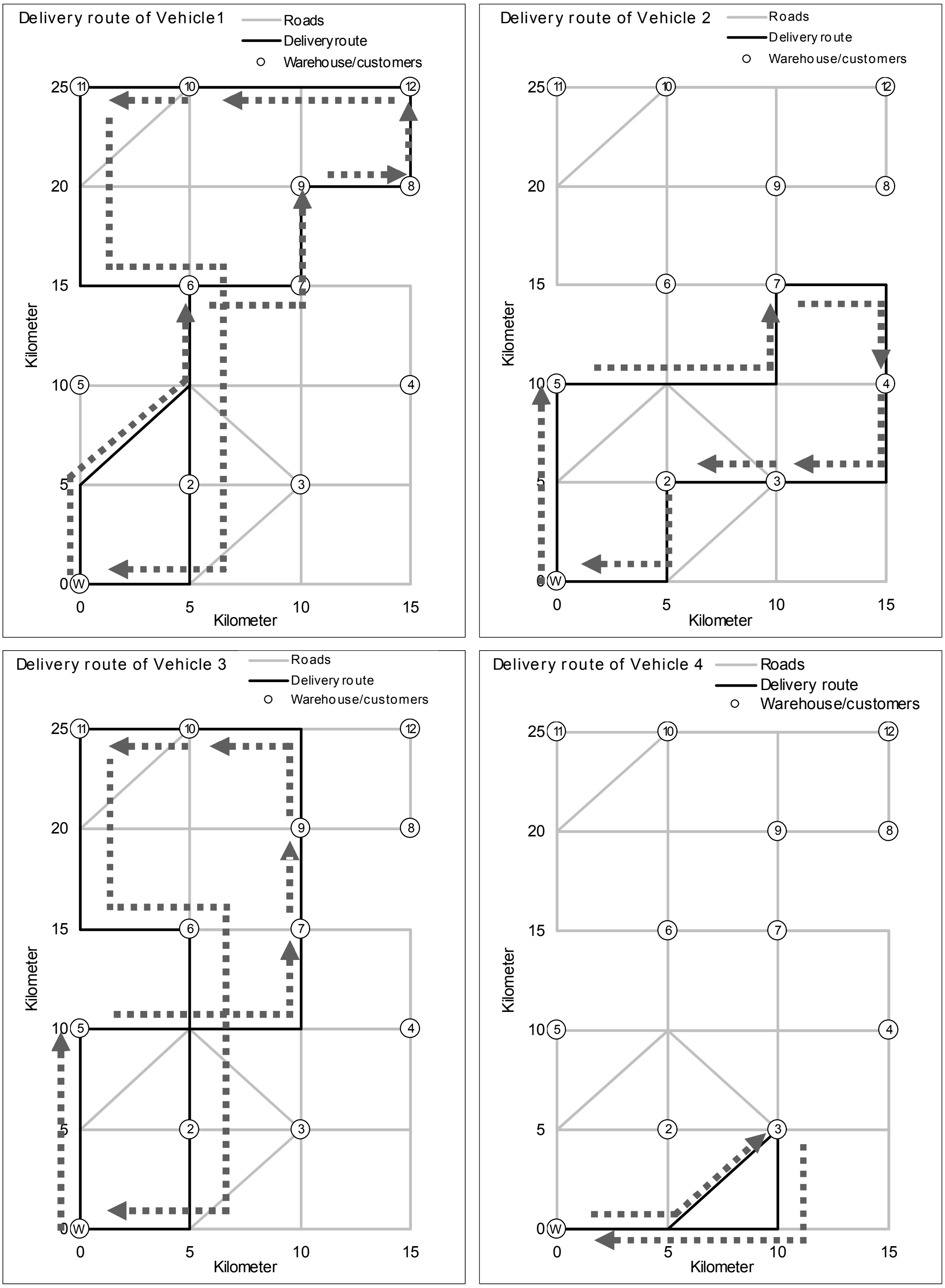


Figure 4. Vehicle delivery routes in Scenario 1

4.2 Scenario 2 – Wide and Non-Staggered Time Windows, and a Smaller Order Size

Five runs with different starting points have been carried out and produce different solutions with an objective function value (without penalties) range of 259 to 291. The best solution so far has an objective function value with and without penalties of 259, which satisfy all constraints of the preferred time windows. Similar to Scenario 1, the departure times are irrelevant because of the wide time window. It is likely that this is at least a near-optimal solution to Scenario 2.

Because of a smaller total order size of chilled goods, Scenario 2 only needs three vehicles to deliver all customer orders, keeping one vehicle at the warehouse. This demonstrates that the GA model can automatically scale down the number of vehicles required to delivery orders if customer demand is not high.

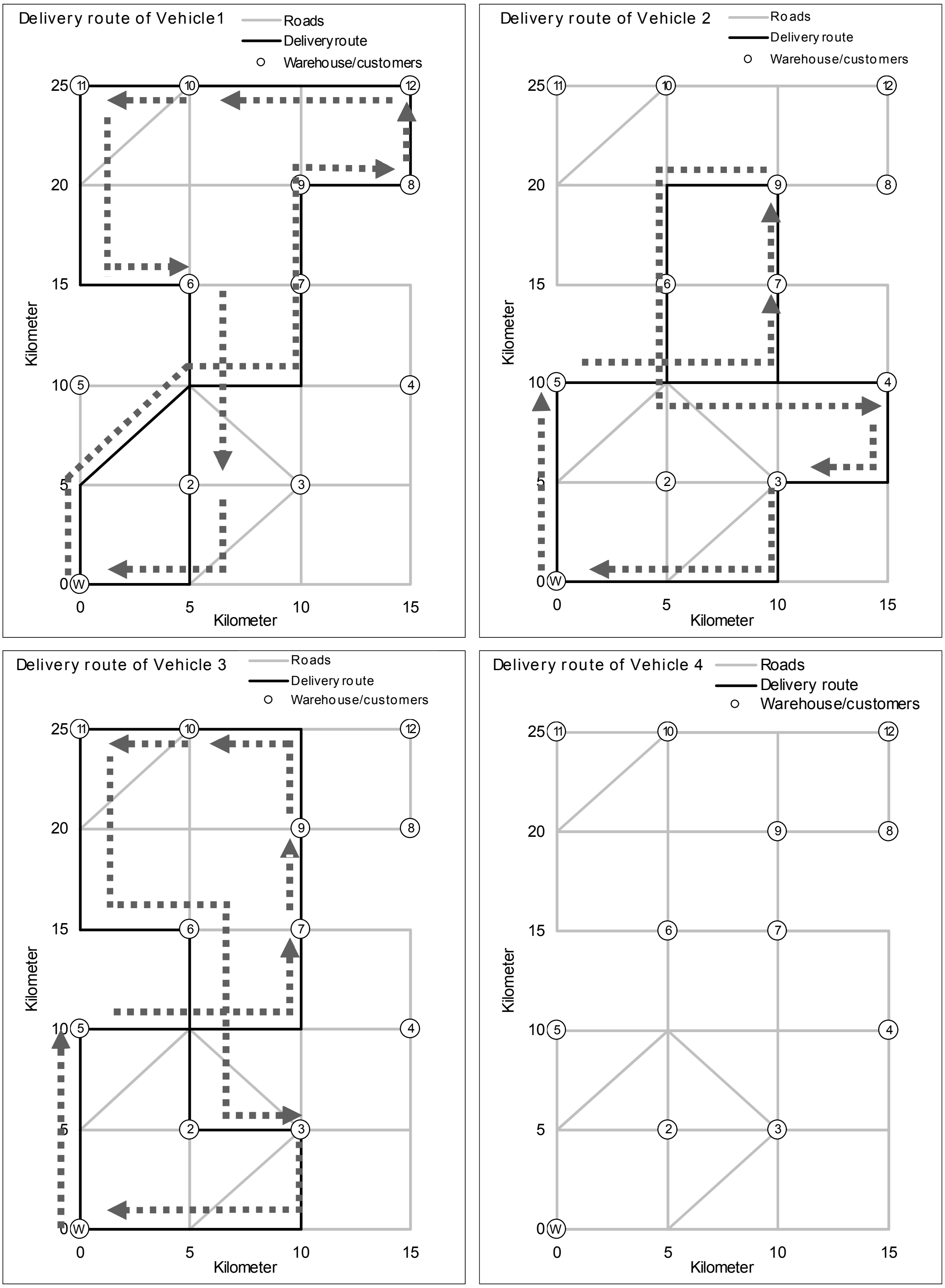


Figure 5. Vehicle delivery routes in Scenario 2

4.3 Scenario 3 – Narrow and Staggered Time Windows

Five runs with different starting points have been carried out and they produce different solutions with an objective function value (without penalties) range from 358 to 491. The best solution so far has an objective function with and without penalties of 358, which satisfies all preferred time windows.

It is worth noticing in Table 2 that Vehicle 1 carries the ordinary goods ordered by the customers which all have a preferred afternoon time window (12:00 – 17:00), and that Vehicle 2 delivers the ordinary goods to the customers most of which have a morning time window (08:00 – 12:00). All orders of chilled goods are placed by customers that prefer time windows in the afternoon (12:00 – 17:00), with an exception of Customer 10. Vehicle 3 delivers the orders of chilled goods in the afternoon and Vehicle 4 only covers Customer 10 in the morning and Customer 3 in the afternoon. The total distance travelled by vehicles is longer than that in Scenario 1.

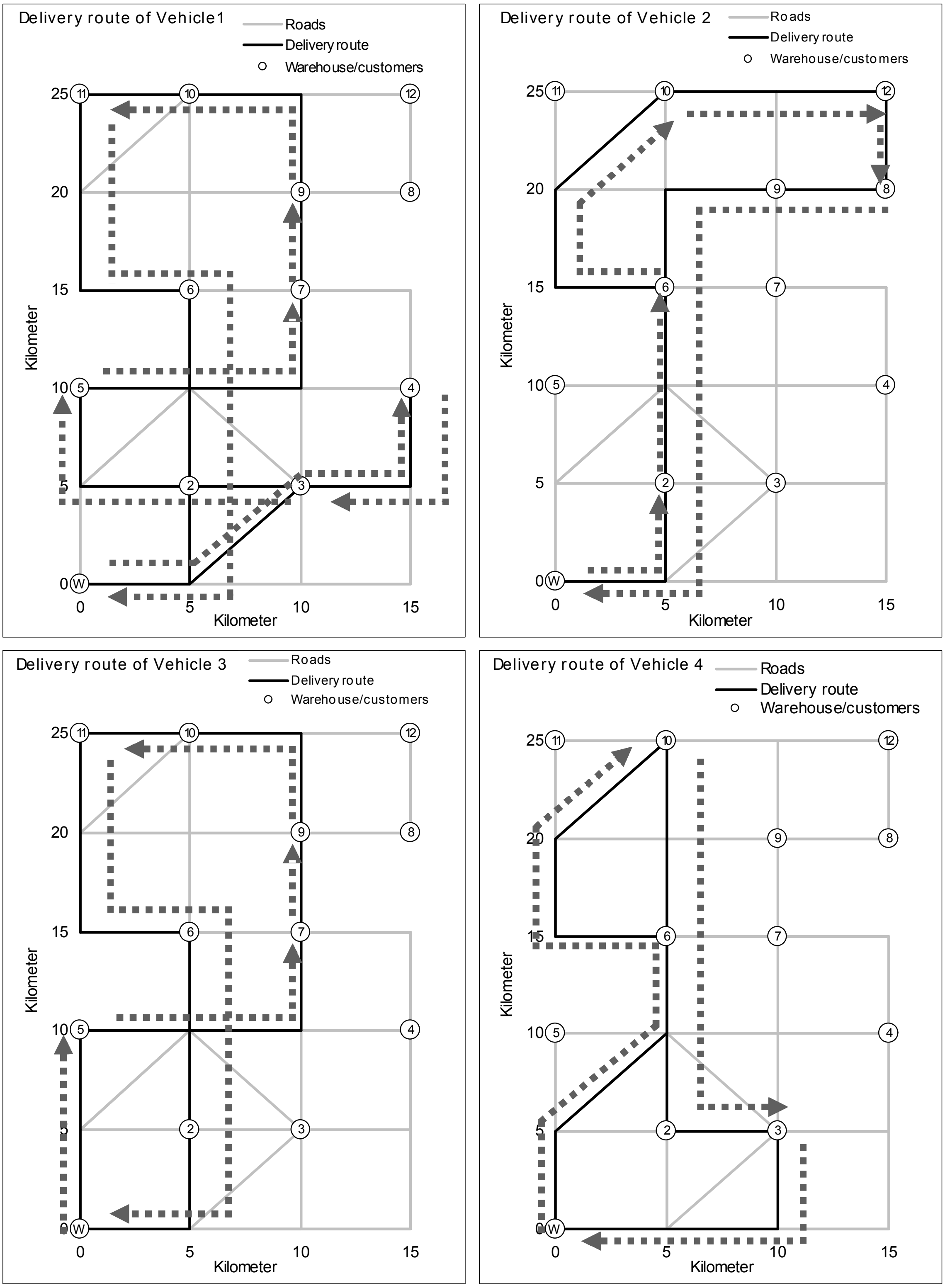


Figure 6. Vehicle delivery routes in Scenario 3

## 5. Conclusion

This paper reports a study of an Excel-based genetic algorithm (GA) model for route planning of delivery vehicles with time windows. The problem is formulated as a mixed combinatorial optimisation process with three distinctive decision variables: the allocation of customer order to vehicles, planning the delivery routes and the determination of departure times from the warehouse.

The model is implemented on the platform of Microsoft Excel, with Evolver as the search tool for the optimal. This spreadsheet-based approach has brought the planning of vehicle routes more accessible by many business analysts, most of them having access to Excel.

The test runs demonstrate that the model is sensitive to a variety of situations or issues in delivering customer orders, including variations in order sizes and different patterns of the time windows that customers prefer. It also can take account of practical issues, such as matching the type of orders with that of vehicles, different average travel speeds of vehicles during periods of a day, and the grid structure of one-way and two-way roads

With the ease of Excel spreadsheet, the model can be further enhanced to include more realistic considerations, such as vehicles picking up goods from multiple warehouses.

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# VALUE CHAIN MANAGEMENT: A CASE STUDY FOR TEXTILES IN TURKEY

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## Abstract

*To survive in today's highly competitive business environment, organizations need competitive advantage. Value chain analysis can help an institution determine which type of competitive advantage to pursue, and how to pursue it. The key to analyzing the value chain is understanding the activities within the institution and the distribution and supplier networks to create a competitive advantage, and then managing those activities better than other institutions in the industry. Value chain analysis is thus a means for examining internal processes and network of organizations to identify which activities are best provided by others. The value chain analysis provides a powerful tool for strategic thinking to gain sustainable competitive advantage.*

*Textile has a unique position as a self-reliant industry, from the production of raw materials to the delivery of finished products, with substantial value-addition at each stage of processing; it is a major contribution to the Turkish Economy. Textiles sector has undergone dramatic change over the last decade. Globalization and competitiveness are major drivers of change. To battle globalization and competitiveness, it is vital important to manage value chain effectively and efficiently. The paper attempts to provide a case study as an example of value chain management in the Turkish textile sector.*

*Keywords: Textiles, Value Chain, Supply Chain, Competitiveness*

## 1. Introduction

Marketing focuses on the revenue generation and the value creation for customer satisfaction. Marketing considers the forces that affect the way in which customers perceive value, finding out the differing needs of customer groups, translating them into product and service packages to meet those differing needs and marketing the packages through customer value propositions (Jüttner, Christopher, and Baker 2005). The key issue is to supply the market with what the customer considers as value. Thus from a broader point of view, the main function of the supply chain is to provide the value required by the customer through the network and manage this value chain.

Value chain is a high-level model of how businesses receive raw materials as input, add value to the raw materials through various processes, and sell finished products to customers. A critical pre-requisite for success in today's business environment is the implementation of an integrated value chain that extends across - and beyond - the enterprise. (http://www.1000ventures.com/business_guide/im_value_chain_main.htm).Value-chain management is managing integrated information about product flow from suppliers to end users in order to reduce defects and inventories, speed time to market and improve customer satisfaction ( http://www.computerworld.com/news/2000/story/0,11280,45129,00.html). The idea of the value chain is based on the process view of organizations, the idea of seeing a manufacturing (or service) organization as a system, made up of subsystems each with inputs, transformation processes and outputs. Inputs, transformation processes, and outputs involve the acquisition and consumption of resources - money, labor, materials, equipment, buildings, land, administration and management. How value chain activities are carried out determines costs and affects profits ( http://www.ifm.eng.cam.ac.uk/dstools/paradigm/valuch.html).

Value chain management traditionally focuses on maximizing the opportunities to add value while minimizing total cost. Net added value is increased by compressing the times when no value is being added and costs continue to rise. To increase the net added value, value chain management aims systematically to reduce the sources of uncertainty in the demand and supply processes. This can be done by the active co-operation of the key players in each value chain. By reducing uncertainty, total service will be improved and overall cost will be reduced.

As maximization of value is the key in the competitive world, Turkish exports should focus on the value management. In today's world, Turkish exports, especially the textiles experience competitive pressure from Eastern Europe, India, Egypt and China. The road to success is to provide superior value when compared to competitors for Turkish textiles. The paper attempts to look at the value chain management process in general and based on in depth interviews draw the value chain process for a catalogue firm based in Europe, working with suppliers from various countries as well as Turkey, and based on the value network, propose strategies for textile firms.

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## 2. Value Chain Management (VCM)

Value chain management is the integration of all resources starting with the vendor's vendor. It integrates information, materials, labor, facilities, logistics, etc. into a time-responsive, capacity-managed solution that maximizes financial resources and minimizes waste. In other words, efficient and effective value chain management optimizes value for the customers' customer. (Kaplinsky, Morris, 2001). Time-to-market is the buzzword of successful competitive positions; the organization that manages its supply chain most effectively tended to have the competitive advantage, at least in terms of customer responsiveness and order fulfillment.

Nowadays, managers realize that time responsiveness was not the only important element in customer satisfaction. The supply chain linkages-the links among upstream suppliers, manufacturers, and downstream distributors-also have a cost element and resource-efficiency element associated with them. This realization generates a need for value chain management, which is the management of all the linkages of the supply chain in the most efficient way.

The *value chain* describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use. Considered in its general form, it takes the shape as described in Figure 1. As can be seen from this, production *per se* is only one of a number of value added *links*. Moreover, there are ranges of activities within each link of the chain. Although often depicted as a vertical chain, intra-chain linkages are most often of a two-way nature – for example, specialized design agencies not only influence the nature of the production process and marketing, but are in turn influenced by the constraints in these downstream links in the chain.

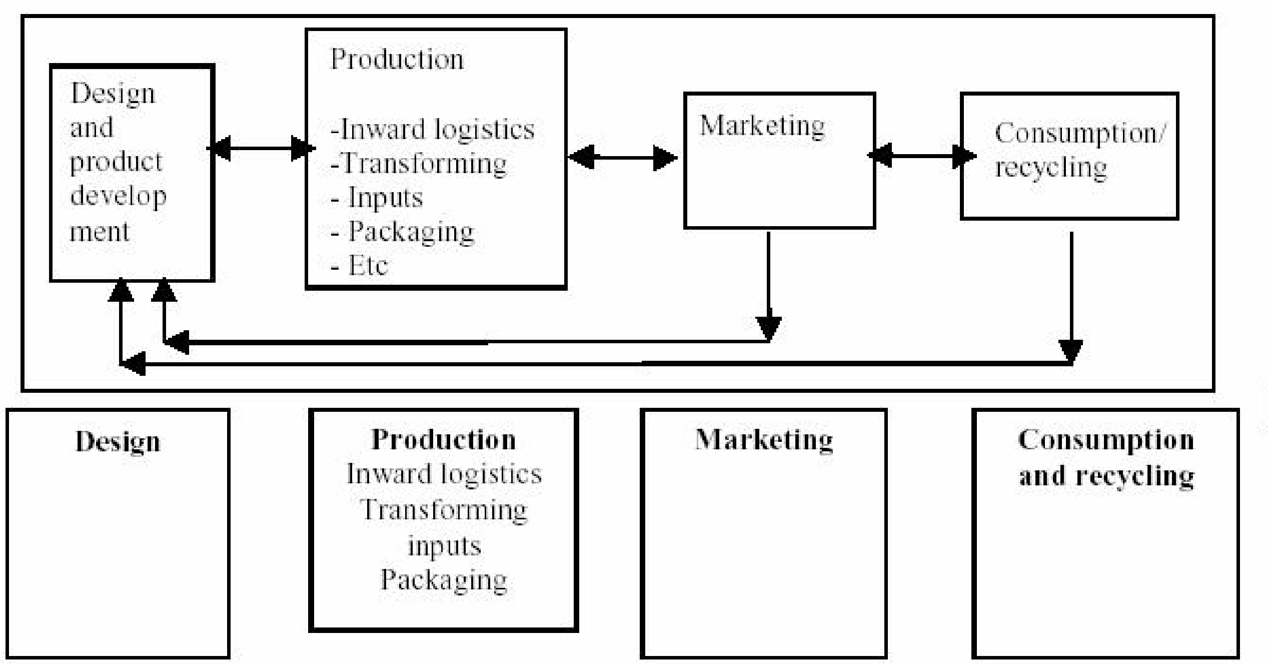


Figure 1. Four links in a simple value chain. (Kaplinsky, Morris, 2001.)

There are three main sets of reasons why value chain analysis is important in this era of rapid globalization.

First of all, with the growing division of labor and the global dispersion of the production of components, systemic competitiveness has become increasingly important. Also, efficiency in production is only a necessary condition for successfully penetrating global markets. Moreover, entry into global markets which allows for sustained income growth – that is, making the best of globalizations requires an understanding of dynamic factors within the whole value chain.

## 3. Supply Chain Management And Value Chain Management

The Supply Chain involved with attaining raw materials and sub assemblies, then getting them through your manufacturing process smoothly and economically. Supply Chain Management is the management of the interrelationships between key stakeholders and enterprise functions that occur in the maximization of value creation which is performed through an efficient logistics management On the other hand; VCM is the model concept where supply chain becomes only a sub-set. Value Chain Management involved in every step starting from raw materials (including suppliers' suppliers use) to customers and end user, right down to disposing of the packaging. The main idea behind Value Chain Management is to deliver maximum value to the end user for the least possible total cost. And it involves the organization, its suppliers and its suppliers' suppliers.

VCM is related with managing integrated information about product flow in order to reduce defects in inventories, speed the process, achieve time to market and improve customer satisfaction. VCM is involved primarily with the customer from start to finish. While, the value chain becomes a design for the business mission, the supply chain offers the strategic direction and organizational vehicle and the operational role which is assumed by logistic management. Supply chain provides a framework in order to achieve the business mission and goals. The supply chain is a microcosm of the value chain in that the objective of its management is ultimately directed toward providing value to the customer. Consequently, supply chain management is not just materials management with a new name as some have implied. Rather it is the guiding philosophy that makes MRP and/or JIT provide value outside of their own limited spheres in optimizing manufacturing or distribution and will almost always be adopted in conjunction with one of these.

Vital difference between supply-chain management and value-chain management has to do with where the emphasis is placed. Supply-chain thinking has traditionally been efficiency-oriented, a cost-reduction and productivity sort of thing, whereas value-chain thinking is effectiveness-oriented. When companies stress effectiveness, they aren't necessarily trying to reduce costs, but rather to create the highest value for the customer, which isn't always the lowest-cost approach.

## 4. Key Aspects In Value Chain Management

Integrated supply chain planning and scheduling, full resource management, cycle-time responsiveness, chain-wide resource optimization, information integration are the key aspects in value chain management. The planning process for managing the supply chain is easy and has existed for many years. Systems like material requirements planning (MRP), manufacturing resource planning (MRP II), distribution requirements planning (DRP), theory of constraints (TOC), just-in-time (JIT), critical path method (CPM), and program evaluation and review technique (PERT) have performed the planning process effectively for the last 30 years. However, under these conditions, capacity has been treated largely as an afterthought, and therefore scheduling has been plagued with performance challenges. The introduction of capacity management tools like finite capacity scheduling (FCS) into the existing planning environments has allowed the development of schedules that were utilizable both in timing and in cost. Most planning systems still do not include these scheduling elements, but rather focus on achieving delivery performance through the utilization of an overriding expedite process. FCS enhancements are a key piece in the development of efficient VCM environments.

Traditional environments focused on managing only the material resources, assuming all the other resources had an infinite capacity. This logical fallacy came from the limitations of the planning systems previously discussed. In a centrally-controlled environment where authoritarian rule existed, the expediting process could make this management style operational. Unfortunately, in multi-stage supply chain integration, the scheduler needs to make sure that capacity limitations are considered at all steps in the supply chain. Expediting across the links of the supply chain was extremely difficult, if not impossible. For example, the constrained resource at one link in the supply chain may be entirely different than the constrained resource at another step in the supply chain. For one step, the constrained resource could be labor while at another step it could be truck capacity. Therefore, a scheduling system that analyzed and constrained all the resource elements at all steps became a critical piece in VCM.

Total cycle time measures are needed because they have, in many cases, become more important than cost when it comes to competitive advantage. Strategic positioning requires a supply chain to be able to supply a customized product at speeds quicker than anyone else, even if the product is not customized. Therefore, a measure of cycle-time performance, measuring the time from when the order for a customized product is placed until it is delivered to the customer, becomes as important as price.

Value chain management adds the evaluation not only of all the traditional resources like labor, materials, machinery, etc., but also the optimal management of time and financial resources. Realizing that the supply chain has more steps than existed in the traditional vertical model in which a single firm integrated many supply chain processes and functions within a single organization, the profit margins of each step have become smaller as firms became disintegrated in order to focus on one or only a few core competencies. This "disintegration" has created the need for profits to be available at multiple points throughout the value chain because each step in the chain needs to share a smaller piece of the overall margin pie. In order to accomplish this, value chain management focuses on value-added optimization. Some organizations have interpreted this to include the elimination of steps in the supply chain, like the elimination of retailers at Amazon.com and elimination of the need for college bookstores by Atomic Dog Publishing. The efficient performance of all the remaining links in the supply chain is also carefully evaluated by each link.

VCM is meaningless if a near-total sharing of information does not exist among all elements of the supply chain. This incorporates multiple levels of information, from the operational information (which includes capacities and work loads), to the strategic levels (which include vision and mission statements). This sharing of information has to be fully accessible and interactive, which often suggests some sort of Web-based database. Each link of the supply chain will need to be able to evaluate the efficiencies and performances of all the other links in the supply chain. However, this information network should not be available to elements outside of the immediate supply chain, like competitors. The shared information within the chain will primarily be utilized by each of the elements of the supply chain for their specific planning and scheduling. It will also be utilized by the sales/marketing functions to generate realistic schedules for the customer and end-consumer of the supply chain process. An overall finite capacity scheduling process that projects realistic and feasible schedules while simultaneously optimizing cost and timing will be necessary.

In short, value chain management increases the number of steps in the supply chain by focusing on core competencies. VCM attempts to optimize the integrated efficiency of these steps in the management of resources, including the response time and the cost resource. Going into the future, VCM will become increasingly important as pressures to globalize mount, competition shrinks industry profits, and new market entrants challenge existing competitors.

## 5. Value Chain Analysis

Value Chain Analysis is a useful way of thinking through the ways in which value is delivered to customers, and reviewing all of the things to be done to maximize that value.

Value Chain Analysis is a three-step process; activity analysis, value analysis, evaluation and planning.

- ActivityAnalysis: is the first step to take for value chain analysis. It involves the brainstorming of activities that the organization undertakes that in some way contribute towards the customer's experience. This will include the step-by-step business processes that the organization uses to serve the customer – Michael Porter calls these "Primary Activities". These will include marketing of products or services; sales and order-taking; operational processes; delivery; support; and so on (this will may also involve many other steps or processes specific to the industry.
- Value Analysis: For each activity identified, the "Value Factors" are listed, what the customer values in the way that each activity is conducted. For example, if a telephone order-taking process is considered, the end user will value a quick answer to his or her call; a polite manner; efficient taking of order details; fast and knowledgeable answering of questions; and an efficient and quick resolution to any problems that arise. Next to each activity that is identified, these Value Factors are written down. And next to these, what needs to be done or changed to provide great value for each value factor is identified.
- Evaluation and Planning: By the time Value Analysis is completed, the organization generates plenty of ideas for increasing the value to deliver to customers. If those can be delivered, the service level will be outstanding. Then the more difficult changes are screened. Some may be impractical. Others will deliver only marginal improvements, but at great cost. If this is the case, they are dropped.

## 6. Case Study

A case study was conducted with the top management of a merchandising agent, managing the relationship between a European catalogue firm and the Turkish ready-to-wear suppliers. The objective of the study to take a snapshot of the value chain developed (Figure 2), so that strategies can be proposed to improve the relationship to gain competitive advantage.

The main players for the merchandising agent in the simplified framework are the end users, customer organization (the catalogue firm), agents, and suppliers.

End users are customers purchasing for personal use and consumption. They receive catalogues (three main catalogues and various monthly catalogues) of the customer organization or go through the catalogues on the website. They order through post, fax, call centers or email. They receive their orders within a week. If they are not satisfied with the good in any way, they send back the good. The freight charges are paid by the catalogue company. The main reasons of the return are:

- The size may not be right, conform to the standards
- The quality may not be what the end user expected
- The style may not be what the end user expected
- End user may not like the product

Customer organization is a mid-fashion firm specializing in marketing, operating in various European countries, serving thousands of end users. The main responsibilities of the customer organization are buying, logistics, selling, and marketing. They have a portfolio of customers they have been serving through catalogues for decades. As the technology changed and catalogue marketing declined in Europe, they added internet as an additional contact method, and some of the orders shifted to the web. In the meantime, they try to increase their customer portfolio as well. In the buying process, the customer organization partners with different agents in different countries. The agent aids the buying process. The customer organization and the agent select and approve suppliers which will make production for the customer organization based on the following criteria; to have a collection, to produce according to the specified quality standards, price level and to act according to the ethical standards.

The customer organization works on the design of styles (supplier produces the design of the customer organization), selects from the collection of suppliers and moreover, prepares the measurement chart in order to standardize the sizes of the production from various suppliers.

Moreover, through statistical data, previous experience, customer contact and fashion shows, the customer company design some of its collection and decides on the colors and sizes to be produced. They contact the agent and send the order sheet specifying the quantity, final price, destination of goods, packaging details and quality description of the goods.

Once the goods are produced and sent to the warehouse of the customer organization, depending on the orders received from the end user, the orders are processed and dispatched using third party logistics firms.

Agent mainly negotiates the buying process. The main responsibilities of the agent are supplier evaluation and selection, negotiating the price, selection from the collection of the supplier, ordering, control of the production process, random quality control of the finished product, and supervising the transportation of the product. Usually the initial order is small like 300 pieces. Then depending on the end customer demands, repeat orders are given. The lead time for the initial order is 8 weeks, while the lead time for repeat order is usually 4-5 weeks. The initial order acts like a market test for the styles. Usually the finished goods are transported with truck which requires 1 week to reach European market. Turkey offers competitive products for jeans, knitted jersey items and woven garments.

Supplier has two main responsibilities, preparing a collection, and producing according to the quality standards. In order to prepare a collection, the supplier has to know the en user, customer organization and agent expectations and the fashion trends. The production processes consists of the following: the yarn/fabric, dying, printing, sewing, labeling, controlling, packaging.

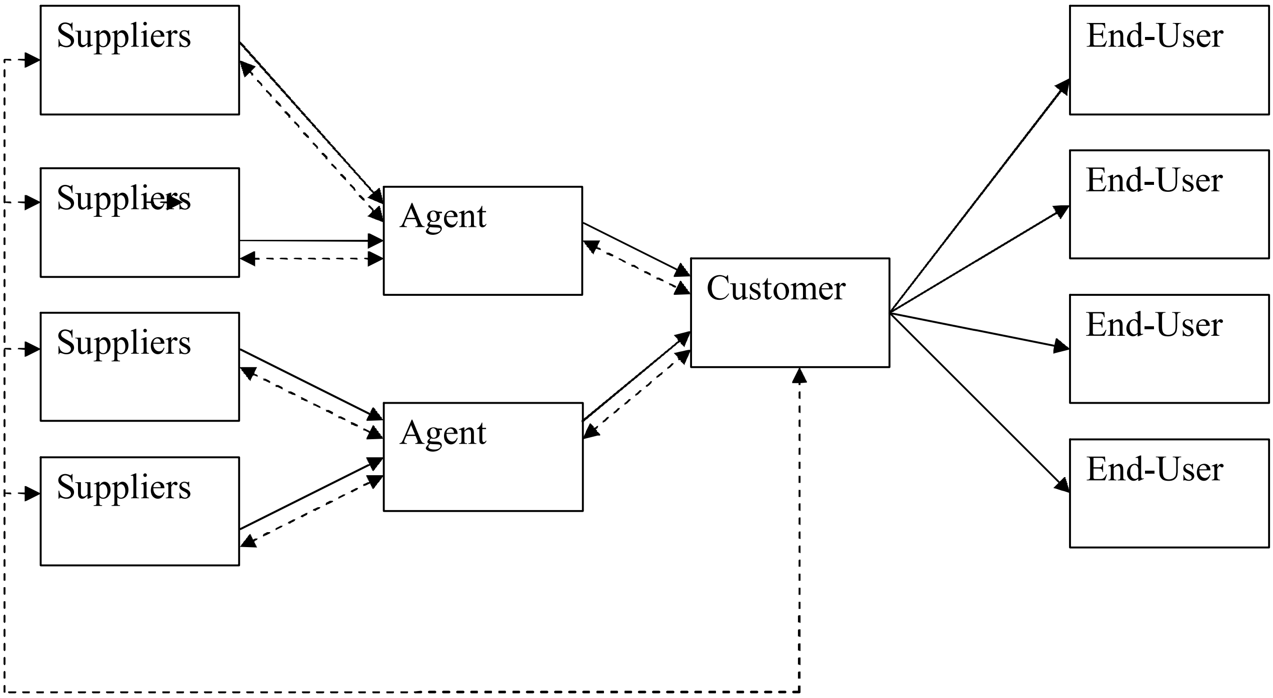


Fig2. Value Chain Framework of a Textile Company.

## 7. Conclusion

Turkey is one of the largest textile and ready-to-wear providers in the world ( www.metrofashion.com/newsmarketitkib.html). Moreover, textile and ready-to-wear industry plays a very important role both in the Turkish economy in general and Turkish exports constituting: About 7.8 % of GDP, 19.9 % of industrial production, 18.4 % of manufacturing industry production, 23.9 % of the manufacturing labor force, 28 % of total Turkish export earnings (Istanbul Textile and Apparel Exporters' Association, 2004).

Textile and ready-to-wear industry is one of Turkey's areas of competitive advantage in international business. In the global business world, countries like China, India, and Egypt are the major competitors of Turkey in textiles and ready-to-wear. In order to survive and grow in this sector, Turkey has to provide superior value compared to competitors. And value chain management is a method for providing the superior value for competitive advantage. Time to market, just-in-time applications, and minimization of stock are the key issues in today's global world for business success. Suppliers have to provide these advantages to their customers for competitive advantage. Quality is considered as given. It is provided for the customer and the end user by all the supplier companies. The main differentiation criterion for a textile company is design. Innovative and popular designs are very important, but it involves a risk as well in terms of colors, sizes, styles. Market testing of the designs, colors, and sizes is essential for a sound sales forecast. Moreover, time is a pressure. For textiles, "time to market" and design are the value consideration to establish a competitive value chain. As the quick response (QR) concept implies, companies have to be quick in order to respond to the market conditions to avoid any problems in stock.

The main competitive advantages of the Turkish textile manufacturers are design and time to market. The value chain should be established accordingly. Also branding and international retailing strategies are to followed for the future.

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# DISTRIBUTION CENTER PERFORMANCE MEASUREMENT

Başar Öztayşi[1], Yasemin Usta[2]

## Abstract

*As retail supply chains become global, the complexity and challenges correspondingly increase. Managing distribution and supply channels, transportation planning, workforce optimization and inventory management in a high piece pick environment become real time business challenges.*

*To maximize picking operations and improve efficiency in warehouse the productivity and accuracy of individuals, work groups, and processes have to be measured. The aim of this study is to define productivity and efficiency metrics of a distribution center in order to measure and manage the distribution center.*

*In this manner, distribution center of an international retail company operating in home furnishing products sector is analyzed. Separate productivity measures are defined for nearly every process in the distribution center. These measures are composed of time usage, space allocation, labor and cost.*

*The measurement process include the evaluation of basic concepts, some of these are; storage methods, inventory accuracy, cycle counting, labor productivity, cycle time measurement (inbound stock processing - outbound order fulfillment).*

*Keywords: Performance Measurement, Analytical Hierarchy, Order Fulfillment, Distribution Center*

## 1. Introduction

As retail supply chains become global, the complexity and challenges correspondingly increase. Managing distribution and supply channels, transportation planning, workforce optimization and inventory management in a high piece pick environment become real time business challenges.

Warehouse and distribution operations are similar in all industry groups that have a combined product movement-storage-pick operation or facility of any size, whether it handles single items, cartons, pallet loads, or bulk materials. To some degree each warehouse or DC operation performs most or all basic warehouse functions which can be seen in Fig. 1 (Mulcahy, 1994).

- Unloading, receiving, checking, and marking inbound merchandise;
- Internal horizontal or vertical product movement to the storage-pick area, workstation, or outbound staging area;
- Storage (deposit, withdrawal, and replenishment)
- Order-pick (distribution) sortation and checking;
- Packing, sealing, weighing and manifesting, and shipping preparation;
- Loading and shipping;
- Handling returns, out-of-season product, and store transfers;
- Maintenance, sanitation and loss prevention;
- Inbound and outbound truck-yard control

Fig 1. Basic Warehouse Functions

To achieve company objectives, logistics departments have to handle greater number of customers and have to reduce order-pick, handling, and transportation costs. It is obvious that, in order to manage effectively, one must measure. This measurement should contain accuracy of individuals, work groups, and processes.

The aim of the study is to define a framework for distribution center performance. Using this framework managers can, trace the performance changes by time, assess the relative performance of DCs and plan actions and tactics. We have built the model on a distribution center of a retail company operating in home furnishing products sector.

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*The organization of this study is as follows. First, we introduce the performance indicators. Next, we define the methodology used to calculate the overall performance. And then, we build a sample model for this case. Finally, we give some conclusions at the end of this paper.*

## 2. Distribution Center Performance Indicators

In our case we have two operating stores placing orders to a distribution center, and one distribution center fulfilling the demands of stores. Main indicators that are to be measured here can be grouped as: productivity indicators, order fulfillment indicators and inventory management indicators. Now we get a short description about these groups.

### 2.1 Productivity

Productivity is defined as the amount of output created (in terms of goods produced or services rendered) per unit input used. We have 4 indicators defined in this group:

*Order lines per hour:*

This indicator defines the labor productivity in terms of order lines. It is aimed to increase this indicator to increase the productivity

$$\frac{\text{Order lines picked/packed (Lines)}}{\text{Total Labor Hours (Hour)}} \quad (1)$$

*Items per hour:*

This indicator defines the labor productivity in terms of items. To increase the items handled within a specific time period is apparently increasing the productivity.

$$\frac{\text{Items picked/packed (Items)}}{\text{Total Labor Hours (Hour)}} \quad (2)$$

*Cost per order:*

This indicator shows the cost per order line. The minimum cost the better performance is.

$$\frac{\text{Total warehouse cost (€)}}{\text{Total Order lines Shipped (Lines)}} \quad (3)$$

*Cost as % of Sales:*

This indicator shows the cost per sales. This is one of the main indicators which more globally shows the actual productivity of the warehouse/distribution center. Increasing the above productivity values will result in a total decrease in the cost and relatively an optimal increase in sales.

$$\frac{\text{Total warehouse cost (€)}}{\text{Total revenue (€)}} \% \quad (4)$$

### 2.2 Inventory Management

Inventory management is one of the key functions in the DC operations. Since it is totally related with cost focusing on these indicators is very important.

*Inventory Accuracy:*

This indicator shows how correct the operation is held. Big differences and smaller ratios highlight points to be corrected in the operations.

$$\frac{\text{Actual Qty per SKU}}{\text{System Reported Qty}} \% \quad (5)$$

*Damaged Inventory:*

This indicator defines the damaged inventory percentage. Aim is to minimize this ratio.

$$\frac{\text{Total Damage (€)}}{\text{Total Inventory Value (€)}} \% \quad (6)$$

*Weeks on Hand:*

Weeks on Hand shows on hand stock in means of weeks. Week is the major calculation time period for most of the indicators including sales for the selected company.

$$\frac{\text{Inventory on Hand } (€)}{\text{Avg. Weekly Sales } (€)} \text{ Weeks} \quad (7)$$

*Storage Utilization:*
This indicator shows the capacity usage of the warehouse.

$$\frac{\text{Average occupied cbm}}{\text{Total storage capacity cbm}} \ \% \quad (8)$$

*Dock to Stock Time:*
Dock to stock time defines the time needed to have a received item placed to its rack.

$$\frac{\text{Total dock to Stock hours}}{\text{Total Receipt Lines}} \text{ hour} \quad (9)$$

*Inventory Visibility:*
Inventory visibility indicator shows the time between the physically receipt time and receipt entry time to the software.

$$\underline{\text{Receipt Entry time - Physically Receipt Time}} \text{ (hour)} \quad (10)$$

2.3 Order Fulfillment

*DC's role is to fulfill all the orders placed by stores and help them to increase product service level.*

*On Time Delivery:*
This indicator defines the percentage order lines shipped on time. It is aimed to increase this indicator.

$$\frac{\text{Order lines On-Time}}{\text{Total Order Lines shipped}} \ \% \quad (11)$$

*Shipment Accuracy:*
Even with the latest technology Still errors occur in the shipments.

$$\frac{\text{Error Free Shipments}}{\text{Total Shipments Made}} \ \% \quad (12)$$

*Order line Accuracy:*
This indicator shows the percentage of error free order lines in the shipments.

$$\frac{\text{Error Free Order Lines}}{\text{Total Lines Shipped}} \ \% \quad (13)$$

*Order Cycle Time:*
This is the difference between store order date and actual ship date.

$$\underline{\text{Actual Ship Date – Store Order date}} \text{ Hour} \quad (14)$$

2.4 Transportation

Transportation is a component of DC operations. Any defect or low service quality in this component may cause all the other works done proper to be zero.

*On Time Arrivals:*
This indicator shows the percentage of on time arrivals to total deliveries. It is aimed to increase this ratio.

$$\frac{\text{On Time Arrivals}}{\text{Total Deliveries}} \ \% \quad (15)$$

*Damage:*
This indicator shows the cost per shipment and performance of transport operation. The minimum ratio is the better the performance.

$$\frac{\text{Shipment Damage } (€)}{\text{Total Shipment Value } (€)} \ \% \quad (16)$$

*Demurrage:*
This indicator shows the cost per shipment. The minimum ratio is the better the performance.

$$\frac{\text{Demurrage Costs } (€)}{\textit{Total Transport Cost } (€)} \% \qquad (17)$$

## 3. Setting up Goals

For each performance indicator a goal is set and the results are analyzed according to the percentage of reaching the goals.

For example goal for Inventory Accuracy indicator is set to 99%. When the actual result is reached as 97 % this means that it is below the goal and it is only fulfilling the demand of the goal by 98 %. This is the number that we use when calculating the overall performance.

## 4. The Methodology

Section 2 shows us that it is not possible to measure the performance of a DC by a single indicator. In this manner the indicators needs to be merged to reach an overall performance value. In order to determine the overall performance value we use AHP (Analytic Hierarchy Process) and pair-wise comparisons matrix.

A description of AHP method is given as follows. The first step in AHP is establishing the pair-wise comparison matrix, which is formed by the pair-wise comparisons of the relative importance wi of the i th goal/criterion among all other goals/criteria. The experts in the field, where AHP is applied, are asked to make judgments in the form of pair-wise comparisons among the criteria considered in the study. These judgments are based purely on their knowledge and experience and they are taken qualitatively and corresponding scale values are assigned to them shown in Table 1. It is assumed that an element with weight zero is eliminated from comparison.

Table 1 Various gradations used for AHP (Saaty, 1989)

| Intensity of Importance | Explanation |
|---|---|
| 1 | Two criteria contribute equally to the objective |
| 3 | Experience and judgment slightly favour one criterion over the other |
| 5 | Experience and judgment strongly favour one criterion over the other |
| 7 | The criterion is strongly favoured and its dominance is demonstrated in practice |
| 9 | Evidence favoring one criterion over the other is of highest possible order of affirmation |
| 2,4,6,8 | Intermediate values |

From these matrixes the relative importance vector is calculated and checked if the results are consistent or not. If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment. Consistency Ratio is a comparison between consistency index and random consistency index.

Relative importance rates can be found by computing the largest eigenvalue of the pair wise comparison matrix. Eigenvalue computation can be realized by using a Expert Choice software or it can be found manually; first the elements in each column are normalized, and then the average value of elements in each row is computed.

Each criteria set in the hierarchy is computed in the same way. As a result the importance rate of criteria is multiplied with the upper levels' rates in order to find the total importance rate of the lowest criteria in respect to realize the main goal.

After finding the importance rates of the criteria, the alternatives are evaluated for each criterion, the importance of criterion and the note of the item for that criterion is multiplied, this is done for each criterion and the results are added in order to find an overall evaluation.

In our study, after building the hierarchy structure, we computed the relative importance of each indicator (Section 5). The evaluation of performance for each criterion is determined as a ratio that is the realized performance divided by the target performance level. For cost criterions the ratio is calculated in means of difference from the goal again in percentage to answer the demand.

## 5. Criteria Hierarchy

For all the criteria that are planning to be part of the overall performance value, AHP is used with the hierarchy shown in Fig. 2.

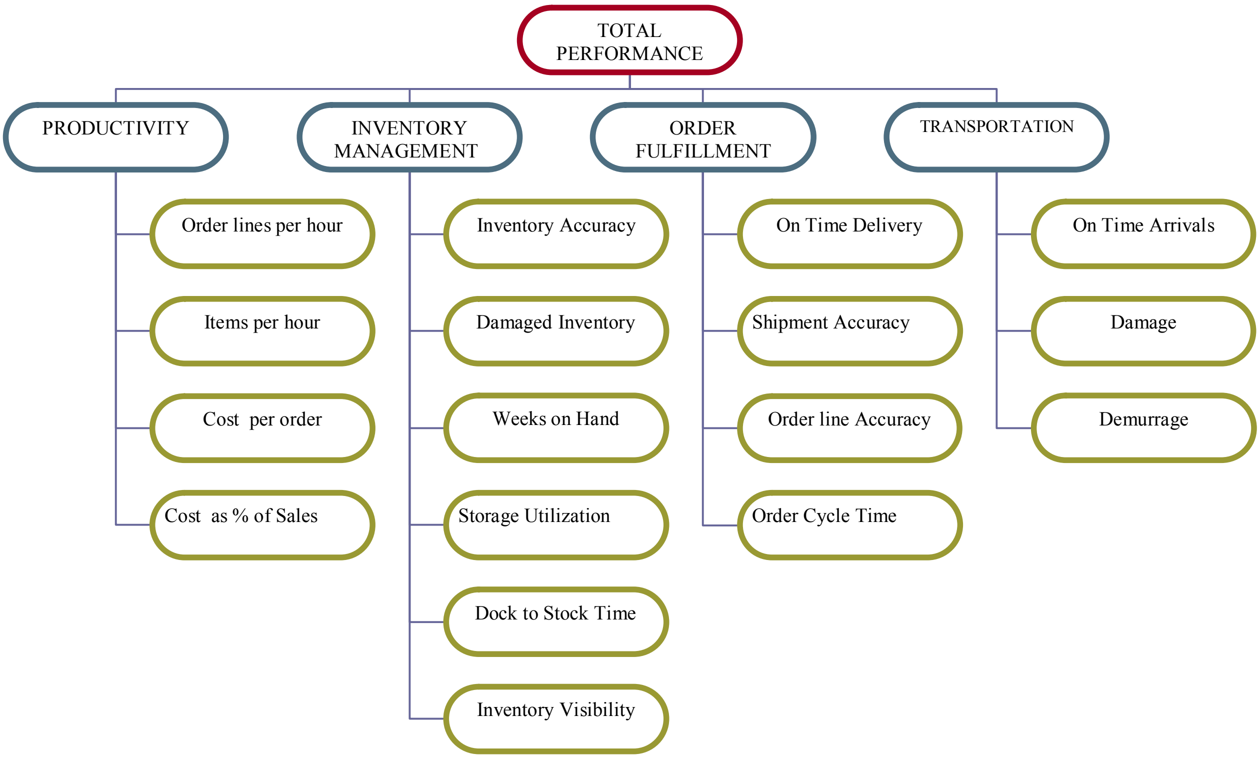


Fig. 2. Indicator Hierarchy

For all groups of criteria pair wise comparison matrixes and weights are calculated and gave examples for some of them in the below Tables.

Table 2 represents the pair wise comparisons of Performance Indicators to calculate the overall performance Table 3 represents the relative importance vectors and Table 3 shows the consistency ratio.

Table 2 Pair wise comparison matrix for Performance Indicators.

| | Order Fulfillment | Inventory Management | Productivity | Transportation |
|---|---|---|---|---|
| Order Fulfillment | 1 | 4 | 7 | 9 |
| Inventory Management | 1/4 | 1 | 4 | 7 |
| Productivity | 1/7 | 1/4 | 1 | 3 |
| Transportation | 1/9 | 1/7 | 1/3 | 1 |

Table 3 Relative importance matrix of Performance Indicators.

| | W |
|---|---|
| Order Fulfillment | *0,61* |
| Inventory Management | *0,26* |
| Productivity | *0,09* |
| Transportation | *0,04* |

Table 4 Consistency Results of Performance Indicators.

| | |
|---|---|
| Consistency Index | 0,077 |
| Random Consistency Index | 0,9 |
| Consistency Ratio | 0,086 <0,1 |

Table 5 represents the pair wise comparisons of Productivity Indicators and Table 6 represents the relative importance vectors.

Table 5 Pair wise comparison matrix for Productivity Indicators.

| | Order lines per hour | Items per hour | Cost per order | Cost as % of Sales |
|---|---|---|---|---|
| Order lines per hour | 1 | 5 | 7 | 9 |
| Items per hour | 1/5 | 1 | 5 | 7 |
| Cost per order | 1/7 | 1/5 | 1 | 5 |
| Cost as % of Sales | 1/9 | 1/7 | 1/5 | 1 |

Table 6 Relative importance matrix of Productivity Indicators.

| | W |
|---|---|
| Order lines per hour | 0,60 |
| Items per hour | 0,25 |
| Cost per order | 0,11 |
| Cost as % of Sales | 0,04 |

Table 7 Consistency Results of Productivity Indicators.

| | |
|---|---|
| Consistency Index | 0,058 |
| Random Consistency Index | 0,9 |
| Consistency Ratio | 0,064 <0,1 |

The consistency Ratio is less than 0.1 as shown in Table 7 we can use 0.60 value for " order lines per hour", 0,11 value for cost per order.

Calculations for Inventory Management and Transportation Indicators are done similarly.

## 6. Calculating Overall Performance

After having the criteria hierarchy and goals defined, actual values are calculated and multiplied by the weights of the indicators. Then they are all summed up to show the overall performance.

For example for indicator Items per hour let's assume that we have a goal set to 75, and actual result is 55. The weight of Indicator Items per Hour is 0.25 as it is seen from Table 4.5. Productivity performance group has a weight of 0.09. So from the Items per Hour indicator overall performance will be affected by (0.25* 55/75*0.09) = 0.0165.

Where as overall performance will be the sum of weights of all performance indicators such as Productivity, Order Fulfillment, Inventory Management and Transportation. The weight of each group is again calculated as defined above.

## 7. Conclusion

In this study we have analyzed a real life problem and set up a solution methodology using Analytical Hierarchy Process. The most important part was combining the different performance indicators together to reach and see the overall performance of the DC.

Using this framework, managers can trace the changes in DC performance by time, besides they can make benchmarks with other distribution centers in the all levels of criteria.

In further studies, a survey research will be done in order to find the sectoral view to this criteria and importance levels. The result of the research can be combined in a group decision making perspective in order to define sectoral importance levels.

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# USING THE CONCEPT OF MATERIAL AND INFORMATION DECOUPLING POINT TO ESTABLISH SUPPLY CHAIN OF COAL IN POLAND

Danuta Kisperska-Moron[1] and Artur Swierczek[2]

## Abstract

*The Material and Information Decoupling Point is one of the most popular concepts in logistics. It is currently perceived as one of the most fundamental logistical solutions, which allows a company to survive and gain a competitive position in the highly volatile environment.*

*There are many publications introducing theoretical background of the MDP and IDP concept, but only a few of them present its practical importance. The paper depicts an illustrative case study analyzing the position of MDP and IDP in the supply chain operating in Polish mining sector.*

*On the basis of analysis of physical flow in a coal supply chain the determinants and requirements of proper location of the Material and Information Decoupling Points are examined.*

*Keywords: Material Decoupling Point, Information Decoupling Point, supply chain of coal*

## 1. Introduction

Polish mining sector is under constant reconstruction and requires both the implementation of modern technology and innovative management. One of vital fields is logistics, whose role and importance over the last decade has risen dramatically. The implementation and use of logistical methods and techniques positively influences the effectiveness of companies and enables them to gain competitive advantage in the permanently changing environment. One of the most popular logistical concepts is Material and Information Decoupling Point, which in the last few years has been a subject of intense research both in theoretical and practical frameworks.

The paper presents an illustrative case study on the analysis of the position of both Material and Information Decoupling Point in a supply chain of coal in Poland.

## 2. Material and Information Decoupling Point concept in supply chains – literature review

The emergence of a supply chain concept in theory and practice was connected to changes occurring in the late eighties of the last century in economical and technological environment: the creation of global market and worldwide economy, a necessity to gain control over new markets with the purpose of having better effect on customers as well as a need to challenge growing pressure from competition, the dynamic development of information technologies, the increasing pressure from customers connected with their newly discovered, more refined needs, the necessity to lower the costs of operations, the development of new managerial techniques and concepts.

Various definitions of a supply chain have been offered in the past several years, as the concept was gaining popularity (see: Cooper, & Ellram, 1993; LaLonde & Masters, 1994). For the purpose of this paper the supply chain is defined as a set of three or more companies directly linked by one or more of the upstream and downstream flows of products, services, finances and information from a source to a customer (Mentzer, 2001).

From the logistical point of view there are at least two pipelines within each supply chain – the material flow and the information flow. Both flows are important and can be perceived as a strategic source of market competitive advantage for the organization. In the flows one can identify two decoupling points – the Material Decoupling Point in material flow and the Information Decoupling Point in information flow.

The Material Decoupling Point has been on the logistical agenda for several years. MDP is a point in the product axis to which the customers' order penetrates. It is where order driven and forecast driven activities meet (Mason-Jones, & Towill, 1999). The Material Decoupling Point is a buffer between upstream and downstream players in the supply chain. This enables them to be protected from fluctuating consumer buying behavior and therefore establishing smoother upstream dynamics, while downstream consumer demand is still met via a product pull from the buffer stock (Mason-Jones, & Towill, 1999).

When a demand for products is transmitted along a series of inventories using stock control orders then the demand variation will increase with each transfer. Market sales data are a catalyst for the whole supply chain,

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holding undistorted data describing the customer demand pattern. The point to which a marketplace order data penetrates without modification is called the Information Decoupling Point (Mason-Jones, & Towill, 1997).

Information Decoupling Point is where market driven and forecast driven information flows meet (Mason-Jones, & Towill, 1999). It is a point at which information turns from the high value actual consumer demand data to the typical upstream distorted, magnified and delayed order data (Hoekstra, & Romme, 1992). The Information Decoupling Point is a vital issue to be considered and its position can be determined by changing the companies' attitude to cooperation and achieving common, interorganizational goals. It is much more difficult to accomplish that with a Material Decoupling Point.

The appropriate position of both Material and Information Decoupling Point is a critical issue in every well-managed supply chain. Theoretical analysis show that there is a governing principle which says that the Material Decoupling Point should be moved as close to the end customer as possible and, on the contrary, the Information Decoupling Point ought to be moved as far upstream in the supply chain as possible. Apart from theory every industry and a particular supply chain is different and there are always some technological, organizational and economic limitations which do not allow to use a model position of Material and Information Decoupling Points. Thereby, it is interesting to analyze the position of the Material and Information Decoupling Points in the Polish hard coal supply chain and to verify the conditions of moving them according to theoretical concepts.

## 3. Research methodology framework

After profound literature studies on the concept of the Material and Information Decoupling Point a primary objective of research was defined: to analyze different options of positioning Material and Information Decoupling Points in the coal supply chain in Poland. On the basis of that objective the following research problems were derived:

- the examination of the possibilities of positioning Material Decoupling Point downstream in the supply chain, close to the market and customers' needs,
- the identification and analysis of the possibilities of moving Information Decoupling Point as far upstream as possible in order to embrace the maximum number of companies in a supply chain of coal in Polish mining sector.

In order to carry out research and accomplish defined objective a case study analysis was used. Research was conducted in exemplary Polish coal mines, belonging to the structure of two holdings, which operate in the southern Poland. The results of established methodology enabled to answer three research questions, namely:

RQ1: Is the Material Decoupling Point positioned in a coal supply chain, close to the market?

RQ2: Is it possible to position the Information Decoupling Point maximum upstream in the supply chain, in its first link – a coal mine?

The strategic position of the Material Decoupling Point depends very much on the product type, consumer demand and supply chain adopted (Kisperska-Moron, 1999). Figure 1 represents typical positions of Material Decoupling Point in the product flow.

The first position is Ship to Stock (STS) - products are standardized and pre-positioned in the market; customers' expectations of immediate availability support the maintenance of speculative safety stock at all points of distribution. The second point is called 'Make to Stock' (MTS) – products are standardized but not necessarily allocated to specific locations; the demand is anticipated to be stable or readily forecasted at an aggregate level. The third possible position of MDP is 'Assemble to Order' (ATO) - products can be customized within a range of possibilities, usually based upon a standard platform. The fourth point is known as 'Make to Order' (MTO) - raw materials and components are common, but can be configured into a wide variety of products. The last position of the Material Decoupling Point is 'Buy to Order' (BTO) point. Products demanded by customers can be unique right down to the raw material level, product variety is virtually limitless, though lead time is long as materials are procured, processed into finished goods, and delivered (Naylor, Naim, & Berry, 1999 and Goldsby, & Garcia-Dastugue, 2003).

Despite the fact that the Material Decoupling Point can be positioned at different points of the supply chain, the governing principle is always to move it as close to the end customer as possible, thereby ensuring the shortest lead-time for the customer. This approach also enables full capitalization of the benefits of divorcing the customer variability from the demands placed on the majority of players in the supply chain (Mason-Jones, & Towill, 1999).

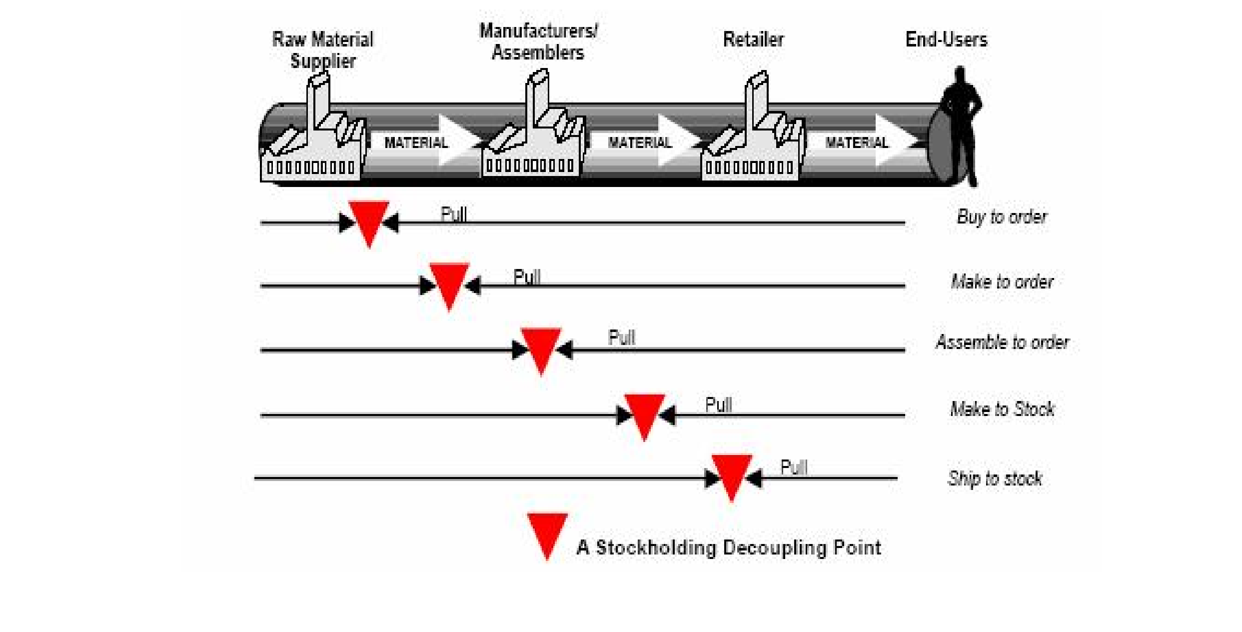


Figure 1. Typical positions of the Material Decoupling Point in a product flow
Source: S. Hoekstra, J. Romme (1992): Integrated logistics structures: Developing Customer Oriented Goods Flow, McGraw-Hill, London.

To maximize the strategic potential of customer data within the supply chain Information Decoupling Point should be moved as far upstream as possible (see: Mason-Jones, & Towill, 1999) to embrace the maximum number of companies. Sharing in-depth information sounds easy, but does not come naturally for most companies (figure 2). In fact, the company policy has in the past frequently actively discouraged it (Mason-Jones, & Towill, 1997).

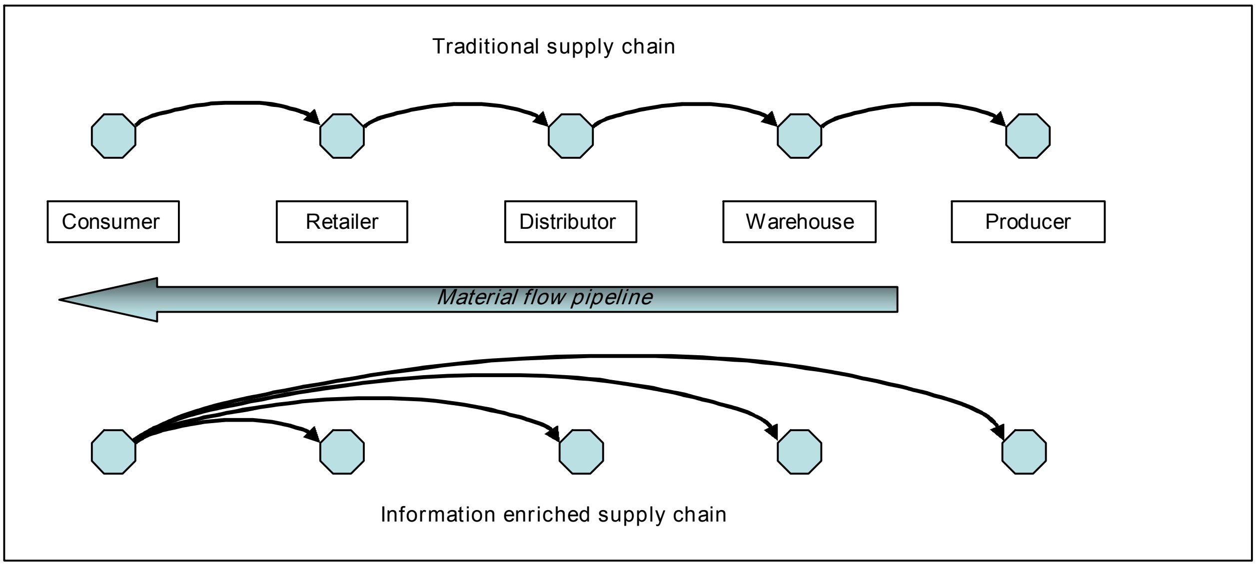


Figure 2. Enriched information supply chain
Source: Adapted from: Mason-Jones R., & Towill D.R. 1997. Information enrichment: designing the supply chain for competitive advantage, Supply Chain Management. Vol. 2, No. 4, pp. 137-148.

Figure 2 illustrates two types of supply chains: one, traditional pipeline, where each supply chain player receives information from its immediate customer from which a decision on a required internal order rate to satisfy its stock targets is made (Mason-Jones, & Towill, 1997). In the second situation information is distributed on-line from one source to all supply chain players. The advantage of such solution is the ability to share many different data, without modification. It means that for example the information about customers' demand, which is transferred among supply chain's partners is real, updated and guarantee an appropriate basis for the decision making process. The position of the Information Decoupling Point is strictly concerned with the implementation of the adequate logistics information system in the supply chain

The logistics information system in the supply chain should guarantee that the organisation will be enriched with information. Although many companies through the implementation of IT are flooded with information, very few gained a competitive advantage via their improved data flow. Implementation of IT is not enough if it only transfers the previous data pool faster; information should also have a different structure. Supply chains successfully enriched with information must view it as a strategic asset and ensure that it flows with minimum delay and minimum distortion (Mason-Jones, Naylor, & Towill, 2000). In this type of structure individual supply chain members remain independent, but their planning and operations are characterized by a high degree of IT-enabled integration, such as enterprise resource planning (ERP) systems. Such off-the-shelf generic systems usually require a compatible IT infrastructure (that can be extremely costly to implement) in order to support efficient data exchange. The IT systems are of key importance, with companies having to change their structures to allow the systems to function correctly structure (Phelan, & Griffiths, 2002).

Some managers may think that IT implementation is a solution, but it is only an enabler, which should be applied properly. The main issue is to overcome the adversial relationships between supply chain members where they regard each other as enemies (MacBeth, & Ferguson, 1994).

The use of information technology and data sharing among supply chain partners enable forming an organization that hears the voice of the market and responds directly to it. Capturing data on real demand directly from point of sales and its sharing between buyers and suppliers is the prerequisite for appropriate position of the Information Decoupling Point. In the opinion of Harrison et al. it means that supply chains are information based rather than inventory based. (Harrison, Christopher, & van Hoek, 1999).

It means that conventional logistics systems are based upon a paradigm that seeks to identify the optimal quantities and the spatial location of inventory. Complex formulae and algorithms exist to support this inventory-based business model. Paradoxically, what we are now learning is that once we have visibility of demand through shared information, the premise upon which these formulae are based no longer holds. Electronic Data Interchange (EDI) and now the Internet have enabled partners in the supply chain to act upon the same data i.e. real demand, rather than be dependent upon the distorted and noisy picture that emerges when orders are transmitted from one step to another in an extended chain (Christopher, 1998). Thereby, appropriate location of the Information Decoupling Point must be supported by intense use of modern information technology, such as: web sites, database systems, expert systems, decision support systems, EDI, Internet, etc.

## 4. The analysis of material and information flows in the supply chain of coal in Poland

### 4.1. Physical flow in supply chain of coal

There are many complex and differentiated material and information flows in a coal supply chain. Figure 3 presents the exemplary coal supply chain from the perspective of the distribution phase and major groups of recipients (main market segments). The phase of coal distribution in supply chains of coal starts with processing plant or coal storage and includes several operations associated with sales of specific type of coal.

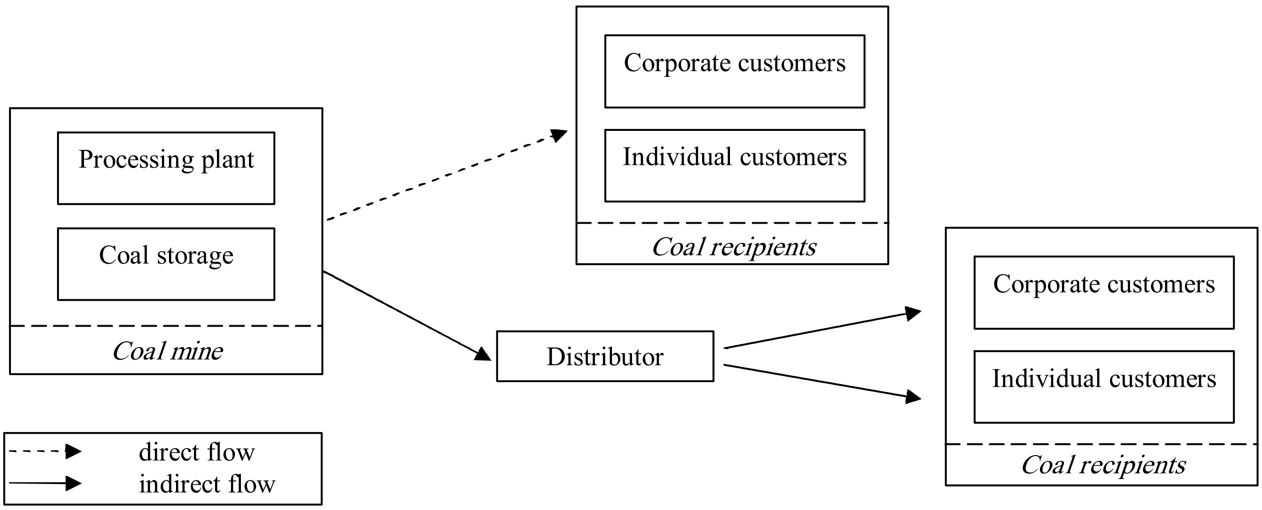


Figure 3. The exemplary supply chain of coal in Poland

There are two types of physical flows in supply chain of coal: direct flow and indirect flow. The direct flow includes recipients which set up long term agreements with a producer, buy coal directly in a coal mine and pay for it with a cash transfer. There are also ultimate users of purchased product. This group of recipients includes mainly corporate customers such as: power plants, heat and power generating plants, heating plants, etc. The indirect flow in a supply chain includes individual customers: private persons and companies which use coal according to their requirements. They purchase the product in small quantities and pay for the received coal at the cash-desk of the coal mine. Special group of partners in indirect flow are trade intermediaries – distributors, who purchase a product from a coal mine, store it and sell to individual customers or brokers, who contact buyers with suppliers, but physically do not purchase any products.

4.2. Production of coal in a coal mine

A coal mine is one of the most important links in the supply chain of coal is the coal mine. It initiates the whole flow of products and affects the efficiency and productivity of the whole supply chain. The major focus of a coal mine is to provide deliveries for large corporate customers on the basis of long term agreements.

Most of Polish coal mines strive to reduce costs of mining and concentrate on the production exploiting two or three mining walls of defined qualitative parameters. The process of coal production can be divided into two main phases: extraction and processing of coal.

Extraction is the first production stage which is measured by the amount of coal delivered within a unit of time from underground to the ground surface for further processing or out-of-mine transport. The extraction of coal includes the following activities:

- Technical and organizational preparatory activities allowing for coal mining,
- Extraction of underground coal,
- Vertical and horizontal transport of coal.

The coal extracted to the surface is directed to mechanical processing – last stage of production phase. It is a very important stage in the process of coal production, as the quality parameters of extracted coal differs from that required by the recipients. Thus, it becomes necessary to process the extracted coal so that it fulfils the customers' demands.

Figure 4 presents detailed material flow in the production phase of coal.

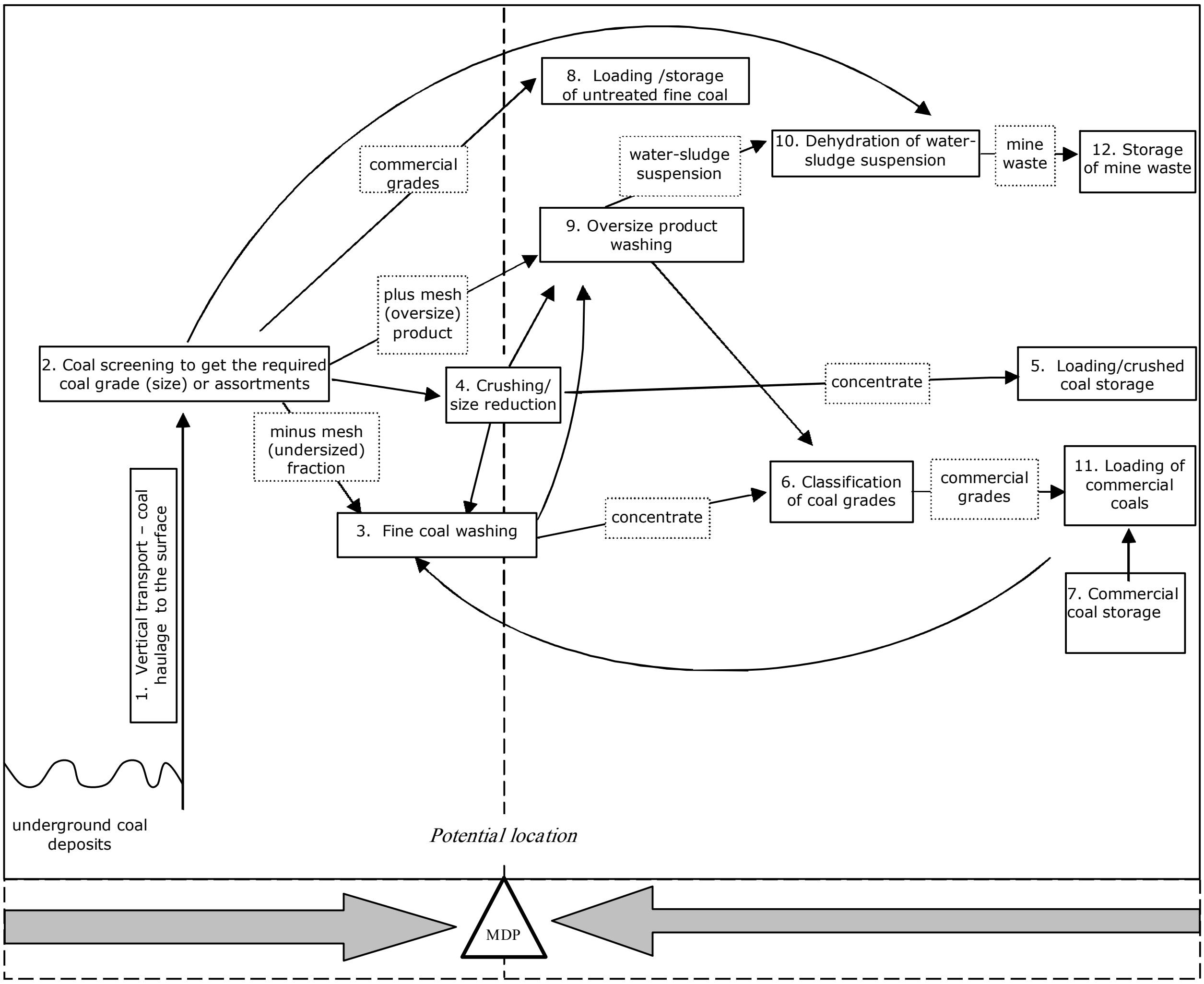


Figure 4. Material flow of coal in the exemplary main

The whole process starts with coal extracting underground. Next coal is delivered by means of horizontal transport infrastructure to the container near a mine shaft, from where coal is vertically transported to the surface (1). Afterwards coal is delivered to the processing plant, where at first it is screened in order to get a required coal grade or assortments. Coal screening can be defined as a main operation, when received product is directed to the market sale (as commercial grades) or as a preparatory (initial) operation, when received coal size is directed to the subsequent technological operations (2). Untreated fine coal is the most requested commercial grade in Polish conditions. It is then loaded and directed to the recipients or stored at the mine (8). An additional activity, which can follow coal screening is coal crushing and it depends on size reduction of coal grades by means of mechanical crushing (4).

In practice, coal crushing can be defined as a main operation or preparatory operation. The goal of coal crushing as a main operation is to reduce size of coal grades according to real demands of market. Most often coal crushing is used as a initial operation in coal processing. Its goal here is to separate (split) useful from useless coal grades. In the result it provides material to the subsequent stages of processing. Most often coal crushing is used to reduce the size of coal grades to the form of crushed fine coal, which is then directed to the market sale or to the isolated place in coal storage at the mine (5).

In the result of screening a plus mesh product and minus mesh fraction are acquired. They are then directed to the process of washing in order to improve their qualitative parameters (3,9). Process of coal washing is essential to fulfill signed contracts and to keep qualitative coal parameters defined by recipients.

The concentrate and water-sludge suspension are additional products delivered in a washing process. The concentrate is subsequently classified (6) and the adequate commercial grades are acquired. The commercial grades are then loaded on railway cars at special platform and directed to the recipients (11) or stored in a special isolated place at the mine (7).

The commercial grades stored at the mine can be directed to the market sale or returned to the processing (3,9). The water-sludge suspension is dehydrated and then directed as a mine waste to the storage (12).

Figure 5 presents the information flow associated with material flow of coal in a coal mine.

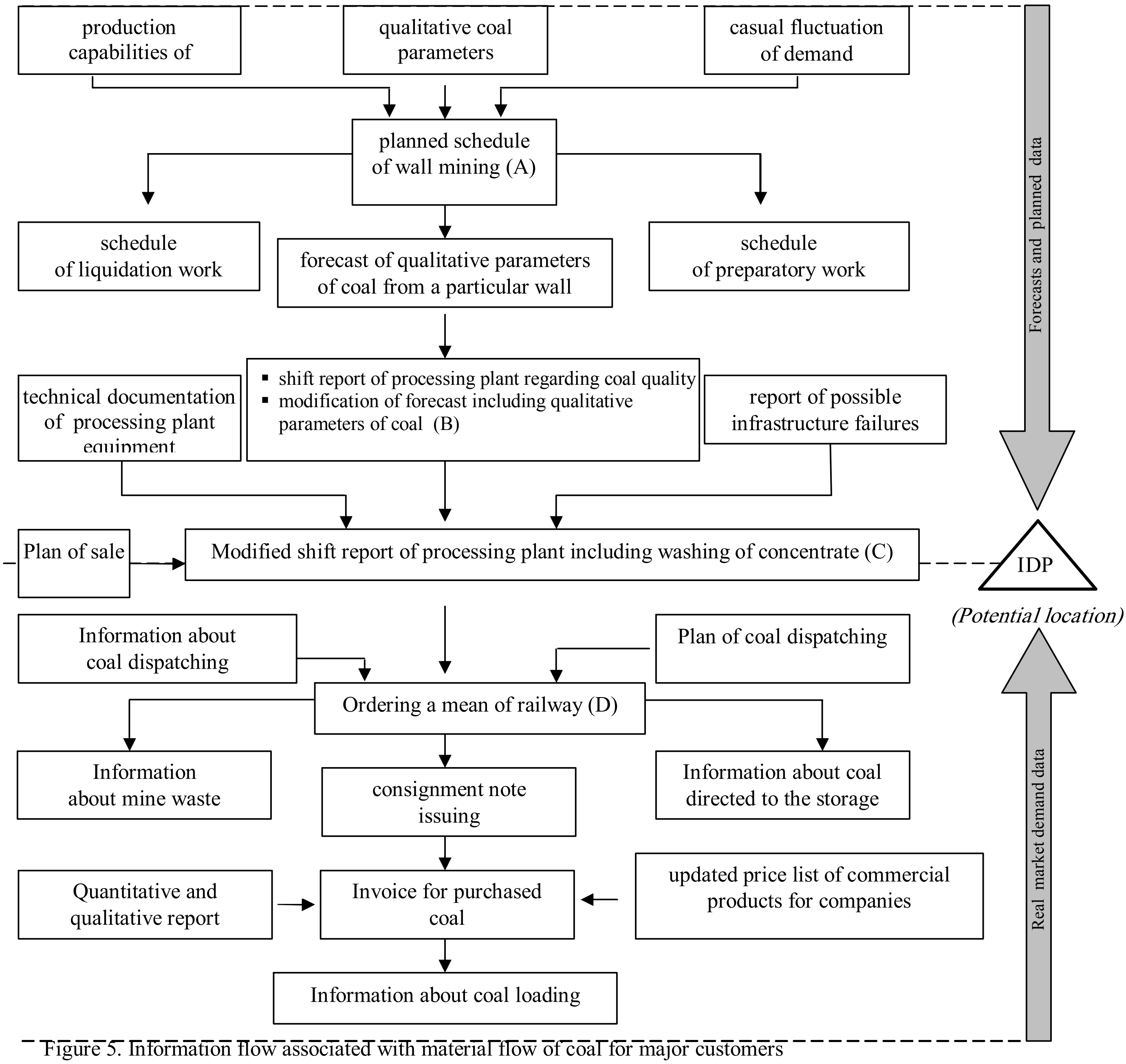


Figure 5. Information flow associated with material flow of coal for major customers

Coal mining process is carried out according to planned schedule of wall mining (A). The schedule is prepared on the basis of long term technical experience of the company, current production capabilities of its infrastructure, availability of coal deposits of adequate quality and seasonal fluctuation of demand. On the basis of the schedule of wall mining the qualitative coal parameters regarding for particular walls of coal are forecasted. The forecast included in the schedule is then compared with a daily report concerning coal quality extracted to the surface. This report reflects real quality parameters of coal and is an integral part of a shift report of processing plant (B). It determines a specific type of product.

A quantitative structure of washed concentrates is then included in the report of processing plant. This document is based on the plan of sale, report of possible infrastructure failures and technical documentation of processing plant equipment (C). There are two sources of final processing plan:

- planned schedule of wall mining and shift report of processing plant regarding coal quality,
- plan of sale – determined by requirements of large recipients of coal (inc. companies and distributors).

The requirements of recipients ordering small quantities and needs of individual customers are not planned in detail. Therefore their exact requirements are not taken into account in the plan. There are able to purchase coal, whenever its production exceeds the needs of large customers.

## 5. The position of Material Decoupling Point in the supply chain of coal – discussion

The analysis of role and functions of a coal mine in the supply chain of coal provides an answer to the first research question stating that Material Decoupling Point is positioned in a coal supply chain, close to the market. The Material Decoupling Point separates forecast driven activities in an initial process of coal production, especially from extracting coal to screening activities and order – driven activities in a coal processing and product distribution. Potential position of Material Decoupling Point has been graphically illustrated in figure 4.

The activities initiated by plans and forecasts are: coal extracting underground, horizontal transport of coal, coal haulage to the surface, coal screening, etc. As a result there are three types of products acquired: commercial grades (mostly untreated fine coal purchased by companies, not by individual customers), plus mesh (oversize) product (mostly washed and purchased by individual customers) and minus mesh (undersized) fraction (mostly washed and purchased by companies). These types of products and activities are initiated and fulfilled according to push strategy.

On the other hand there is a large amount of activities initiated or potentially originated by customers and their needs. Three types of products are then directed to loading/storage (especially untreated fine coal), washing (especially minus mesh fraction and plus mesh product), crushing in order to reduce coal size. As a result of coal processing there are different types of products:

- concentrate, its classification and finally commercial grades, which are immediately loaded on the means of transport or set to storage,
- water-sludge suspension, its dehydration and mine waste, which is finally stored,
- crushed coal, which can be immediately loaded on the means of transport, stored or mixed with fine coal of worse quality in order to obtain coal blend with better quality parameters.

Figure 6 presents a complex analysis of the Material Decoupling Point in a coal mine. There are forecast driven activities on the left side of MDP. All activities here are initiated by push strategy, according to plans and forecasts. There are order driven activities on the right side of Material Decoupling Point. Thus, all activities are originated by pull strategy, according to customers' market demand.

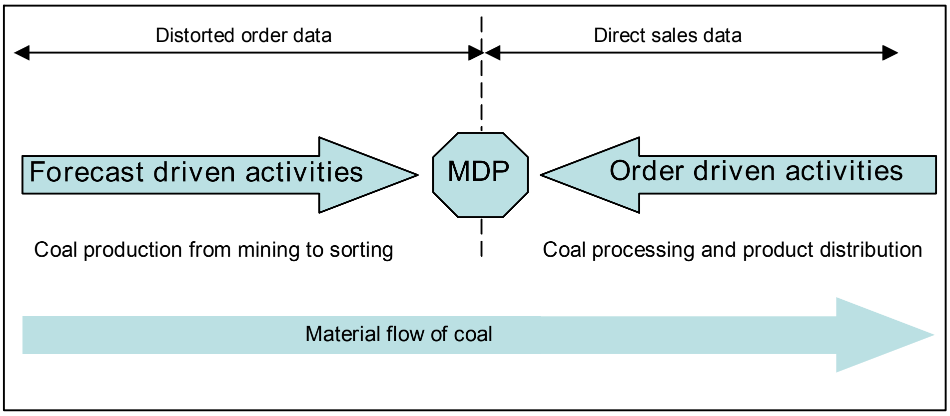


Figure 6. The position of the Material Decoupling Point in a product flow of coal

The analysis allows to conclude that contrary to theory a Material Decoupling Point is positioned in the first tie - coal mine in the supply chain of coal. Additionally, the results of analysis suggest that Material Decoupling Point can not be moved downstream because of the technological and organizational restrictions of coal production in Polish mining sector. There are several reasons, which determine such conclusion:

- appropriate washing of untreated coal results from information about qualitative and quantitative parameters of recipients' demand;
- coal extracted and not sold in a particular period of time, stored temporarily, is put to direct sale or can be set to coal processing stage in order to obtain quality parameters according to customers' demand;
- quality parameters of fine coal requested by a customer result from blending of two types of fine coal: one crushed from plus mesh product and the other fine coal of lower quality extracted from underground.

The Material Decoupling Point is strictly positioned in the first link in supply chain mainly due to technical factors. If the product was moved downstream to the next ties of the supply chain it would have to return to the first tie (coal mine) to processing phase of production in order to meet recipients' requirements of coal quality. Thus, the listed factors suggest that from the perspective of management theory the position of Material Decoupling Point is not appropriate, profitable and optimal taking into consideration the whole supply chain. Additionally, it determines the position of the Material Decoupling Point in the whole supply chain of coal in Poland and doesn't allow to reap benefits from implementing methods and techniques of effective material flow management (e.g. postponement, quick response logistics, etc.).

## 6. The position of Information Decoupling Point in the supply chain of coal – discussion

The analysis reveals that there are two potential locations of the Information Decoupling Point in supply chain of coal:

- typical for direct orders and deliveries for large customers (indicated in figure 5). This information is fully used to plan production and organize deliveries. The Information Decoupling Point is in the same position for individual customers in a direct channel, but that information is neglected by a coal mine and customers are served on the basis of availability of commercial products. This results in queuing, arguing and lots of confusion in delivery performance.
- Typical for indirect channel, the Information Decoupling Point is located at the distributors' point and generally allows to organize transactions and deliveries between distributor and ultimate customers. If the distributor has long-term agreements with coal mines than it is very likely that he will be able to provide accurate deliveries to its customers.

The position of Information Decoupling Point in a coal mine separates extraction of coal from processing phase and coal distribution stage. Usually moving the Information Decoupling Point upstream in the coal mine means the interdependence of extraction phase of production and current market demand. Moving the Information Decoupling Point upstream in the first tie of the supply chain of coal does not require a high level of capital expenditure. A proper website is one of such solutions. That kind of website has been developed by one of holding operating in a coal industry. It's an electronic interface allowing the customers in direct channel to place their orders. The centralized system informs the users about potential location of available coal stocks and its type. That tool aims at elimination of queues and confusions while shopping for coal.

It is technically impossible to search for coal and exploit underground coal deposits according to needs of particular customer or market sector. It requires implementation of the selective coal mining strategy, which at present situation of mining technology is not feasible. It would be also irrational to respond to current market demand by selective coal extraction due to high costs of production. In order to optimize production costs the management of coal mines strives for maximum utilization of production capacities and increased work efficiency. As a result of focus on efficiency issues coal mine have also to face seasonal fluctuations of market demand. It also influences the level of capacity utilization through slowing down of operations.

The answer to the second research question is more complex, because there are two options of positioning of the Information Decoupling Point in supply chain of coal: in direct channel IDP is located in a coal mine, in case of indirect channel, IDP is positioned at the distributor.

However practically in both cases situation depends on relationships between customer, distributor and coal mine. If the sale of coal is based on long-term agreements, the Information Decoupling Point is located in a coal mine. Long-term planning and long-term agreements serve as an enabler of proper delivery performance. Correctness of long-term agreements should be guaranteed by proper demand forecasting.

## 7. Conclusion

The analysis reveals that logistical methods and techniques do not influence the process of mining and coal haulage to the surface. It is the result of technological deficiencies (coal deposits are located very deeply underground, which prevents from mining at current technological level) and investment expenditure concerning diversification strategy, dealing with increasing number of various mining walls. Most of Polish coal mines strive to reduce a cost of mining and concentrate on the production comprising two or three mining walls of defined qualitative parameters.

The Information Decoupling Point seems to be located in an appropriate stage because in case of direct channel it is positioned at the coal mine, and in case of indirect channel it is located at the distributor.

In all instances the Material Decoupling Point is strictly located at the initial stage of processing of extracted coal. At the same time there is always a gap between IDP and MDP:

- in case of direct deliveries a gap exists between the Material Decoupling Point located at the beginning of processing and the Information Decoupling Point at the distribution stage,
- in case of indirect channel a gap is even larger, because the Material Decoupling Point is still positioned at early stage of processing and the Information Decoupling Point is located at the distributor.

It would be very difficult to eliminate the existing gap between MDP and IDP, because the Material Decoupling Point strictly depends on mining technology. The only option left in order to coordinate the position of the Information and Material Decoupling Points would be to try to shift the Information Decoupling Point more upstream closer to the Material Decoupling Point.

The coal supply chain analysis suggest that it is impossible to apply the concept of Material and Information Decoupling Point in Polish coal supply chain according to pure theoretical recommendations. However, the consolidation of coal market and permanent pressure put on delivering better quality of coal will bring about further attempts to eliminate the gap between IDP and MDP in coal supply chains in Poland.

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# VALUE-BASED DIFFERENTIATION IN THIRD PARTY LOGISTICS: CORE DIFFERANTIATORS FOR THIRD PARTY LOGISTIC SERVICE PROVIDERS

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## Abstract

*The aim of this study is designed to identify the core differentiators among third-party logistics service providers in the Turkish market context. Another aim is to specify the distinguishing characteristics, and the evaluation criteria of this market context. Based on the theoretical framework and previous researches a questionnaire with third-party logistics service providers' customers has been conducted. Although relevant literature on TPL industry mainly devotes attention and emphasized cost considerations to using TPL services and creating customer value, findings of this study emphasized the importance of benefits dimensions of the relations between the TPL providers and their customers in creating value. In terms of benefits dimensions service quality and delivery performance, and the personnel interactions with customers found to be very important dimensions creating customer value in TPL services. Thus, these two dimensions and their subvariables can be considered as core differentiators for the providers of TPL services. In terms of cost dimensions, reducing transportation costs is considered to be main differentiator. In addition this, reducing personnel costs and financial costs of customers are also regarded as important differentiators in creating value for the customers of TPL providers.*

Keywords: Third party logistics (TPL) providers, value-based differentiation, core differentiators

## 1. Introduction

The use of Third party logistics (TPL) has gained prominence since 1990s. The need for developing sustainable competitive advantage, the growing emphasis on providing good customer service effectively and efficiently, and the strategic value of focusing on core business, reengineering organizations and supply chain strategies resulted in the evolution of TPL. A changing context and new demands on logistics are driving an ongoing transformation and differentiation of the buying process for TPL services (Andersson and Normann, 2002).

The logistics system of the company can be differentiated to provide its target service level. The close relationship between logistics and customer service, and its effects on a company's competitiveness dictate that companies handle their logistics function prudently so as to achieve its full potential as a source of competitive advantage. Outsourcing logistics functions appears to be an important tool to realize that objective.

Various terms have been introduced to describe outsourcing logistics functions to TPL providers, such as third party logistics (Lieb et.al., 1993, Murphy and Poist, 1998, Virum, 1993) and logistics alliances (Bowersox, 1990, Bagchi and Virum, 1996), contract logistics (Africk and Markeset, 1996; Razzaque and Sheng, 1998). These definitions reflect the phase of third party cooperation. Lieb et al. (1993) defined TPL concept as the use of external companies to perform logistics functions that have traditionally been performed within an organization. Typical services outsourced to TPL providers are transport, warehousing, inventory management, value added services, information services, and reengineering of the chain. The first three are the most common services outsourced from the companies. Bachi and Virum (1996) have developed the term logistics alliance defining as a close and long term relationship between a customer and a provider encompassing the delivery of a wide array of logistics needs. The parties ideally consider each other as partners in a logistics partnership and TPL providers create value for their customers.

Definitions of TPL emphasize certain characteristics of the relationship between the buyer and seller of logistics. These characteristics include certain duration, joint efforts to develop further cooperation, a customerization of the solution, together with a fair sharing of benefits and risks.

Turkey has a great potential for TPL providers when such evidences as its strategic position, developments in its trade volume and accelerating economic activities around the region considered. In recent years, the transition from the characteristics of seller's market to those of a buyer's market has led Turkish companies to concentrate on different ways of contemporary management. Logistics management has attracted these companies as a new frontier (Ulengin and Uray, 1999). The number of outsourcing and supply chain practices has increasingly developed in Turkish market since 2000s. It is reported that both the volume of the logistics market and competition among

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logistics service supplies are increasing (Özer and Tuna, 2001; Ulengin and Uray, 1999). New actors both from local and global logistics environment have entered into TPL market in Turkey. These trends in Turkish logistics market have forced TPL companies to search for differentiating their services and creating superior value for their customers. Although the importance of third party logistics services has been increasing among companies in Turkey the number of the comprehensive studies is negligible. Thus this study aims to fill this gap in terms of value-based perspective.

## 2. Literature Review

TPL literature mainly covers extent and use of TPL services, driving forces to outsource logistics functions, TPL provider selection and performance criteria and benefits obtained from TPL relations. Although previous researches help to shape current study, it is noticed that they studied the TPL from organizational and managerial perspective rather than marketing and operational perspective. Operational dimensions of TPL and customer relations in terms of value based differentiation are not sufficiently detailed. Relevant literature was given below considering the value-based perspective.

### 2.1. Driving Forces of Using TPL Services

Reviewing the TPL literature on the driving forces of using TPL highlights the ways to create creative customer value for the customer of TPL providers. Most of the early papers on TPL focus on reasons for outsourcing logistics activities and what to expect from. Firms outsource logistics functions for variety of reasons. Laerhoven et al., explored the driving forces behind using TPL in European market and ranked the factors in terms of importance as: the need to reduce cost and amount of capital investment, service or quality improvement, the need for strategic flexibility and focus on core competencies and change implementation respectively. Important factors affecting the outsourcing logistics decisions were found as cost savings, customer satisfaction and flexibility in Singapore market (Bhatnagar et al., 1999). Reasons of outsourcing in USA according to Sheffi (1990) and Lieb and Randal (1993) are the need to focus on core business, better transportation solutions, cost savings and improved services, development of technological expertise, need for professional and better logistics services. Similar reasons for decision to outsource logistics functions were also reported by other studies (Rao and Yong, 1994; Dapiran et. al., 1996; Larsen T.S, 2000, Sohail and Sohal, 2003). These reasons mainly include ability to focus on the core activities, gaining the use of sophisticated technology, coping with reductions in the resources (i.e.funding), reducing capital investment, using the expertise of a third party, receiving very customized service, reducing inventory, penetrating market, having a single point of contract, becoming more active in international shipping, exploiting logistics to gain competitive advantage.

To sum up the reasons to outsource logistics functions, not only the cost factors but also the benefits which create value for customers is the main reason for customers. Previous studies mainly explored the reasons of outsourcing from the managerial and strategic perspectives.

### 2.2. Selection and Performance Evaluation Criteria of TPL Providers

Because both selection and performance criteria are of critical importance to shippers in terms of achieving high customer service level, cost savings and efficiency in the overall supply chain the relevant literature was regarded as important to discover value based differentiators for TPL providers. Sink et al., (1996) found that the most important criterion for the selection of TPL providers is core competencies. Issues of expertise, reputation, experience and reliability were often mentioned in relation to the emphasis on supplier core competencies. Price was used as a tie-breaker, or considered a secondary issue to service in the evaluation criteria of potential suppliers. Roberts (1994), reported that the level of service provided, quality of the people, and costs are the three most used evaluation criteria when choosing a qualified logistics supplier. Bhatnagar et al., (1999) suggest that while costs and service are the major issues, the most noticeable change is the emphasis on the quality of personnel, particularly in the operational area. Therefore, knowledge, expertise and skills of the personnel can be regarded as core differentiations for TPL companies. This is also reflected in the study of Dapiran et al., (1996) and Lieb et al, (1993) who explored that while cost and service are the most important criteria, prior experience with TPL company, company reputation, range of services offered, information handling capability and compatibility of information systems were other important factors. In Deveci, Tuna and Cerit's (2005) study on shippers' selection criteria in Aegean Region of Turkey personnel interaction of TPL provider with the customers and providing favorable financial conditions for customers are the most important factors among other factors in selecting TPL suppliers. Murphy and Daley (1997) found that the expertise, reliability and information are three most important factors in selecting TPL providers.

Performance of TPL providers was assessed by several authors using meaningful measures. Bhatnagar (1990) explored that on-time shipments, inventory accuracy, shipping errors, and customer complaints are the most important performance measures regardless of whether or not they outsource these functions. Menon, McGinnis and Ackerman (1998) found that on-time performance, low error rates, the ability to meet or exceed promises, and the availability of top management when necessary are important in terms of performance requirements. Lu (2003) evaluated the satisfaction level of shippers using carriers and founded that availability of service, low damage and loss records, accurate documentation, reliability and courtesy of inquiry are the most important factors for shippers satisfaction. In his correlation analysis it is revealed that four critical service factors are effective on customers' satisfaction: timing related, pricing, warehousing and sales services. This shows that service attributes are very important for shippers' satisfaction in partnering relationship. Pearson and Semejin (1999) explored the service priorities of small and large firms engaged in international logistics. Findings of their research showed that reliability, transit time, costs and over/short/damage records are most important factor both for small and large. Rahman (2006) ranked on-time delivery, total support of customer needs and consistency of order cycle as the most important in defining logistics service quality.

Reviews of all these researches prove that shippers do not only consider the price/cost as the most important factor in choosing and evaluating the performance of TPL provider. Non-price factors such as reliability, quick response to problems, equipment availability, documentation, delivery of cargo without damage are also as important as the price considerations.

### 2.3. Benefits of Using TPL Services

Many researches analyzing TPL explored that customers obtain benefits from TPL relations but the operational dimensions of these benefits were not sufficiently detailed in these studies. As can be noticed from the relevant literature these benefits mainly include cost reductions and service improvement.

Lieb et al. (1993) studying TPL among USA manufacturers explored that customers' most frequently cited benefits to use TPL services are lower costs, improved expertise/market knowledge, improved operational efficiency, improved customer service, ability to focus on core business and greater flexibility. Dapiran et al., (1996), found that the impact of TPL on the international logistics performance and the logistics cost had been positive for the industrial firms. Cost reduction, opportunity for the user firm to focus on its core business, improved service quality levels, increased productivity of the user firm and savings on time were mentioned as the most frequently obtained benefits in Bhatnager's study. Actual outcome of relations with TPL in the study of Laarhoven, Berglund and Peters (2000) is not much different; main element is cost, though the difference between cost and both service and quality is smaller. The main benefits of logistical alliances according to a study are improvement of economies of scale and scope, efficient operations, bargaining power, range of services, faster learning, network with other providers, knowledge of various kind, fast implementation of new systems, restructuring the supply chains, reduced investment base, smoother production base (Hertz and Alfredson, 2003; Aghazadeh, 2003).

TPL can reduce freight costs, and shorten order cycle and delivery times for their customers. Outsourcing logistics activities can reduce cost of operations, inventory handling, transport, order cycle time and so forth. Buyer of TPL services avoids the hidden costs of having to deal with the issues of labor turnover. Downsizing results cost reduction especial in personnel costs. Likewise, by using outsourcing strategy firms can save on capital investments because they do not purchase assets they only buy services.

The benefits gained for the customers in outsourcing logistics functions to TPL provider are depended on how it balances the coordination activities and the degree of adaptation to the individual customers. Thus satisfaction of customers from the services of TPL suppliers requires customization and differentiation of logistics services to the needs of customers.

### 2.4. Value Based Differentiation

Increasing competition among TPL companies to obtain competitive advantages and main logistics service supplier have forced TPL companies to differentiate and customize the services offered. Differentiation, as an important concept in strategic thinking, has been one of the widely researched topics in related literatures. Its popularity among scholars from different departments, however, has led to fuzziness in its identification. As Sharp and Dawes (2001) argue it is generally referred without any formal definition and mostly considered, in narrow manner, as a tool for reducing price sensitivity. An alternative definition offered by Sharp and Dawes (2001: 739) is as follows; "differentiation is when a firm/brand outperforms rival brand in the provision of a feature(s) such that it faces reduced sensitivity for other features". Provision of a valuable, rare, costly to imitate and non-substitutable feature may allow a firm to take advantage of opportunities such as reduced sensitivity for other features and save cost accordingly or neutralize threats in external environment.

Representing the difference between the customer's evaluation of all the benefits and all the costs of the offer and making comparisons between alternative possible sources of value, customer value is a core concept of modern marketing thought. Specifying three core customer values as quality, service and price, Kotler and Keller (2006:25), further, argue that "marketing can be seen as the identification, creation, communication, delivery and monitoring of customer value". It is a relative concept, since a product may have many features that may be appreciated by customers within its own market context.

When researched from a value-based perspective, differentiation can be regarded as a strategy that contributes to customer value by either providing benefits to the customer or lowering a customer's costs (Ulaga and Eggert 2006). Since what is considered as valuable is contextual, i.e. may depend on social, cultural, economical, industrial etc. contexts, there may arise a need to generate an understanding of value-creating dimensions in different industries.

Traditionally, the factors that drive the business buying process which is characterized with rational motives and personal relationships among channel members are thought to rely heavily on price and quality. This is true for TPL services. Nevertheless, facts related to the transformation to post-fordist industrial economies, such as resembling of rival products to each other in technical and functional terms, shortening of product life cycles, time to market and flexibility becoming two important factors in global competitive environment, has raised the need to reconsider the values the customers are supposed to put importance on. Market dynamics in current global and competitive market environments has led to the recognition of the strategic importance of supplier relationships and supply chain management. So as to manage relationships successfully, there is an obvious need to explore the values that customers appreciate as differentiators among rival offerings. Findings of one study (Ulaga and Eggert 2006) revealed that service support, personal interaction, supplier's know-how and its ability to improve a customer's time to market prevail over product quality, delivery performance, along with acquisition and operation costs and price as differentiators within the supplier-business relationship. Third party logistics service providers are regarded as one of the main suppliers of supply chains.

## 3. Research Methodology

The aim of this study is designed to identify the core differentiators among third-party logistics service providers in the Turkish market context. Generating such an understanding may provide managers with instruments for gaining competitive advantage as well as contributing to the marketing literature for clarifying core values that drives business relationships within current industrial contexts. Another aim is to specify the distinguishing characteristics and evaluation criteria of this market context. Based on Ulaga and Eggert's (2006) theoretical framework in business market, Deveci, Tuna and Cerit's (2005) focus group study findings and other relevant literature on TPL (Menon, McGinness, Ackerman, 1998; Murphy, Daley and James, 1997, Lai, Ngai and Cheng, 2002) the questionnaire was developed. After conducting a pilot test with 5 companies, the questionnaire was revised so that inapplicable questions and ambiguous wording could be avoided and clear instructions could be provided throughout the questionnaire. Data collection process, in general, has been very challenging due to the unwillingness of the customer companies to participate. TPL companies in Aegean Region of Turkey were conducted both to assess their primary customers who outsource logistics functions and to facilitate the participation into survey. In addition to this, Alumni Association of Maritime Business School facilitated the data collection. After conducting with TPL providers totally 150 companies who outsource logistics functions were determined in the Aegean Region of Turkey. Thus, although it is aimed to reach 150 companies, only 57 usable questionnaires could be collected, which leads to 38 % response rate. This may be regarded as a limitation against the generalizability of the findings. On the other hand, findings of this study might illuminate the core differentiators within the TPL logistics market context and arouse interest.

The questionnaire included four sections; the first section includes statements about benefits which can be derived from their exchange relationship with their main supplier. The statements which aim to measure the benefits are mainly inspired from Ulaga and Eggert's (2006) study and the relevant studies on TPL services (Lu, 2003, Lai, Ngai and Cheng, 2002). Applying Ulaga and Eggert's (2006) theoretical framework to the third-party logistics service market context, we developed five dimensions; service quality and delivery performance (core offering), service support, personal interaction, supplier know-how and time to market. After that, the respondents are wanted to asses the level of the change in their costs incurred in their relationship with their main supplier. Third section includes four statements which aim to measure the perceived level of relationship value. These statements are also inspired from Ulaga and Eggert's (2006) remarkable theoretical framework. Last section includes information about the respondent and his/her company.

### 3.1. Findings of the Research

*Sample characteristics*. Majority of the respondents engaged in a business relationship with a domestic (82,4%) service provider, while the others do business with a foreign supplier. Their relations with their main supplier last on an average of 4,15 years (min. 1, and max 15 years). 87,1% of the respondents have a one-year contractual agreement with their supplier. They choose to renew their agreement every year. Most respondents work with 2 (22,9%) or 3 (22,9%) and 5 service providers (14,6%), whereas only 12,5% of them work with only one supplier. Their average trade volume is 1057,14 TEU with a standard deviation 1556,5.

*Respondent characteristics*. Respondents held senior positions (such as general manager, vice general manager and/or chief of marketing/ foreign trades) in their firms. They averaged 47,17 months of experience with their companies. They reported to have a high (61%) and medium (36%) level of purchase decisions.

In order to be able to determine which benefit dimensions (service quality and delivery performance, service support, personal interaction, supplier know-how and time to market) are regarded relevant when evaluating their main logistics service provider, several one-sample t-tests has been conducted. As the figures in Table 1 portray, all service quality and delivery performance variables are seen as relevant and favorable. The respondents believe that their main supplier deliver high quality service. Considering the mean values, it is possible to suggest that reliability and consistency in service quality are the variables which satisfy the customers. These two variables are followed by ability to provide a more satisfactory amount of transportation vehicles and equipments, accurate services, high-quality standards and ability to conform to the delivery due dates. Although respondents are in general satisfied, their satisfaction level is not as much as others when we consider efficiency in warehousing and inventory management, and customs and insurance management services and fittingness of the main supplier's physical facilities (warehouse etc.). Considering the reliability coefficient Cronbach alpha, we can assume that the scale of core offering, i.e. service quality and delivery performance, variables is reliable.

Table 1. Service Quality and Delivery Performance (Core Offerings) Assessments of Respondents

| | Mean | t | Sig. (2-tailed) |
|---|---|---|---|
| Compared to other suppliers, the main supplier meets our quality standards better. | 4,14 | 9,033 | ,000 |
| Compared to other suppliers, the main supplier's services are more reliable. | 4,32 | 12,336 | ,000 |
| Compared to other suppliers, deliveries from the main supplier are more accurate. | 4,19 | 9,269 | ,000 |
| Compared to other suppliers, the main supplier provides us with more consistent services quality over time. | 4,32 | 11,167 | ,000 |
| Compared to other suppliers, the main supplier performs better in conforming delivery due dates. | 4,12 | 8,959 | ,000 |
| Compared to other suppliers, we have less delivery errors with the main supplier. | 4,30 | 11,327 | ,000 |
| Compared to other suppliers, the main supplier provides us with more efficient warehousing and inventory management services. | 3,49 | 3,221 | ,002 |
| Compared to other suppliers, the main supplier provides us with more efficient customs management services. | 3,70 | 4,741 | ,000 |
| Compared to other suppliers, the main supplier provides us with more efficient insurance management services. | 3,46 | 2,953 | ,005 |
| Compared to other suppliers, physical facilities (warehouse etc.) of the main supplier suit our deliveries better. | 3,58 | 4,299 | ,000 |
| Compared to other suppliers, the main supplier provides us with a more satisfactory amount of transportation vehicles. | 4,28 | 10,283 | ,000 |
| Compared to other suppliers, conditions of equipments of the main supplier are more convenient for our needs. | 4,14 | 10,333 | ,000 |
| Compared to other suppliers, the main supplier handles our orders more effectively. | 3,91 | 7,109 | ,000 |
| Cronbach alpha | 0,8887 | | |

Notes: 1. Likert scale has been used. (1: completely disagree, 5: completely agree).
2. Test value is 3.
3. Degree of freedom is 56.

Table 2. Service Support Assessments of Respondents

| | Mean | t | Sig. (2-tailed) |
|---|---|---|---|
| Compared to other suppliers, the main supplier provides us with all-encompassing and customized services. | 4,18 | 8,556 | ,000 |
| Compared to other suppliers, service organization network of the main supplier is wider and competent. | 4,23 | 8,175 | ,000 |
| Compared to other suppliers, the main supplier provides us better financial conditions. | 4,35 | 9,468 | ,000 |
| Compared to other suppliers, the main supplier provides us with more appropriate and reliable information. | 4,35 | 12,224 | ,000 |
| Compared to other suppliers, the main supplier is more competent in responding to our urgent orders. | 4,46 | 13,321 | ,000 |
| Compared to other suppliers, the main supplier responds faster when we need information. | 4,42 | 13,401 | ,000 |
| Compared to other suppliers, the main supplier provides us with more accurate, timely and complete documentation services. | 4,39 | 14,415 | ,000 |
| Compared to other suppliers, the main supplier provides us with more accurate, timely and complete invoice services. | 4,32 | 12,336 | ,000 |
| Compared to other suppliers, in our relationship with the main supplier we need less documentation and invoicing. | 3,93 | 5,959 | ,000 |
| Compared to other suppliers, the main supplier provides us with more efficient tracking and tracing services. | 4,23 | 9,269 | ,000 |
| Compared to other suppliers, the main supplier provides us with more efficient information technology (IT) services. | 3,74 | 4,871 | ,000 |
| Compared to other suppliers, the main supplier provides us with more competent value-added logistics services (packaging etc.). | 3,58 | 4,541 | ,000 |
| Cronbach alpha | 0,8537 | | |

Notes: 1. Likert scale has been used. (1: completely disagree, 5: completely agree).
2. Test value is 3.
3. Degree of freedom is 56.

As the figures in Table 2 portray, all service support variables are seen as relevant and favorable. The respondents believe that their main supplier performs well in terms of service support. The most satisfactory performances emerged to exist in terms of competency in responsiveness to customer's urgent service support and information needs, accuracy, completeness and timeliness in documentation services, providing better financial options and appropriate and reliable information. Although respondents are in general satisfied, their satisfaction level is not as much as others when we consider competency in providing supportive value-added logistics services, such as packaging and efficiency in providing information technology (IT) services. Considering the reliability coefficient Cronbach alpha, we can assume that the scale of service support variables is reliable.

The respondents believe that their main supplier performs satisfactorily in terms of personal interaction (Table 3). The most satisfactory performances emerged to exist in terms of availability of service provider's personnel in charge when needed, easiness to relate with the service provider and addressing problems with the service provider and the skill of the main supplier to cultivating a feeling of being treated as an important customer. Considering the reliability coefficient Cronbach alpha, we can assume that the scale of personal interaction variables is reliable.

Table 3. Personal Interaction Assessments of Respondents

| | Mean | t | Sig. (2-tailed) |
|---|---|---|---|
| Compared to other suppliers, we can reach the main supplier's personnel in charge easier. | 4,61 | 14,508 | ,000 |
| Compared to other suppliers, it is easier to work with the main supplier. | 4,44 | 12,845 | ,000 |
| Compared to other suppliers, we have a better working relationship with the main supplier. | 4,35 | 9,938 | ,000 |
| Compared to other suppliers, there is a better interaction between the main supplier's people and ours. | 4,44 | 10,858 | ,000 |
| Compared to other suppliers, we can address problems more easily with the main supplier. | 4,44 | 12,845 | ,000 |
| Compared to other suppliers, we can discuss problems more freely with the main supplier. | 4,39 | 10,510 | ,000 |
| Compared to other suppliers, the main supplier gives us a greater feeling of being treated as an important customer. | 4,40 | 10,623 | ,000 |
| Compared to other suppliers, the main supplier's working hours match ours better. | 4,04 | 8,115 | ,000 |
| Cronbach alpha | 0,9069 | | |

Notes: 1. Likert scale has been used. (1: completely disagree, 5: completely agree).
2. Test value is 3.
3. Degree of freedom is 56.

The respondents believe that their main supplier also performs satisfactorily in terms of allowing their customers to benefit form their know-how and speeding up their customer's time-to-market (Table 4) The most satisfactory performances emerged to exist in terms of supplier's ability to provide their customers with proficiency and knowledge about service improvement and flexibility and frequent delivery to reach their customers to the market. Although respondents are in general satisfied, their satisfaction level is not as much as others when we consider supplier's support for their customer's market development activities. Both supplier know-how and time-to-market scales appeared to be reliable (Table 4).

Although the respondents reported satisfactory levels of benefits, they derived from their business relationship with their main supplier, as the figures in Table 5 portray, noteworthy percent of them reported no or low level of cost reductions due to their relationship with their main suppliers. Results of the median tests reveal that the reductions in customs clearance costs, costs of investment in physical equipments, handling costs and costs of other value-adding logistics services (such as packaging) are not different from low level (z values in the respective order; -0,492, -0,015, -0,916 and 1,049 with significancy levels below 0,05). The reductions in storing and inventory management cost, transportation costs, financial costs, personnel costs and coordination and communication costs appear to be at medium levels (z values in the respective order; -0,731, -0,948, 0,656, -1,453 and 1,574 with significancy levels below 0,05). This preliminary finding leads to a notion that the benefit dimensions may be the core differentiators, not the costs as organizational purchasing literature presume. In order to support this finding some regression tests are conducted.

Table 4. Supplier Know-How and Time-to-Market Assessments of Respondents

| Supplier Know-How | Mean | t | Sig. (2-tailed) |
|---|---|---|---|
| Compared to other suppliers, the main supplier knows better how to improve our customer service level. | 4,11 | 9,073 | ,000 |
| Compared to other suppliers, the main supplier knows better how to improve our transportation and distribution network. | 3,96 | 8,044 | ,000 |
| Compared to other suppliers, the main supplier provides us with more flexibility. | 4,18 | 8,039 | ,000 |
| Compared to other suppliers, the main supplier provides us with higher proficiency. | 4,35 | 11,135 | ,000 |
| Compared to other suppliers, the main supplier knows better how to assist us in market development. | 3,37 | 2,368 | ,021 |
| Cronbach alpha | 0,8089 | | |
| Time-to-Market | Mean | t | Sig. (2-tailed) |
| Compared to other suppliers, the main supplier helps us more in getting our products to market faster. | 3,70 | 4,810 | ,000 |
| Compared to other suppliers, the main supplier helps us more in improving our cycle time. | 3,86 | 6,030 | ,000 |
| Compared to other suppliers, the main supplier provides us with more frequent delivery to reach to the market. | 4,23 | 9,269 | ,000 |
| Cronbach alpha | 0,8082 | | |

Notes: 1. Likert scale has been used. (1: completely disagree, 5: completely agree).
2. Test value is 3.
3. Degree of freedom is 56.

Table 5. Frequencies of Costs Reductions Derived From Relationship

| | Level of Cost Reduction | Frequency | Valid Percent | | Level of Cost Reduction | Frequency | Valid Percent |
|---|---|---|---|---|---|---|---|
| Warehouse and Inventory Management Costs | No reduction | 14 | 25,0 | Transportation Costs | No reduction | 3 | 5,4 |
| | Low | 11 | 19,6 | | Low | 13 | 23,2 |
| | Medium | 21 | 37,5 | | Medium | 21 | 37,5 |
| | High | 10 | 17,9 | | High | 19 | 33,9 |
| | Total | 56 | 100,0 | | Total | 56 | 100,0 |
| Customs Management Costs | No reduction | 19 | 35,2 | Financial Costs | No reduction | 7 | 12,3 |
| | Low | 18 | 33,3 | | Low | 8 | 14,0 |
| | Medium | 11 | 20,4 | | Medium | 21 | 36,8 |
| | High | 6 | 11,1 | | High | 21 | 36,8 |
| | Total | 54 | 100,0 | | Total | 57 | 100,0 |
| Costs of Investment in Physical Equipments | No reduction | 24 | 43,6 | Personnel Costs | No reduction | 17 | 29,8 |
| | Low | 7 | 12,7 | | Low | 10 | 17,5 |
| | Medium | 13 | 23,6 | | Medium | 20 | 35,1 |
| | High | 11 | 20,0 | | High | 10 | 17,5 |
| | Total | 55 | 100,0 | | Total | 57 | 100,0 |
| Handling Costs | No reduction | 17 | 29,8 | Coordination and Communication Costs | No reduction | 3 | 5,3 |
| | Low | 18 | 31,6 | | Low | 18 | 31,6 |
| | Medium | 13 | 22,8 | | Medium | 20 | 35,1 |
| | High | 9 | 15,8 | | High | 16 | 28,1 |
| | Total | 57 | 100,0 | | Total | 57 | 100,0 |
| Costs of Other Value-Adding Logistics Services | No reduction | 15 | 26,8 | | | | |
| | Low | 18 | 32,1 | | | | |
| | Medium | 15 | 26,8 | | | | |
| | High | 8 | 14,3 | | | | |
| | Total | 56 | 100,0 | | | | |

In order to identify the core differentiators more efficiently, a factor analysis of relationship benefits and costs has been conducted. Nevertheless, due to the small number of completed questionnaires, satisfactory results could not be extracted. Thus, with the intention of using regression tests and avoid the shortcoming of including lots of statements in the tests, indexes based on averaged scores of each dimension has been computed. A relationship value index has also been computed from the related statements. Some descriptive statistics of service quality and delivery performance (core offering), service support, personal interaction, supplier know-how, time-to-market and relationship value indexes appear in Table 6. They, all, appear to be relevant and satisfactory.

Table 6. Some Statistics About the Benefit and Relationship Value Indexes

| | N | Min. | Max. | Mean | Std. Dev. | t | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|
| Relationship value | 57 | 1,50 | 5,00 | 4,281 | ,909 | 10,64 | ,000 |
| Service quality and delivery performance | 57 | 1,62 | 4,92 | 3,996 | ,639 | 11,76 | ,000 |
| Service support | 57 | 2,17 | 4,92 | 4,180 | ,602 | 14,80 | ,000 |
| Personal interaction | 57 | 1,13 | 5,00 | 4,388 | ,758 | 13,83 | ,000 |
| Supplier know-how | 57 | 1,40 | 5,00 | 3,993 | ,761 | 9,86 | ,000 |
| Time-to-market | 57 | 1,00 | 5,00 | 3,930 | ,901 | 7,79 | ,000 |

Results of the step-wise regression test, with the relationship value index as dependent and the five relationship benefit indexes as independent variables, reveal that the highest $R^2$ has been achieved with only two significant benefit indexes; personal interaction and service quality and delivery performance. These two variables explain 70,3% of the variance in the relationship value derived from respondent's business relationship with their main supplier (with a value of F=64,02 d.f.=2/54 p=0,000). The correlation between the relationship value and personal interaction index (r=0,818 p=0,000) appear to be stronger than the correlation between the service quality and delivery performance and the personal interaction index (r=0,740 p=0,000).

Although there are positive and strong correlations between the relationship value index and other three benefit indexes (service support (r=0,759 p=0,000), supplier know-how (r=0,717 p=0,000) and time-to-market (r=0,557 p=0,000)), they do not appear to significantly explain variance in the relationship value index. Regression model is as follows; [Relationship Value = -0,502 + 0,725 Personal Interaction + 0,400 Service Quality and Delivery Performance]. Results of the step-wise regression test, with the relationship value index as dependent and all of the cost variables as independent variables, reveal that the highest R2 has been achieved with only reductions in transportation cost variable. The reductions in delivery costs variable explain only 33,3% of the variance in the relationship value derived from respondent's business relationship with their main supplier (with a value of F=24,91 d.f.=1/50 p=0,000). Regression model is as follows; [Relationship Value = 3,201 + 0,554 Transportation Cost Reduction].

Other cost related variables do not seem to explain variance in the relationship value. Moreover, except three variables (reductions in transportation costs, financial costs and personnel costs) there are no significant correlations between the relationship value and cost related variables. This finding also supports the notion that relationship benefits have a stronger potential for differentiation than do cost considerations. Whereas relationship costs account for 33% of the variance, relationship benefits explain more than three times as much. This finding supports Ulaga and Eggerst's (2006) findings.

## 4. Conclusions

Although relevant literature on TPL industry mainly devotes attention and emphasized cost considerations to using TPL services and creating customer value, findings of this study emphasized the importance of benefits dimensions of the TPL relations. Ulaga and Eggert's (2006) findings in business market reveal that cost factors serve as key criteria to get a main service supplier of customers in the supply chain, relationship benefits dominate when evaluating which supplier to name first among a set of competing suppliers, were supported with this study. Following this line of reasoning, cost competitiveness appears as a necessary but not sufficient condition to gain key supplier status for customers.

Value-based approach provides useful approach to analyze the relationship between TPL providers and their customers and assess core differentiators for in industrial services. Value-based differentiation considering both the benefits and related costs seems to measure value created for customers in TPL. It can be also used to optimize the level of logistics service provided by the TPL companies.

Service quality and delivery performance, supporting services, personnel interaction and supplier know-how and time-to- market are important dimensions of the benefits. Within the benefits dimensions perceived, mainly two dimensions -personnel interaction, and service quality and delivery performance- explain the relationship value derived from customers' relations with their TPL. Thus these two dimensions and their sub variables are core differentiators for the customers of TPL providers. The benefit created by personnel interaction was also explored in the previously mentioned literature as knowledge, skill, expertise and responsiveness. Reduction of customer's logistics costs has not been perceived as much as expected in the literature in outsourcing logistics functions to TPL providers. In terms of cost dimensions, mainly transportation costs explain the relationship value of customers with the TLP provider. There are no significant correlations between the relationship value and cost related variables except three variables: reductions in transportation costs, financial costs, and personnel costs. Reduction in customs clearance costs, costs of investing assets, handling costs and cost of value added activities are at very low level compared to reduction in transportation, coordination and communication costs, financial and personnel costs. Importance of providing favorable financial conditions emphasized in an earlier study (Deveci, Cerit and Tuna, 2005) has proven to be true for Turkish customers TPL companies should try to reduce all the cost items in logistics process especially in transportation, personnel, and financial costs of the customers. Calculating each customer's lifetime value is vital in differentiating logistics services since it is not easy to differentiate industrial services, especially services which require huge investment costs.

As a result, offering superior benefits to the customer is essential for obtaining substantial share of customer's logistics functions. TPL companies must explore the core differentiators to win the competitive struggles in obtaining main supplier status. Factors related to personnel interaction, service quality and performance are more important than cost considerations for the customers using TPL services. On the other hand, TPL companies must reduce the logistics costs. Thus, reducing costs of transportation, personnel, and finance seem to be core differentiators for TPL providers in creating value for the customers.

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# DETERMINANT FACTORS OF THE PERFORMANCE OF CUSTOMERS SERVICE IN AN SUPPLY CHAIN APPROACH

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## Abstract

*Nowadays, all the companies, in the European context particularly, are getting transformed in their management modes and logistics' organizations. The companies create new logistic systems allowing consequently to improve service levels, to reduce the costs and at the same time, to ensure a constantly increasing reactivity with regard to the new requirements. In this context, the performance evaluation of the customers service should not only measure the accomplishment of the customers' expectations but, also, the whole means management that the organization employ to satisfy its customers.The indicators retained by the managers must, so to be related to the company strategy while being sufficiently targeted to direct the action of the logistic chain various actors towards the satisfaction of the aims in view.*

Keywords: Supply Chain Management, Service to the customers, Criteria of Performance, Logistics

## 1. Introduction

The changes of behaviour of the worldwide market require an answer much nimbler of the company and of its partners in the supply chain. In the past, the success of marketing was founded on strong marks and innovating technologies. At the present time, the marks and the innovation are still important elements but they are not crucial any more. The success combination consists of a strong mark and the new technologies supported by a supply chain nimble able to answer the request more rapidly. A veritable competing advantage is obtained when the organization can uniformly fulfil the customer requirements with more precision and more reactivity.

In the past, the world was characterized by standard products, bulk products for a generally expected request of the market. Nowadays, the world is located almost at the opposite. The customers require much customized product in small quantities with a degree increasingly higher of uncertainty (Christopher, 1999). The organizations which in the past felt were protected from foreign competition at low prices note that they, therefore, must not only create value for their customers, but at a lower price (Christopher, 1999). The customers are the first concern of any firm which seeks to be competitive. From now on, the logistics of operation with the customers forms integral part of the customer's needs and their perception of the firm (Eymery, 1997).

Nowadays, the offensive of the companies on the various markets get organized about services which integrate, more than ever, the respect of the deadlines and the user-friendliness of the contacts between companies and their customers. The strategies of costs became easily imitable options by the competitors and, so they do not represent more of the ways of differentiation for the customers (Kyj, 1987; Quin, 1994; Tixier, & al., 1998). From this point of view, the observers are increasingly numerous to stress that the products offer few competing advantages in them - same and, that in fact; the service brings a major differentiation appropriateness (Livingstone, 1992).

The importance attached to the service to the customers finds also justification in strong competing pressures which are translated, in particular, by the increased requirements of the customers on the aspects of guarantee, after-sales service, maintenance (Loomba, 1996). The service to the customers takes, among others; support on logistics, that is, the capacity of the company to coordinate flows of matters and information, of the acquisition of the raw materials until the after-sales service. For the managers, the service to the customers appears from now on as one of the sources of competing advantage which the companies can offer; what, moreover, explains its dominating place in the new concerns of the logistic function (Brockmann, 1999). Indeed, if the quality of the service offered to the customers were long enough associated, naturally, with the concerns of the function marketing, it constitutes more and more one of the stakes of the logistic step. In this direction, the managers must ensure themselves of the coherence of the indicators selected, a task which is not so simple since the service to the customers overlaps two great departments of the company: marketing and logistics (Tchokogué, 1999).

In front of such a tendency, the problems of the performance evaluation of the service to the customers take a new dimension. Several questions are open. In particular, it is necessary to define what the concept of service to the customer's covers and under which angles the performance of the company can be evaluated from this point of view. Thence follows the central question which we try to answer: Which are the explanatory variables of the performance of the service to the customers in particular in an approach of Internal Supply Chain? This article aims to bring lightings on this interrogation. For that, this document is articulated around five points: first of all, the first point is devoted to the introduction with a whole of reports and the positioning of the problems. A second section is devoted to the delimitation of the theoretical precise details of the concept of supply chain management. In a third

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section, we locate the concept of service at customers at the same time compared to marketing and logistics. In a fourth section, we approach the logic of measurement of performance of the service customers. Finally, we present a conclusion of the communication.

## 2. The concept of the supply chain management (SCM)

This section is devoted to the examination of various contemporary approaches mobilized to include/understand dynamics supply chain management. We accordingly mobilize the approach of Christopher, Michigan State University and study of Ohio State University. We do not seek to make an exhaustive presentation of these various approaches, but to stress certain elements which seemed significant in our communication.

### 2.1 Contemporary approaches in terms of supply chain management

#### 2.1.1 Definitional approach

The literature on the supply chain management proposed diverse definitions. Several academic research highlights the role-played by logistics, judged as being at the origin of the step SCM (Colin, 2002). It is more or less explicitly the position of Council of Logistics Management which, on its Internet site, defines logistics as: " (...) the part of the process of the chain of provisioning which plans, implements and control the transit and the effective and efficient storage of the goods and services as well as adjacent information, place of their creations until that of consumption, with an aim of fulfilling the requirements of the consumers ". For (Mentzer, & al., 2001: 18), SCM is defined as: "(...) systemic, strategic coordination and the tactical management of the actions within the departments of a particular organization, as well as businesses carried out inside the chain of provisioning of the organizations as a whole".

#### 2.1.2 Approach of Christopher

(Christopher, 1992) defines SCM as " the network of the organizations which requires, through bonds upstream and downstream, and in various processes and activities, to produce value in the products and services held between the hand of the ultimate customer " (Christopher, 1992: 12).

*The strategic and integrating role of the supply chain*

According to the author, it is initially by the model of the "4p" that the emergence of SCM is explained. Three first, namely, the product, the price and promotion, (actions of marketing) while the fourth element, described by the good product, in the good place, the good time (place), concerns a logistic dynamics. So that this one is exerted as well as possible, it is necessary to allot to SCM a strategic and integrating role. (Christopher, 1994) adds to this approach three competing advantage factors: 3 R [Reliability, Responsiveness, Relationship].

First of all, the reliability of an organization returns to the need for guaranteeing a delivery in time and necessary quantities; then, the sensitivity (upon request) evaluates the capacity to answer within the shortest possible times, with the largest flexibility; finally, the relational one stresses the importance of partnerships in the implementation of continuous improvement as regards quality, innovation, reduction of costs and adjustment of the notebooks of delivery. In the same way, each sensitive company must proceed to a major reorientation of its management system (Christopher, 1997). Thus, it must modify its organisational diagram according to four points: - To pass from a system in terms of functions to logic in terms of process. This means that the company must regard the horizontal character of the structure as a unit of inter-functional processes based on the requirements of the customer; - To pass from a concept of profit to a concept of performance. This point underlines the obligation to provide to all the speakers financial and non-financial indicators; - To pass from a management of products to a management of customers: “because the satisfaction of the customer must be the ultimate objective of any commercial organization, it is imperative that the structures of management and the systems of measurement are also the mirror” (Christopher, 1997: 149).

#### 2.1.3 Approach of Michigan State University

The approach of Michigan State University introduces codes of conduct to be followed at the time of the setting up of SCM. Its interest is to let clearly think that SCM takes form in an organization first of all given, for then deploying it in a network of intermingled firms, because into narrow relation of exchange. Two principal contributions: the model world class logistics and the structure supply chain 2000.

*The model World Class Logistics*

The first contribution is the model World Class Logistics (1995), the model provides a nomenclature in four key dimensions relatively easy to take into account for the design of a logistic chain. The model World Class Logistics (WCL Model)), elaborated in 1995, has as a characteristic to propose a synthetic grid of reading of an efficient and effective logistic chain where four fields of competence are mixed together which are articulated " inside a specific environment [and] which it is difficult for the competitors to duplicate". Initially, strategic positioning selects the strategic and structural approaches which guide the logistic operations. At a second level, integration establishes what it is advisable to do and how to carry it out with reactivity. At a third level, the agility is intended like the aptitude to obtain and maintain to competitiveness like with obtaining the confidence of the customer. The criteria of anticipation before, adaptability and flexibility attempt to answer this field of performance. It is a question of remaining vigilant with respect to the volatility of the request of the customers, while being able to decrease the response time to the exceptional requests. This highlights the adaptability of the structure at all the unexpected circumstances. Finally, at a forth level, the measurement of the performance evaluates the internal and external logistic chain. The company determines choices of internal indicators static and dynamic enabling him to refine the evaluation of the process supply chain along the chain by techniques of benchmarking which enrich and diversify the modes of evaluation. The second contribution is the structure supply chain 2000.

*Structure supply chain 2000*

(Bowersox, & al., 1999) tried to supplement the model World Class Logistics by what they name a "structure supply chain 2000". This second contribution proposes a sequential step, since the reasoning proposes the relations and methodologies to apply to arrive step by step to coordination between the individuals and the organizations implied in a step SCM. In the other words, from a methodological point of view, the sample must seek to gather internal and external actors who revolve around the same finality of design of a product or a service. This structure seeks to clarify the comprehension of SCM as a step of strategic management. The latter seeks to clarify the comprehension of SCM as a step of strategic management.

2.1.4. Approach of Ohio State University

Lastly, on her side, the team of Ohio State University (1997, 1998) recommends thinking beyond logistics, and is located in that halfway of the first two approaches presented; she seems nevertheless interesting insofar as she expresses more precisely certain strategic changes to take into account. Other more recent works specify certain features of SCM such as the role of and the relation information systems of confidence and/or being able in the inter-organisational exchanges.

2.2. Typologies of the supply chain management in its ultimate form of Harland (1996)

(Harland, 1996), announces 4 typologies of the supply chain management: SCM within the organization; Dyadic relation; external chains several organizations for a vision a general direction. If supply chain management is appreciated, first of all, within an organization, (Harland, 1996), thinks seriously of applying an analysis in terms of inter-organisational relations which are implied to connect two units between them.

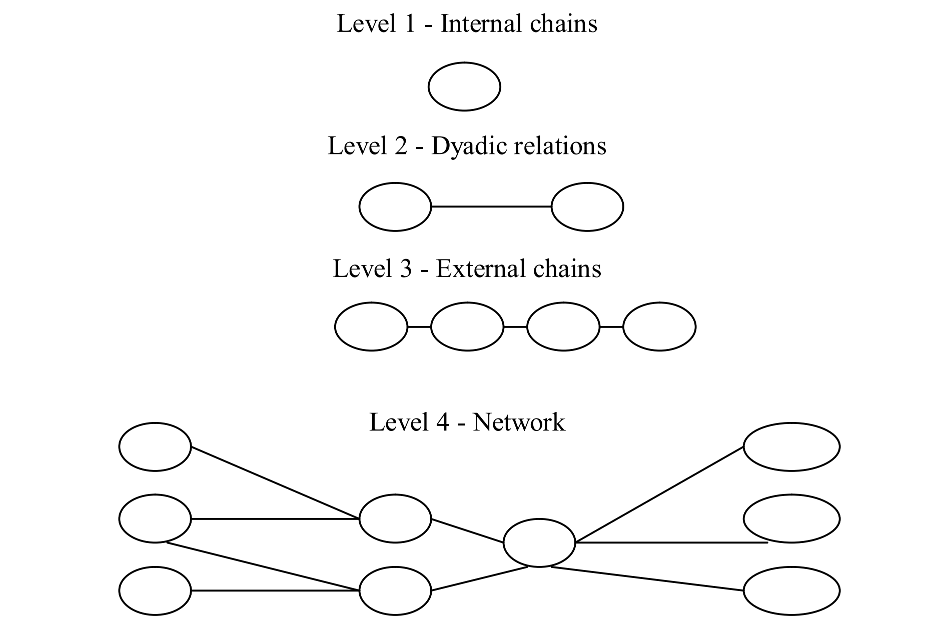


Figure 1. SCM typologies in its ultimate form of (Harland, 1996)

## 3. The concept of the customers' service and the concept of performance

This second point of the literature review aims to better apprehending the concept to the customers' service. Our matter revolved around the following axes: We present initially the definitional approach, of (Samii, Baglin, & al.). At a second level, we endeavour more specifically to present the various components of the service at the customers (continuum). We finish by the presentation of a synthesis on the concept to the customers' service.

### 3. 1 Various definitional approaches

As recalled by (Tucker, 1983), the definition of the customers' service influences the way of evaluating the performance of the company from this point of view. For that, it appears judicious to agree on the direction and contours of the concept of service. In the majority of the companies, the customers service is defined in three different ways (Samii, 2004: 77): like an activity: for example, placing of orders, the management of the dispute, invoicing; like a measurement of performance: for example, capacity to deliver 95% of the orders in the 48 hours; like element of philosophy and strategy of the company, rather than an activity or a measurement of performance.

The definition of the customers' service varies from one company to another. For (Samii, 2004), generally, the customers' service can be regarded as the means used by the logistic system to create the utility of time and space of a product. (Samii, 2004), defines the customers' service like: "a process which takes seat between the purchaser, the salesman and the thirds. This process leads to a value added for the produced or the exchanged service. This added value can arise in the short run in a simple transaction or long-term like a contract of partnership. Thus, the customers' service is the process by which significant advantages are reached in a value chain and that in an effective way. (Samii, 2004: 80). The implementation of the concepts marketing implies to be able to keep the customers by increasing their satisfaction. That makes it possible the company to invest in the long term in the acquisition of new customers. In this direction, "the customer service is the capacity of the company to answer the customer order starting from stock available. If the order is not satisfied, a rupture results from it." (Baglin, & al., 2005: 391). It is the supply chain (logistic integrated) which takes part in this manner in the definition of the total product. This continuum returns to a process made up of three levels of activities: pre-transaction, transaction and post-transaction (Tucker, 1983; Lambert, & Stock, 1993).

### Three components of the customers' service

#### Elements of pre-transaction

The elements of pre-transaction relate to the means which the company is given to effectively offer a service to its customers. It is about and the system of control structural design which ensures the good walk of the operations related to the customers' service. The customer will be never aware of these elements, but a bad proportioning of each one of them can have significant consequences on the two other levels of transaction.

*Customer service policy statement*

This written engagement of the customer service policy statement is based on the analysis of the needs for this one, the definition of the standards; it determines which will have to bring back measurements of the customers service performance and according to which frequency, so that this written engagement can become operational.

*Diffusion next to the customers*

It is immoderate to establish such an engagement intended to improve the penetration of the various markets and to forget to inform the customers of them. A written engagement reduces the probability that the customer expects unrealistic performances; but it provides him also the means of communicating with the company if the levels of performances specified are not reached.

*The organisational structure*

Although there is not any typical organisational structure for each customer service policy, the selected structure must facilitate the communications and the co-operation between the functions implied in the written engagement of customers service. Moreover, the company should provide to its customers the names and phone numbers of service and individuals designated specifically to satisfy their needs for information. The people who manage the components of customer service must be invested of responsibility and authority (empowerment, compensated financially, in manner such that they are encouraged to actively manage the interfaces between the various functions of the company (reward system).

*Flexibility and services*

A flexibility of the system is necessary to answer events not planned such as the strikes, snowstorms or shortage of provisioning. Formations and meetings will make it possible the company to improve integrated management of the customer service. Handbooks of computerized procedure make it possible to include/understand the impact of the decisions of customer service on the inventory control and the policies of marketing. The whole of these five elements constitutes an essential component of the logistic strategy.

#### Elements of transaction

The elements of transaction are those which link the exchanges between the customer and the organization. It is on this level that the customer starts to evaluate the performance of the service of the company. Normally, these elements are directly associated to the traditional concept of customer service.

*Stock-out level*

The stock levels are a direct measurement of the availability of the product. In the case of rupture, the satisfaction of the customer can be safeguarded either by offering a substitute product higher in conformity with its requirements and a tempting price, or by dispatching the product with a delay compensated by an advantage.

*The role of the strategic stock in the supply chain*

According to ( Baglin, & al. 2005), " the strategic stock is the stock which one must maintain in order to satisfy any request higher than the quantity planned for a given period. This variation is frequent in many situations because the forecasts are rarely right. The system of inventory control must face risks of several natures " (Baglin, & al., 2005: 383): The real request is different from the estimated request; The request resulting from many individual requests is random; The delivery period supplier is higher than what was announced; The delivered quantity is lower than the ordered quantity or controls it with the reception eliminates the products witch are not in conformity.

*Function of service*

In this context, (Baglin, & al., 2005), indicate that the function of stock service (or commercial function) aims to ensure the customer an immediate delivery. This function is present in the retail stores as in the factories which deliver standard articles to a distribution network.

When the delivery period is lower than or the production procurement lead time of the product, it is necessary to anticipate the customer order. The Stock materializes anticipation in ambiguous future. Thus, when a retail store stores goods, it is because it must place a replenishment order wishes to have its goods without delay. If the customer agrees to place his order in advance, while waiting for that the tradesman itself is delivered, stock does not have any raison to exist (except for other reasons, like the fact of buying great quantities to pay the goods less expensive) (Baglin, & al., 2005: 70).

*Information on the order*

It is a question of being able to communicate to the customer, in a fast and precise way, the levels of stock, the progress report of order, the dates of forwarding and delivery envisaged and possibly the follow-up of postponed orders. The management of the late orders (back-order and time necessary to enclose an order) total order cycle time constitute an essential measure of the performance of the logistic system. The number of late orders should be recorded by category of customers and product in order to identify and improve an inadequate performance of the system.

*Elements of the order cycle*

The order cycle is the time necessary between the initialization of the order and the complete delivery, in final operating condition, at the customer. The components of order cycle are the reception of the order, its implementation, handling, packing, the forwarding and the flow of information. But the customers being mainly concerned by the total cycle time (total order cycle time, it is essential to have a data-processing follow-up making it possible to locate any cause of variation in the components defined above.

*Forwarding*

Some must be faster than others. Although the expenses of a fast forwarding are higher, it is particularly significant to identify the customers who will have to profit from this specific service: it is the role of logistic management to lay down a coherent policy on the matter, making it possible to support the customers contributing more to the rise of trade.

*Transfers*

Transfers are often operated before the customers request or forecast of the risk of break stock condition on certain sites of storage.

*Systems precision*

The precision of the quantities and products categories is significant as the precision of the invoicing. Errors can appear very expensive, in terms of disagreement and of relations quality with the customer. The gaps must be the subject of a report: the errors percentage compared to the total number of orders constitutes a critical measure of the performance of the logistic systems.

*Product substitution*

Substitution can improve the customer service. She takes place when a product must be replaced by another to bring higher or equivalent satisfaction to the customer. To develop a coherent substitution policy, the company must maintain good relations with the customer to inform him and gain his consent. It should keep a trace of the market products in substitution in order to manage the performance and to try of it to improve it. The key element of this policy remains a good communication with the customer.

Elements of post-transaction

Finally, the elements of post-transaction relate to the capacity of the company to support the customer, once that it bought the product.

*Installation, guarantee, repair and change parts*
These elements can made up a key factor of purchase: they should be evaluated with the same care as the elements of service customers during the transaction. It is necessary to provide assistance in the installation of the product or, at the very least, to check its correct operation before the consumer does not use it; an availability of repairers and change parts; a documentation and handbooks ensuring the performance of the repairers; an administrative office which manages the guarantees.

*Location of the products*
The location of the products is another essential component of the service customers. As soon as a product appears potentially dangerous, even defective, the company must be able to locate it in order to be able to withdraw it market and to thus prevent the risk of dissatisfaction of the customers.

*Complaints and returns*
Normally, the logistic systems are conceived like a flow in a direction: from the company towards the customer. Nevertheless, very undertaken can be confronted with returns of goods. Not to have a routine to manage these taken again articles can appear very expensive. A policy and procedures should thus specify how to manage the possible complaints, complaints and returns. The company should conserve the information relating to these aspects which can help better developing the products and their logistics.

*Replacement of the product*
In certain circumstances, a product can be replaced temporarily at a customer who waits the delivery of an order; a product of replacement can also be provided throughout repair, like element of service customers. These elements belong to the service of support to the customers after the sale of a product.

## 4. Performance evaluation of the service customers

### 4.1 The performance: a polysemous concept

This point aims at drawing the general framework of the concept of performance. We do not seek to make an exhaustive presentation of this concept of performance, but to stress certain elements which seemed significant for this communication. Traditionally, the performance is considered from a financial point of view where the satisfaction of the shareholders, as a recipient, is privileged (Batsch, 1996; Bolt, 1997). However, more and more of research conceive an evaluation multicriterion and multidimensional in which the interests of all the actors are integrated (Kaplan, & Norton, 1996; Book, 1997; Charreaux, & Desbrières, 1998; Bourrier, & al., 1998; Teller, 1999; Berman, & al., 1999).

#### 4.1.1 The piloting of the performance (adapted of Malo, & Mathé, 1998)

The subjacent assumption of piloting of the performance approaches the problems of the formulation of operational and strategic measurements according to a vision multidimensional (Cross, & Lynch, 1989; Cauvin, 1984; Atkinson, & al, 1997; Malo, & Mathé, 1998; Teller, 1999). The manager must face other groups of actors (in addition to the shareholders) in the organization. Those represent the Authorities, the investors, the political groups, the customers, the suppliers, the communities, the employees and the property owners' syndicate (Hill, & Jones, 1992; Donaldson, & Preston, 1995; Atkinson & al., 1997). Thus, for (Berman, & 1999), the customers substantially support the financial performance of the firm. This relation is obvious when the customers appreciate products of quality and ready to guarantee the safeguard of the ecosystem. In literature to the performance, the presence of the statement of a series of indicators is omnipresent. The indicator can be appreciated under several angles. First, it undergoes a classification. (Cross, & Lynch, 1989), or (Nanni, & al., 1992), refer to the financial and non-financial indicators. The financial indicators relate to the countable system of costs and the non-financial indicators put forward a countable management of which the objective and to get a support of decision to the strategic actions and training (Nanni, & al., 1992). In addition, the indicator is qualitative and quantitative. For example, (Bughin-Maindiaux, & Finet, 1999) isolate eight qualitative topics from non-financial indicators which are respectively: (1) the quality of the product and the processes, (2) the satisfaction of the customer, (3) cycle time [lead times, delivery, etc], (4) human resources, (5) the productivity, (6) inventory control, (7) the innovation, (8) flexibility.

#### 4.1.2 The model of the Pyramid of the measurement of performance (Lynch, & Cross, 1995)

Measurements of performance are fastened on the vision to which the company adheres. In fact, they are useful first of all for measuring the attack of the objectives which rise from the strategy installation in order to concretize the vision of the company. Each sector of the company, each function and each action must ideally be based on this strategy. The service to the customers, a fortiori by her strategies character, does not escape this rule. It must thus be evaluated from every angle necessary.

### 4.1.3 The appreciation of the concept of efficiency and effectiveness

To develop the distribution between the external effectiveness (example: improvement of quality, better management of times of delivery) and internal efficiency (example: reduction in the cycle times and the costs of exploitation).This point takes as bases reflexion the argumentations formulated in the pyramid of the performances of (Cross, & Lynch, 1989). By preserving the framework of reference proposed by (Lynch, & Cross, 1995), it is possible to propose a whole of indicators which covers the multidimensional nature of the service to the customers. It is obvious, accordingly, that the quality of service offered to the customer is the result of the quality of service of the actors intervening throughout the logistic chain. By nature the performance of an organization, or the performance resulting from relations which tie between them several organizations, requires to be evaluated starting from multidimensional and multicriterion measurements able to answer waiting of each actor. In the review of the literature, extremely fortunately, a number growing of work and models propose management tools taking account of this reality. It is thus significant that the companies can measure the quality of their customer service but, also, that they can find in their working procedure the explanation of their performance.

In other words, it is a question of operating a judicious reading of the realization of the services, justified by the interdependences between all the components of the logistic chain of the company. The recourse to a combination of indicators of process and result is then impossible to circumvent (Imai, 1989).The inherent advantage in such an approach is, certainly, to make it possible the company to judge in a relevant way the performance generated by its logistic process but, therefore, to locate this performance compared to that of its competitors and to obtain means to improve it.

## 5. Conclusion

At the end of this review of literature communication, several forces ideas emerge. The setting up of SCM rests on the ability to make evolve the behaviours and the organisation on all the levels. The organisation is reconsidered in internal and in its relations with customers, the suppliers and providers. The company must be proactive ahead of the cultural change that SCM implies (involves) and accept the decompartmentalization. It must share its resources and its information with partners; otherwise the risk is that the company well be desynchronizing remainder of the chain and to create narrow parts. All the functions will be concerned: purchase, commercial, production, logistics and subsidiary functions, informatics (guarantor of the implementation and the correct operation of the internal and external information system), finance (which will provide indicators to measure the performance and the information effectiveness) and human resources which will be incontestable added value. When a supply chain is examined, it is recognized that the companies of the logistic chain are dependent between them and that the good performance depends on the partners' performance. We cannot succeed on the market if there are not good suppliers and good distributors. SCM is thus the search for an excellent global performance in a chain constituted of independent company although related by a common objective: the satisfaction of the final customer.

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# FUNCTIONS OF BUSINESS-TO-BUSINESS E-MARKETPLACES IN SUPPLY CHAIN MANAGEMENT AND TURKEY PERSPECTIVE

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## Abstract

*Supply chain management has reached to a new stage via using internet in all kinds of transactions worldwide in the late 1990's. Main objective of supply chain is to create value and increase efficiency of the businesses to be more competitive in the market. Buyers and sellers have to be more engaged each other in order to increase sales and reduce transaction costs. Supply chain requires information integration, and it is achieved by electronic marketplaces. E-marketplaces manage the information sharing between supplier-customer, logistics service provider-customer, and retailer-customer. E-marketplaces are commonly used in developed countries; however, developing countries may face with losing their market shares because of lack of information sharing and supply chain integration. As a candidate of European Union, Turkey has to pay more attention on information integration in businesses with their suppliers and customers in order to survive in a global marketplace. This study focuses on developments of business-to-business e-marketplaces in Turkey by describing the types, functions, structures and roles of e-marketplaces in supply chain management. In addition, the importance and current structure of business-to-business e-marketplaces in Turkey will be discussed and examples for each type will be given.*


Keywords: Business-to-Business E-Marketplaces; Turkish E-marketplaces.

## 1. Introduction

In recent years, business-to-business (B2B) electronic marketplaces (e-marketplaces) that use Internet protocols as communication standards have gained widespread application in supply chain management. The goal of supply chain management is to link the marketplace, the distribution network, the manufacturing process, and the procurement activity in such a way that customers are serviced at higher levels and yet at a lower total cost.

The Internet technology has enabled companies to create a new marketspace that facilitates electronic interactions among multiple buyers and sellers. B2B commerce shifts to the Internet very rapidly. And, e-marketplaces plays an important role in B2B e-commerce.

The evolution of e-marketplaces are into three phases (Zeng and Pthak, 2003): The first generation e-marketplaces were founded in the ".com boom" time period, especially in 1999, and the main function of the e-marketplaces to provide information and basic order activities to the customers at this stage; in the second phase, large companies started their own exchanges with their partners and customers, e.g. GM-Ford-Chrysler, ForestExpress and Aero Exchange International; finally in the third phase, e-marketplaces offers a hub-and-spoke network, knowledge-based, and each model is used for each kind of transaction.

In early phases of e-marketplaces, a lot of study are researched transaction costs suggested that the transaction cost savings alone from B2B exchanges could be a substantial portion of the total cost of production and order fullfillment. By lowering search costs and making it easier to match buyers and sellers, e-marketplaces raised the possibility that firms could conduct large volumes of their B2B transactions using dynamic channels such as auctions and exchanges. Later, e-marketplaces sought to provide value by offering services to facilitate collaboration and information sharing, rather than just online commerce. Proposed services included collaborative design and systems to facilitate the sharing of supply chain information such as forecast and inventory levels. The e-marketplaces also sought to improve supply chain efficiency by automating business processes such as procurement, order management, and fulfillment (Grey et.al, 2005).

Some critical characteristics of an effective e-marketplace platform include: Quick to market, highly flexible, unified content, dynamic trade mechanisms, open, standards-based architecture, ease of integration, built for success (IBM, 2000).

An ideal industry to succeed to an efficient e-marketplace must include large number of players with no dominant player, B2B focus, commodities must be available and prices are key buying criteria, high search costs to find qualified suppliers and transaction inefficiencies in traditional trade process (IBM, 2000).

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The first e-marketplaces in Turkey were established at the same time with in other countries but, Turkish businesses couldn't be benefited as their counterparts worldwide. The reason may be the commercial use of internet has not grown rapidly in Turkey. The Undersecretariat of the Prime Ministry for Foreign Trade and some civil public organizations supported establishing new e-marketplaces, to increase sales and improve export of small and midsized companies. Large companies have founded their own e-marketplaces to supply their demand (e.g. Migros B2B). There are numbers of e-marketplaces serves only for a pecific industry, and the others have a wide variety of members from different industries/sectors.

This paper analyzes the business-to-business e-marketplaces in Turkey by describing the types, main functions, sources of revenues, and insudtries served.

## 2. Functions, Types, and Benefits of E-Marketplaces

At a basic level, "e-marketplaces can be viewed as information technology (IT) facilitated markets" (Bakos, 1998: 35). E-marketplaces employ a combination of technologies and services to enable buyers and sellers to interact in a dynamic environment and to establish and maintain relationships with supply chain partners. An e-marketplace effectively brings buyers and sellers together in an online environment to facilitate B-to-B trade (IBM, 2000). The primary objectives of them are to streamline complex business processes and gain efficiencies to businesses. E-marketplaces also enable companies to eliminate geographical barriers, and expand globally to reap profits in new markets that were once out of reach (Eng, 2004). E-marketplaces contains industry-specific search engines, databases, online-auction markets and dynamic trade places.

E-marketplaces maintain an online platform that brings together many businesses from a lot of sector and try to facilitate business-to-business electronic trade.

E-marketplaces are using different softwares in order to create an online platform by bringing together huge numbers of buyers and sellers and reduce transaction costs for all the players.

### 2.1. Functions of E-Marketplaces

The functions of an e-marketplace may vary depending on individual market makers ( or Internet exchanges ), e-marketplaces built upon a shared Internet-based infrastructure could provide businesses with a platform for ( IBM, 2000, 11):

- "Core commerce transactions that automate and streamline the entire requisition-to-payment process online. including procurement, customer management and selling.
- A collaborative network for product design, supply chain planning, optimization, and fulfillment process.
- Industry-wide product information that is aggregated into a common classification and catalogue structure.
- An environment where sourcing, negotiations, and other trading processes such as auctions can take place online and in real time.
- An online community for publishing and exchanging industry news, information and events".

From a different point of view, Bakos (1998) determines the key functions of e-marketplaces as:

- Matching buyers and sellers (determination of product offerings, search, price discovery).
- Facilitation of transactions (logistics, settlement, and trust).
- Institutional infrastructure (legal, regulatory).

And finally Eng (2004) describes as auctions/reverse auctions, processing, catalogues, buyers/sellers search, communication and exchange, demand and inventory management, forecasting and replenishment, interfirm relationship management, collaborative project, technical exchange and development.

The functions of e-marketplaces seem to change traditional supply chain management processes by lowering costs and increasing speed to respond to supply and demand needs of buyers and sellers.

### 2.2. Types of E-Marketplaces

There are millions of e-hubs in different types in different sectors around the world. Classification of e-marketplaces is very important because of determining the functions, roles and benchmarking of e-hubs. In the literature, there are different types of e-marketplaces, for example, sell-side, buy-side, vertical, horizontal, hierarchical (biased), market-driven (third party), MRO (Maintenance, Repair and Operating goods) hubs, catalog hubs, yield managers, exchanges etc.

To fit with the e-marketplace structure in Turkey, we divide the B2B e-marketplaces into four broad categories by adopting the classifications of Kaplan&Sawhney (2000) and IBM (2000), Eng (2004); Kırçova (2006):

- Sell-side : These e-marketplaces are improved and operated by large suppliers in order to optimize their traditional business processes and customer relations by using internet. In this type of e-marketplaces, the reverse aggregator model and online reverse auctions are applied.
- Buy-side : The objective of these e-marketplaces are to realize business-purchasing processes effectively for member businesses. These e-marketplaces are oriented by large buyers. The forward aggregator model is applied.

- Vertical : Vertical e-marketplaces operate in a specific industry or market in order to automate transactions among buyers and sellers. Exchanges and catalog hubs function in various industries; e.g., plastics, steel, chemical, paper, telecom, energy, etc.
- Horizontal : Horizontal e-marketplaces are realized by third party providers which operates in online transactions among specific buyers and sellers. MRO hubs and yield managers are horizontal e-marketplaces and function for investment recovery, MRO, benefits and staffing project management.

After giving a broad classification, we would like to extend these main types of e-marketplaces. Kaplan and Sawhney (2000) classifies B2B e-hubs depending on *what businesses buy:* manufacturing inputs and operating inputs; and *how they buy:* systematic or in spot sourcing. Manufacturing inputs enter directly to the production system as raw materials or components in order to be a part of the final product or service; however, operating inputs are often called maintenance, repair, and operating (MRO) goods, such as office supplies, spare parts, airline tickets and services.The Systematic sourcing provides the businesses long term supply; therefore, supplier and seller create a trust and close relationship each other. Kaplan and Sawney (2000) introduce a B2B matrix starting with this classification. In the matrix, MROs and yield managers are determined as operating inputs; and catalog hubs and exchanges are manufacturing inputs. As the purchasing point of view, MRO hubs and catalog hubs are determined as systematic sourcing; and yield managers and exchanges are determined as spot sourcing.

Zeng and Pathak (2003) categorize the e-hubs as the industrial (provides buying and selling process) and functional (provide exchange information on transportation, logistics or selling process). The authors gives six types of e-marketplaces, as introduced by Hajibashi: one-to-many marketplaces, aggregator hubs, broker hubs, collaboration hubs, translator hubs and true e-marketplaces.

### 2.3. Benefits of B2B E-Marketplaces

The benefits of e-marketplaces have been discussed in literature extensively. These benefits change with the expectations of businesses which use the e-marketplaces their primary purposes. Eng (2004) collects the benefits of e-marketplaces in two main points: Transaction based and strategic based. Transaction based benefits are the short term benefits to the customers; therefore, the e-marketplace users reach their goals immediately. However, Strategic based benefits are the long term benefits which the users will develop a strong organizational structure between inside and outside of their businesses.

As *Transaction Based*, e-marketplaces may lower procurement costs, efficiently provide and use dynamic and global sourcing, reduce time between billing and payment, provide efficient exchange of information, improve order of accuracy, unload excess inventory, connect markets faster, reduce stock outs, improve service levels and quality, improve consumer information.

*As Strategic Based, e-marketplaces may* improve internal and external communications, obtain efficient product introduction, streamline electronic processes, increase customer satisfaction, forecast accuracy, increase profitability, improve store assortment, improve replenishment, provide efficient promotion, improve relationship with trading partners.

Specifically, buyers can reduce purchasing costs and achieve higher volume contract terms with preferred suppliers by aggregating purchasing across divisions and companies. It provides, a single point of contact and minimizes off-contract buying and lowering selection costs through access to multiple suppliers (Eng, 2004).

## 3. Turkey Perspective

### 3.1. Selected B2B E-marketplaces in Turkey

After giving functions, types and benefits of e-marketplaces, we would like to give some examples of e-marketplaces in Turkey. We selected those e-marketplaces by extensive search on the internet, espaecially business-to-business type, and the information about the markets and their activities were collected from their website. For missing information, we contacted with the e-marketplaces representatives to fill the gaps. These e-marketplaces are also published in the Foreign Economic Relations Board (DEIK).

#### Boyex

Boyex's first mission is to create the most value added, user-friendly and useful information portal for the paint sector. In the later stages; Boyex developed into a global paint and paint raw materials marketplace by bringing the sellers and buyers of the sector together on an e-commerce platform. In order to successfully implement these missions, Boyex's Internet vision and experience as well as partner companies' sector know-how and knowledge are utilized.

Membership to Boyex is free of charge. There are 1254 members of Boyex .

Some of Boyex's services to its members are as follows:

- E-trade every kind of paint raw materials in a global platform.
- Technical support; answers to common paint producing problems of production managers.
- Exclusive Paint Sector Development Committee articles.
- Searchable company catalogs.
- Boyex6; Boyex's paint index for 6 publicly traded paint companies.
- Sector forums&news.

### ChemOrbis

ChemOrbis is an independent B2B e-marketplace, and market intelligence provider for the chemicals&plastics industry, which aims to increase the efficiency and profitability of its members' trading activities.

ChemOrbis's product portfolio has 11 groups, e.g., PP, PVC, PE, PS, ABS, PET etc.

Members of ChemOrbis are more than 1000 businesses in Turkey and all of them are active players.

In order to become a part of this refined global community, businesses have to pay a membership fee. In e-commerce transactions, buyers and sellers don't pay a charge.

By registering this e-marketplace, the businesses benefit from access to this community and will be eligible to participate in transactions initiated by its members. Member businesses receive buy/sell offers published by ChemOrbis members and extend their opportunities for making business without having to incur extra costs.

ChemOrbis services which provides to its member businesses are explained below:

- Market intelligence: ChemOrbis provides crucial market information about local and global operations and trends. Also, it keeps on all market developments; submitted offers, buy and sell ideas, done deals, the supply-demand balance, expected trends, new investment projects, plant startups and shutdowns.
- Marketplace: Trading tools by offered ChemOrbis are request for proposal, auction and spot market.
- Advertisement: Businesses adverts on ChemOrbis can be targeted to a refined audience and linked to firms web page, e-mails, videos and presentations.

ChemOrbis provides member businesses the crucial elements, which make and close the loop of trade, and offer member businesses new opportunities beyond the capabilities of conventional buying&selling methods.

### Eximinter

Eximinter is an e-marketplace which moderates buy/sell transactions of member businesses. Also, it provides accurate and timely market information about various markets, allow opportunities for profitable business connections, and assist members in meeting the right partners through the various services.

There are 1240 active national and international members of this marketplace are buying and selling 30 different products.

Membership to Eximinter is subject to a charge.

The services which Eximinter provides its members are about new business opportunities, export-import, law, e-commerce, computer software and global expositions.

In this e-marketplace, spot and second-hand products are being sold.

### Textileonly

Textileonly is Turkey's first B2B e-marketplace which is functioning in the textile sector and providing crucial textile products to member businesses. The product categories which are buy/sell in this e-marketplace are raw material, yarn, wowen fabrics, textile machiery&parts, home textile, accessories, dye stuffs, apparel&clothing, and knitted fabric.

Membership to Textileonly is free of charge. Its revenue comes from advertisement fees.

In this e-marketplace; there are services about latest inquiries, useful information and links for exporter and importer firms, special promotions, customer service, shipping news and also free web site opportunities for member businesses. Also, it is promoting member businesses worldwide and keeping up them with new developments and trends in textile sector.

### Turk Business Center (TBC):

TBC is a B2B e-marketplace which aims to develop a new trading platform by using internet. The membership is free, but, if a company wants to put its auction information on the front page, the company must pay a small fee. TBC serves to a wide-variety of industries from packaging to energy, food and textile.

### Tim Trade Point (TTN)

TTN was established by different Exporter Unions in Turkey. TTN is a non-profit organization which aims to increase export by using the profit for the building infrastructure. The company charges for membership, digital catalog, professional picture shooting, and information submission/update and catalog update. TTN has 34000 members (all exporters) from 23 sectors. It is a neutral e-marketplace which doesn't play a mediator role between transactions. It focuses on auctions. The search can be done by buy list or sell list at the website.

### SteelOrbis

Steelorbis is a e-marketplace serves for the domestic and foreign steel producers and buyers. The main objective of the portal is establishing a reliable e-trade platform besides providing news, market analysis, statistics and gathering price information from the real trades. It is a neutral e-marketplace. Steelorbis provides auction, spot market and request for proposal.

### TurkTicaret.Net

The portal serves for the Small and Mid-sized companies. Its revenue comes from selling domain name. It serves a wide-variety of sectors from packaging to chemistry, computer, electric-electronics, small appliances. It is a neutral e-marketplace. There are 3 main functions of the company: Internet services, import-export electronic marketplace business, and software (Enterprise Resources Planning and commercial software packages).

### TurkFreeZone

TurkFreeZone has more than 70,000 active members, 60,000 offers as of 11.08.2006, and majority of its members are currently from Turkey, and others from Germany, the U.S.A. , China, India, England, Pakistan and Russia. There is an average of 4 responses for every offer on the e-marketplace. The company provides hardware and software required for their customers to trade on the internet. The membership is for free. Every commercial demand is broadcasted after checking and confirming. With the free standard membership, a member can broadcast only one good, but the company also offers Gold, platinum and VIP membership for more than one product. The marketplace serves for many industries and sectors. E-catalog is available fort he Gold, Platinum and VIP members.

### Migros B2B

Migros is a large supermarket chain which has a lot of customer in Turkey. In recent years, Migros has constructed a B2B electronic business platform which operates trading between Migros and its suppliers named Migros B2B. The business started this system in November 2000. Migros is engaged with 700 firms doing 70% of its purchase via B2B system. The business is also planning to use Vendor Managed Inventory, Collaborative Forecasting and Planning for Replenishment, Customer Relations Management on B2B for receiving full benefits of internet and B2B transactions. It is a biased e-marketplace.

## 3.2. Main Characteristics of E-marketplaces in Turkey

By analyzing these e-marketplaces, we conclude the main caharcteristics of Turkish e-marketplaces are as follows:

<u>B2B:</u> E-marketplaces in Turkey started to increase export sales; therefore, business-to-business (B2B) type e-marketplaces are more common than business-to-customer or customer-to-customer or government.

<u>Informative:</u> Since the number of Small & Mid-sized companies in Turkey are very high (about 95%), The e-marketplaces choose those businesses as their target. Therefore, the e-marketplaces have main mission as giving information what the e-marketplaces and benefits are. In addition to this mission, the websites provide market intelligence (e.g. spot price of a particular product), technical support and domain names.

<u>Industries and Sectors Served:</u> 3 main types of e-marketplaces appear in Turkey: Vertical, Horizontal and Buy-side. Vertical e-marketplaces serve to provide raw materials for a specific industry. Horizontal e-marketplaces, on the other hand, includes many industries to buy/sell final product. The large companies prefer creating their own e-marketplace to obtain products from suppliers.

Table 1: Main Characteristics of B2B e-marketplaces in Turkey

| Company | Industries Served | Main Functions | Additional Functions | Sources of Revenue | Type |
|---|---|---|---|---|---|
| Boyex | Paint & paint raw materials | Buy & Sell Auction | Catalog, Technical support, Informative articles | Advertisements | Vertical |
| ChemOrbis | Chemicals & Plastics | Proposal, Auction(Neutral), Spot Market | Market Intelligence | Membership fees, Advertisements | Vertical |
| Eximinter | Multi-sectoral | Buy & Sell Auction | Spot, Second hand products, Market intelligence | Membership fees | Horizontal |
| Textileonly | Textile | Buy & Sell Auction | Market Intelligence, Website construction support without any charge | Advertisement | Vertical |
| Turk Business Center | Multi-sectoral | Buy&Sell Auction | Catalog, Web services | Fee for being offers on the front page of e-marketplace | Horizontal |
| Tim Trade Point | Multi-sectoral | Buy&Sell Auction | Digital catalog, Professional picture shoots | Membership fee, Digital catalog & update fees | Horizontal |
| SteelOrbis | Steel | Proposal, Auction, Spot Market | Market intelligence, Sector Statistics, Market database | Membership fees, Advertisement | Vertical |
| TurkTicaret.Net | Multi-sectoral | Auctions, Internet services, Software package sales | Online fairs, Market intelligence, Catalog | Advertisement | Horizontal |
| Turk Free Zone | Multi-sectoral | Auctions (Buy&Sell) | Catalog | Membership fees for other than standard memberships, Spot product fees | Horizontal |
| Migros B2B | Retailer | Buy | Vendor managed Inventory, Collaborative Forecasting and Planning for Replenishment, Customer Relations Management on B2B | | Buy-side |

Neutral: Majority of the e-marketplaces in Turkey are neutral which means that they do not play an active role in transactions other than getting together buyer and seller. Buyer and seller are responsible for logistics, billing and payment functions of the transactions.

Functions: Auctions (spot market) and cataloging are the main functions of e-marketplaces in Turkey. To support those functions, they provide software sales (e.g. Enterprise Resource Planning ERP), professional picture taking, website domain name and to create a website to their members as supportive functions.

Sources of Revenues: In some of the e-marketplaces standard membership is free, but, there is charge for advanced memberships. Those e-marketplaces are supported by the Foreign Economic Relations Board. The sites charges for cataloging, advertisements, picture taking, and software sales.

Purpose: Increase sales (especially exporting) is the main reason of establishing and being a member of an e-marketplaces in Turkey.

Integration: The e-marketplaces in Turkey is not fully integrated with automatic billing and payment system. Lower transaction cost is true only for procurement expenses (providing information time and personnel).

## 4. Conclusion

E-marketplaces in Turkey are still at the premature stage, and it is hard to fully predict their impact on the structure of B2B markets. However it is becoming clear that they will promote greater economic efficiency, and help sustain economic growth in the near future. The e-marketplaces which are analyzed in this study are performing functions that mostly include matching buyers and sellers, providing product information to buyers and marketing information to sellers, aggregating information goods. Also, they are informing members about export-import opportunities, logistics, e-commerce, computer software and global expositions. But, the most valuable feature of the supply-chain management has not been reach yet in Turkish e-marketplaces: full integration between matching buyer-seller, then automated billing and payment system, finally may be the connection to the production systems of the businesses.

When the e-marketplaces reach the full-functionality, Turkish businesses will benefit more than just providing foreign business partners. Lowering procurement and replenishment costs of Turkish businesses may be reached by e-marketplaces as a first step, but, a very serious attempt is needed to obtain full-benefits of e-marketplaces.

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# THE EFFECT OF INFORMATION TECHNOLOGY ON E-COMMERCE AND E-MARKETING IN IRAN

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## Abstract

*Due to fast changing in ICT, we see some more political, emotional and social changing in the world. Globalization is the fruit of development of ICT. As management experts say, nowadays just companies which are familiar with function and language of ICT can compete in the marketing world. Success in e–commerce requires some marketing characteristics in the electronic world. It is clear that if they want to be successful in new century, they should try to find some new attitudes and paradigms to have a remarkable presence in competitive market. The aim of this article is to recognize the effect of IT on different dimensions of marketing activities and managing relationship with the customers. Also in this article we elaborate on the challenges of E- commerce in Iran.*

*Keywords: Information Technology, E- Marketing, E- Commerce, Managing Customer Relationship*

## 1. Introduction

The majority of economists and experts believe that in recent years a revolution like Industrial Revolution has occurred in the world and the entire world is involved in a new concept called Information Century. This approach has deeply changed different economical, social and cultural aspect of the human life. One of these changing dimensions is deep changing in economic relationship between people, companies and government. Economical transmissions between people, companies and government are converting from old systems - which were based on paper documents - to a new system which is based on electronic information.

Increasing public access to the Internet made the E- commerce very important and gave it a new prestige. The characteristics of the E- commerce like globalizing of commerce, vanishing the time and place limitations, decreasing the price of sources for purchasing, increasing the amount of dealing, having no time and place limitations in transactions, having easy access of information, decreasing transactions expenses, decreasing chronological expenses of transactions and many other advantages of E- commerce are the secret of its development.

E –commerce has also changed the competitive environment of trading. For example, the arrival and advent of new rivals even out of commerce environment, globalization of market and global competition, high competition in standardization are some of these changing. The people who visit sites usually search for cheap products. Therefore in E–marketing, competition is very high and lasting relationships are emphasized.

About 80 percent of dealers in United States of America believes that the most important factor in revisiting a site by people is the price of goods. And even some companies for making their sites attractive, let the visitors visit the sport tables, or listen to their favorite music.

## 2. Electronic commerce

IT has had huge effects on all aspects of trade and economic fields.

So that for every commerce phenomenon we have an electronic version (equivalent), like E-banking, E-cash, E–government, E–economy, E–market, E–trade, E– commerce, E–marketing and etc.

The main difference between E – commerce and old system commerce is the way of exchanging the information. In old commerce system, people used to communicate face to face or ultimately by phone and postal system. But in E-commerce this process is done by computer. Of course there are some problems like security in commerce, trustworthiness, real identity of people in the Internet and etc. Although there are some ways to solve this problem, we need some facilities and technical knowledge.

## 3. Economic reasons for starting E- commerce in Iran

### 3-1 Profit

It is necessary to start E- commerce because of decreasing the expenses of transmissions, increasing the rate of transmissions, empowering of Iran's competitive status in the world, using some transient opportunities in export, Some times purchasing some goods from foreign countries decreases the expenses and inflation and also increases export, employment and production.

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In this part of article, we try to estimate the deduction of expenses in transmissions, because it accounts for E-commerce by itself.

According to the different reports, the current value of global export of goods and services is about 7 billion dollars, but 500 million dollars of this amount is used for making documents of transaction and exchanging. In other words, about 7 percent of exchanging value is used for making documents.

By using electronic system, the expense of making documents will be decreased seriously. According to the estimates, it is proved that using electronic transaction system instead of old system– the average of paper expenses will decrease between 21 up to 70 percent. But how much is the value of transaction in Iran? Between 1996–99, the current value of internal production was twice as much as cash.

In other words, the rate of money currency is more than 2, and by using this number at the base. we see that the value of exchanging in Iran is twice as much as GNP.

## 4. Hindrance and challenging

Using and expanding E- commerce have some hindrance and challenges as follows:

A: The shortage of legal base for using E- commerce like accepting E – documents and electronic signature in our rules and statements.

B : Absence of electronic system for transaction of money and credit cards.

C: Some limitation in communication system and low speed in data transaction.

D: Absence of main E- commerce system in our country and its soft ware and hard ware.

E: Shortage of information of small and big companies regarding the advantages of E-commerce.

F: High primary expense of E- commerce in government and private institute and absence of motivation for using this system.

G: Absence of knowledge and culture for using E- commerce and the Internet.

H: The necessity to protect the E- commerce user's rights.

I: Custom rights and chargeable taxes of E- commerce

J: Creation of enough security for electronic transactions and keeping them as a secret.

## 5. Iran's policy in E-commerce

### 5-1 Objective

Due to the extended development of E- commerce in the world and necessity of using in different activities , the important role of E- commerce in keeping , empowering and developing of Iran's competitive statue and even decreasing the expenses of E- commerce trends , Iranian Government has decided to use and expand E- commerce in Iran according to these policy and aims:

### 5-2 Policy

A: Iran will create legal and required basement for using E-commerce.

B: To prevent some private limitations and create some competitive planning, Iranian government will help private institute to expand this category(E- commerce)

C: Islamic Republic of Iran will prevent any unjust activities in E- commerce

D: Islamic Republic of Iran will try to expand the Internet for using E- commerce and simultaneously will try to make the contents of the Internet safe

## 6. The effect of IT on different accepts of marketing

The Internet has created a new environment, and it needs some new view points. A clear definition of marketing in this new century needs some brand new view points and paradigms. As Noak and Haffman said, the communication model from one to one has changed. In one to many models, organizations try to find customers through media like TV and newspapers.

In many to many model, transmission of information is not in simple form, but the people even are involved. In other words, there is an interaction between customers and companies and even they take part in selecting the contents of advertising.

Sviokla and Rayport believe that, today every company has to compete in two world area: physical world (market) and virtual world (the space of market). In the space of market or virtual value of information there is a source to make value for customers.

These two researchers believe that today we should concentrate on supply and demand rather just on supply and we should adjust our strategies in demands .Urban believes that the Internet has empowered the customers that leads to a new marketing paradigm from customers to the commercial companies. In marketing related to customers, to business (C2B) customers demand the best goods with low prices.

Porte's says the internet has changed the previous roles of strategies and competition. There is no doubt that the amount of benefit in different industries is decreased due to emerging of the Internet. So the lasting competitive advantage is very important for companies.

Lasting competitive advantages manifest themselves in two ways:

One of them is functional effectiveness which means whatever our rivals do we do too and also we should do it better.

Functional effectiveness is available by better technology, better data, well educated clerks and effective management policy.

Another way to reach lasting competitive advantage is finding strategic position. It means that we should provide some new and unique services for customers.

Due to existence of the Internet, it is very difficult to keep the lasting competitive advantage, but from another perspective the Internet provides new environments to make strategic positions which are completely different from the rivals.

Brynglfsson and Smith believe that the Internet has created a new market .It is completely available and the public and customers can visit and investigate the services and companies.

In fact marketing is an interactive process which makes a social relative space[ ] All of the ICT'S effects on marketing environment can be seen in national and international markets. Although there are some different factors in international markets like: cultures, rules, spiritual possession and the foreign languages in different parts.

## 7. The management of relationship with the customers and its importance in E- commerce

Today E- commerce is not buying and selling (transaction) some goods , it offers some to customers due to the importance of managing the relationship with the customers in which some software are used called managing the relationship with the customers.

In general, customer relationship management is an approach which puts the customer at the center of business and the top position of the company will be effective management of this relationship. Sometimes this approach is a close relationship with relative marketing, but all relative marketing is not customer relationship management.

Relative marketing is a wide concept that covers and shows the relationship of two customers with each other. So every customer should have ability to change his behavior according to the customers needs.

But in customer relationship management, there's an idea that says every

Customer has different interests and we should change our behavior facing different customers. So the customer relationship management is more important than selling and marketing. Because the company should be able to produce according to the customers, demands. Successful firms let the customers have roles even in producing goods. Customer oriented means paying attention to the average demands of customers. But in one to one and relative marketing, the company should have interaction with every customer. One of the most important advantages of customer relationship management is the loyalty of customers which help to increase the benefit of the company. In network there are some services that can be shown like.

-Fulfilling the customers demands

-Providing some abilities for searching and comparing

-Giving some technical information to customers to investigate the demands status

-Helping the customers to have regular demands

## 8. Challenging of customer relationship management related to ecommerce

After analyzing the market data, we can find out real demands of customers .the First steps in this regard are:

A: Selecting a positive attitude for programming and making some good relationship with customers.

B: Selecting some strategic standards related to customers like the rate of keeping the customers, the rate of profit, etc, which are necessary to evaluate the strategi caims of relationship management?

Definition of customer and its related factors are different in marketing trade (B2B) and trade to customers.(B2C)

In trade marketing, a customer can be a company or its clerk, but in trade to customer to customer is a person or its family.

A big problem in this management is the amount of information for analyzing and creating analyzing means. Development of integrated systems has increased the web systems for customers. And the main point is availability of data which can be used faster than analyzing and using them in analyzing forms.

Unfortunately managers try to solve this problem technologically. They try to divide the data , throughout the organization. Companies are to obtain benefit, crate and divide it, not the list of purchased products or the services that customers need.

There aren't many facilities for analyzing data and using it. The Organization in commerce processes does not have good programs to use available information. For this reason, we see gap between information of customers in a company and using information. In this regard, we should ensure that the information should be driven directly from the aim of commerce and the Customers, concept not due to availability of information.

So we should define the Customers demands and by investigating previous data, also find the real demands of customers and its amount.

## 9. Conclusion

Every technology has its new opportunities and threatening situation for different companies. New changes in technology lead to changing in economic trading systems of companies.

The organizations and governments are paying more attention to commerce which is very important and has positive effect on economical and social environment. (OECO,1990) But the characteristics of Iranian society are different. Having keyboard, community intermediation and some software are not ICT, but hyper function with effecting on behavior, moral, positive attitude, identity and human rights and social and commerce relation ship is the ultimate aim.

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# SUPPLY CHAIN MANAGEMENT ONTOLOGY: TOWARDS AN ONTOLOGY-BASED SCM MODEL

Sevinç Üreten[1] and H. Kemal İlter[2]

## Abstract

*Supply chains are complex and dynamic networks that involve quite a lot of constituents beginning from suppliers and ending with the customers. Supply chain management is a flourishing area that needs special attention and there is consensus among researchers and practitioners about the importance of shared knowledge among the constituents for effective supply chain management. Ontologies on the other hand is the study of the categories of things that exist or may exist in some domain, and they provide a common vocabulary for the purpose of knowledge sharing, communication and reuse about some topic. Viewed as a conceptualization of general knowledge into understandable and readable formats, ontologies are precious tools for supply chain decision-making situations. The paper aims to create an ontology for supply chain management by following a methodology driven from the literature. At the end of this study a conceptual schema is created that identifies the common concepts of supply chain management systems.*

Keywords: Supply Chain Management, Ontology, SCM Mode, SCOR, Supply-Chain Operations Reference-Model, Operations

## 1. Introduction

New businesses are constantly emerging around circles of horizontal and vertical supply chain structures in most industries. Supply chains are becoming more important and more difficult to manage because of the complex interactions and flow mechanisms within these structures. Businesses should understand the basic building blocks of their supply chains in order to conceptually develop and manage their supply chains for efficiency and sustainability. As this is quite important to gain competitive advantage, any tool that will help, should be appreciated and ontologies may be accepted as a tool that can be used to reveal the basics of supply chains.

Ontologies provide a simplified and explicit specification of a phenomenon that we desire to represent (Gruber, 1995). They are useful as they explicate the components which define a phenomenon and, thus, can help in systematically understanding or modeling that phenomenon.

The goal of this paper to show a general-purpose supply chain management (SCM) ontology that can be used by practitioners, researchers, and educators. The ontology is characterized in terms of formal definitions and axioms that have evolved from a collaborative ontology design process. The ontology presented here may be extended, refined, modified, or even replaced, but in its current form it provides a foundation for systematic SCM research, study, and practice.

A brief SCM-related literature survey will be given first, after which some fundamental ontology issues for building SCM ontology will briefly be discussed. Importance of SCM for modern economy and definition of SCM is a good beginning point. Following this, we will introduce ontological engineering together with the current practices in this area. The last section will be devoted to SCM ontology properties and frame of ontological architecture.

### 1.1. Supply Chain Management

Supply chain management represents a critical competency factor in today's global business environment (Nissan, 2000) and accordingly supply chain management, analysis, and improvement efforts are becoming increasingly important. The literature includes approaches to supply chain management (see Lamming 1996; New, 1996; Waters-Fuller, 1995), in addition to supply chain models (Beamon, 1999).

Put simply, supply chain management is a collaborative, cross-enterprise operating strategy that aligns the flow of incoming materials, manufacturing, and downstream distribution in a manner responsive to changes in customer demand without creating surplus inventory (Cooper and Ellram, 1993; see also Quinn, 1998). As noted by Balsmeier and Voisin (1996), supply chain management is not the old wine of "supplier management" poured into a colorful bottle. Instead, supply chain management is a fresh, potent approach that integrates a network of operating entities into a delivery system that enhances customer value and satisfaction and that protects the competitiveness of the

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entire supply chain (Lummus and Vokurka, 1999), as is demonstrated by benchmarking studies conducted by the Pittiglio Rabin Todd & McGrath consulting company.

These economic enhancements do not flow inevitably from supply chain management (Jarrell, 1998). Effectiveness is required. Therefore, the traditional approach of managing the supply chain as a loose collection of independent segments, each concerned with achieving its own objectives regardless of the effect on other segments, squanders the promised benefits of supply chain management (Balsmeier and Voisin, 1996). A leading reason for the traditional approach's failure is its reliance on cost management systems that emphasize the minimization of controllable costs. Having recognized this, some companies have tried to mitigate the effects of biased cost management practices by expanding their ABM systems to partly cover supply chain activities (see Barr, 1996; Cooper et al., 1992; Player and Keys, 1995; Pohlen and La Londe, 1994; and Ortman and Buehlmann, 1998). Their efforts will likely end in disappointment because ABM focuses on the internal economics of activity costs; it fails to address the issue of how supply chains can improve customer value and satisfaction. (Smith and Lockamy III, 2000)

In today's markets, technological and competitive forces are changing at an ever increasing rate. To respond to these forces, radical changes in organizations have become necessary. The viability of a firm now depends largely on how well it is capable of responding to customer requirements while becoming lean. It is becoming increasingly more difficult and less economical for companies to produce their needs on their own. Instead, outsourcing is becoming one of their main strategies. Also, the ever-increasing trend in globalization and customer orientation requires a logistics-sensitive organization. Supply chain management (SCM) is an approach that has evolved out of the integration of these considerations. A definition of supply chain (Stevens, 1989) is:

> *A system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via the feed forward flow of materials and the feedback flow of information.*

From the beginning of this decade, SCM has been studied and practiced, and has been reported in the literature.

The field of supply chain management is reaching a new stage. After a period dominated by enthusiasm for the newness of the idea of managing the stream of products across the whole chain from supply through manufacturing to end-users, it is now realized that "one size does not fit all". An important contribution to the refocusing of the attention on this subject in SCM-literature is the contribution of Fisher (1997) that explains the need for matching the supply chain management technique to product characteristics. Aitken et al. (2003) state that there is a "need for tailored logistics channels" in delivering products, while Frohlich and Westbrook (2001) distinguish different levels of integration in supply chains, and Ho et al. (2002) emphasize the need for the relationship between context and integrative practices in supply chains. More generally, Mouritsen et al. (2002) state that there is a need for further research to explore how supply chains are managed under different circumstances, and at what point integration of activities and processes across the supply chain is beneficial for the participants. So far, the idea of focusing the supply chain has been developed across different lines. Fisher (1997) differentiates between functional and innovative products, while Aitken et al. (2003) relate the management of the supply chain to different stages of the product life cycle. One of their results is, for example, that MRP is more appropriate in the growth-stage, while KAN-BAN appears to be more suitable in the maturity stage of the product life cycle. Generally, this type of research concentrates on issues related to managing the supply chain. Less attention has been paid to supply chain design, and in the context of this paper, to the question of which resources can be shared to gain from economies of scale, and which resources have to be tailored to the needs of specific buyers in order to align processes across the supply chain (Fawcett et al, 2006).

In the mid-1990s, many industry pundits looked to the future, claiming that competitive success would depend on collaborative supply chain teams (Blackwell, 1997; Christopher and Ryals, 1999; Elliff, 1996; Harps and Hansen, 2000). For example, Harold Sirkin, Vice President at the Boston Consulting Group, noted that, "As the economy changes, as competition becomes more global, it's no longer company vs. company but supply chain vs. supply chain" (Henkoff, 1994).

The increased complexity of products and hence the higher level of outsourcing have moved the level of competition from single companies to groups or chains of firms (Gomes-Casseres, 1994; Rice and Hoppe, 2001). For this reason, literature widely acknowledges the strategic relevance of supply chain management as a source of competitive advantage (Christopher, 1992; Fine, 1998). This can be achieved by considering the network as a whole, and hence pursuing global instead of local optimization (Ellram, 1991; Cooper and Ellram, 1993; Simchi-Levi et al., 2000), and by integrating all key business processes from end-users to original suppliers (Cooper et al., 1997; Burgess, 1998, Cagliano et al, 2006).

Closed-loop supply chains, embodying remanufacturing and reverse logistics, might be expected to be important means to enable businesses to meet the growing demands of corporate social responsibility, and to meet wider social goals to reduce the resource-intensity of contemporary economic life (Hart, 1997; Steinhilper, 1998; Environmental Protection Agency, 1997; Commission of the European Communities, 2000). There is a clear resonance with the concepts of eco-efficiency (Schmidheiny, 1992) and eco-modernism (Ayres et al., 1997): that closed loops offer opportunities to achieve the so-called "triple bottom line" of social, business and environmental benefits (Hawken et al., 1999). Waste streams – including mechanical products that can be made serviceable again – can provide useful value added business opportunities (Wells and Seitz, 2005).

Organizations seek competitive capabilities that enable them to exceed customers' expectations and enhance market and financial performance (Hayes and Pisano, 1994; Lado et al., 1992, Tracey et al, 2005)

### 1.2. Ontology Theory

An ontology is nothing else than a rigorously defined framework that provides a shared and common understanding of a domain that can be communicated between people and heterogeneous and widely spread application systems (Fensel 2001).

Gruber described an ontology as "an explicit specification of a conceptualization." This definition is short and sweet but patently incomplete because it has been taken out of context. Gruber was careful to constrain his use of *conceptualization* by defining it as "an abstract, simplified view of the world that we wish to represent for some purpose" – a partial view of the world consisting only of those "objects, concepts and other entities that are assumed to exist in some area of interest and the relationships that hold among them."

Ontology today is in a state similar to that of analysis in the late 18th century. The practical power of the calculus had been convincingly demonstrated in the work of Newton and his great successors. Moreover, the field of real analysis itself had seen an explosion of creativity, exemplified most notably in the work of Euler. However, Euler's own work also revealed worrisome foundational problems. For techniques used with great success in one instance to prove deep and dramatic theorems in another instance could lead to absurdities, e.g., that the value of certain monotonically increasing infinite series was -1. Such results led to a conceptual crisis—how can any results be trusted when the methods that generate them can lead to error? This crisis was addressed, and successfully eliminated, by the development of rigorous foundation for analysis — widely known as the arithmetization of analysis — by Cauchy, Weierstrass, Bolzano, and others in the early 19th century. Building on the sound foundation of number theory, mathematicians replaced the intuitive but undefined notions of analysis — limit, continuity, series, integration, real number etc. — with clearly defined counterparts (e.g., the now-familiar $\epsilon$; $\delta$ definition of limit) and banished unruly notions like that of an infinitesimal altogether.2 With these solid underpinnings in place, mathematicians were able to identify clear conditions of applicability for their analytic methods that prevented the derivation of absurdities without limiting their ability to prove desirable results. (Menzel, 2002)

A similar foundation is needed in the study of ontologies. As with analysis prior to arithmetization, the potential of ontologies is evident, but the fundamental notions remain largely intuitive; notably, there is no precise characterization of the notion of an ontology. What we need, then, is our own "arithmetization"—in a nutshell, we need *ontology theory*: a mathematical framework, akin to number theory or modern analysis, which enables us to characterize the notion of an ontology formally and develop accounts of their properties and the various ways in which one ontology can be related to another. It is in this respect analogous to computability theory. No one actually programs turing machines (except as a heuristic exercise). Rather, the notion provides a model of computation that serves as a foundation for both theoretical and, therefore, indirectly, applied computer science.

## 2. Ontological Engineering

Merriam-Webster definition: *a branch of metaphysics concerned with the nature and relations of being or a particular theory about the nature of being or the kinds of existents.*

This is the abstract philosophical notion of "ontology", a more applicable term for this field is "formal ontology" (McGuinness, 2002). (Gruber 1993) provides the definition "a specification of a conceptualization". An ontology thus provides a set of concepts from a certain domain that are well specified.

"Ontology" is the term used on the internet when discussing the semantic web. The Web Ontology working group at W3C emphasizes that ontologies (in their definition) are a machine-readable set of definitions that create taxonomy of classes and subclasses and relationships between them.

McGuinness (2002) states that the minimum requirements of an ontology are a finite set of unambiguously identifiable classes and relationships, including strict hierarchical subclass relationships. Typical, but not mandatory is property specification on class basis.

The term ontology has been in use for many years. Merriam Webster, for example, dates ontology circa 1721 and provides two definitions (1) a branch of metaphysics concerned with the nature and relations of being and (2) a particular theory about the nature of being or the kinds of existents. These definitions provide an abstract philosophical notion of ontology. Mathematical or formal ontologies have also been written about for many years. Smith (1998) points out that at least as early as 1900, the notion of a formal ontology has been distinguished from formal logic by the philosopher Husserl. While ontologies (even formal ontologies) have had a long history, they remained largely the topic of academic interest among philosophers, linguists, librarians, and knowledge representation researchers until somewhat recently.

Ontologies have been gaining interest and acceptance in computational audiences (in addition to philosophical audiences). Guarino (1998) provides a nice collection of fields that embrace ontologies including knowledge engineering, knowledge representation, qualitative modeling, language engineering, database design, information retrieval and extraction, and knowledge management and organization.

## 3. Supply Chain Management Ontology and Ontology-Based SCM Model

As there is no standard supply chain configuration, the specific requirements must be analyzed in the process of establishing a SC. A close co-operation of all parts in a SC is required in order to attain the common goal. The criterion to accept compromising solution should be the maximum pay-off for the system as a whole, not to accept maximum pay-off for individual subsystems. (Frankovic et al. 2002)

Many current applications, such as commerce, production, delivery, sales etc., which appear also in supply chains, with different types of resources or agents to interoperate with each other may be solved on the basis of the ontological methodology. In some cases, interoperation becomes more complex, because agents might have been developed independently; therefore it is not possible to assume that agents use the same communication language and the same terminology in a consistent way. When dealing with independently developed agents, their interoperability depends on the agent's ability to understand them, which leads us directly to ontology. Ontology is an explicit formal specification of a shared conceptualization, where *conceptualization* refers to the abstraction of some phenomenon by having identified the relevant concepts of that phenomenon, *explicit* means that the type of concepts used, and the constraints on their use are explicitly defined, formally refers to the fact that the ontology should be machine readable. The ontology provides a formally defined specification of the meaning of those terms that are used by agents during the interoperation.

Ontology usually consists of a set of class (or concepts), definitions, property definitions and axioms about them. The classes, properties and axioms are related to each other and together form a model of a system or in general of the world. We suppose that a change constitutes a new version of the due ontology.

Methodology of ontology development may be considered in the following steps: (Frankovic et al. 2002)

Specification - which may be the determination of classes

Conceptualization - which is the modeling at the knowledge level using for example tables and graphs. The proposed tables and graphs allow modeling, concepts, attributes, first order logic formulas etc. and they are thought to be manipulated by experts in the domain to be modeled. The methodology does not propose how to add a new type of table, how to add a new field to a type of table, how to delete one of the types of the proposed graphs, or how to elaborate a completely new modeling way with completely new graphs and tables. Therefore several groups in different locations (or different situation) have to build an ontology collaboratively, there are problems to agree and change the characteristics of the tables and graphs to be used.

Formalization - using for example a formal language or some frames.

Implementation - using for example a special language of ontology.

It is needed to notice that the potential of ontology is evident, but the fundamental notions remain largely intuitive.

Building the supply chain ontology requires the concepts in the domain or classes and subclasses to be identified, together with the properties of each concept describing various features and attributes of the concept (slots), and allowed values for these slots (facets) The ontology together with a set of individual instances of classes will constitute a knowledge base for SCM systems.

In our SC ontology we preferred to use product, agent (member), flow and operations as the classes. We thought that it is a good approach to cover the main elements of a supply chain.

Our supply chain management ontology framework is given below:

Table 1: Supply Chain Management Ontology Framework

PRODUCT

Goods
- Parts, components, supplies
- Nondurable (consumer) goods
- Durable goods
- Industrial goods

<u>Goods Properties:</u>
Process Type: (facets: extracted from the nature; made-to-order; made-to-stock; assemble-to-order; imported)
Weight: (facets: bulky, heavy, light)
Size (facets: small, large)
Resistance (facets: fragile, non fragile)
Durability (facets: perishable, non-perishable)
Characteristics (facets: functional, innovative)
Type (facets: food products, electronics, textile, etc.)

Service
- Governmental services
- Municipal services
- Trade services (wholesale retail)
- Finance, insurance, real estate
- Medical (healthcare)
- Personal services
- Business services
- Education

<u>Service Properties:</u>
Service content (facets: high, low)
Service location (facets: in- house, at site)

AGENT (MEMBER)

Supplier
- 1st tier
- 2nd tier

Producer
Transporter
Distributor
Customer
- Consumer
- Industrial user

<u>Properties:</u>
Kind of production activity (facets: manufacturing, transportation, trade)
Utility created (facets: form, place, time, ownership)
Produces (food products, electronics, textile, transportation service, trade service, etc.)
Size (facets: small, medium, large)
Geographic location (facets: domestic, global)
Service content (facets: low, high)
Make-buy decisions (facets: produce in house, outsource)
Operations performed (facets: plan, source, make, deliver, return)

Degree of customer contact (facets: high, low)

| FLOW | OPERATIONS |
|---|---|
| Material<br>Money<br>Information<br>Properties:<br>Direction of flow (facets: forward, backwards, both sides)<br>Flow between (facets: supplier-producer, producer-customer, producer-wholesaler etc.) | Plan<br>• Plan supply chain<br>• Plan source<br>• Plan make<br>• Plan deliver<br>• Plan return<br>Source<br>• Source Stocked Product<br>• Source Make-To-Order Product<br>• Source Engineer-to-Order Product<br>Make<br>• Make-to-Stock<br>• Make-to-Order<br>• Engineer-to-Order<br>Deliver<br>• Deliver Stocked Product<br>• Deliver Make-to-Order Product<br>• Deliver Engineer-to-Order Product<br>• Deliver Retail Product<br>Return<br>• Return Defective Product<br>• Source Return MRO Product<br>• Deliver Return MRO Product<br>• Return Excess Product<br>Properties:<br>Performed by (facets: supplier, producer, transporter, distributor, customer) |

A supply chain is considered as a loop from customers' demand to customer's satisfaction by final product or service. It is a complex and dynamic system which has a character of hybrid-distributed system. It consists of a chain of producers, suppliers, distributors, and transporters. In MAS language, a supply chain can be modeled as a system of intelligent agents, which agree to cooperate to reach the final goal. A new, modern, and cost-effective implementation of supply chain management (SCM) is enabled by rapidly developing information and communication technologies. (Frankovic et al, ) SCM covers a process of creating and configuring a supply chain, identifying measuring metrics in the chain, determining weak points in the chain and works to achieve the best results to meet customer demands. It aims to develop strategies for managing all resources (raw materials, services) and balance cumulative demands and supplies. Each basic SC is a chain of Plan, Source, Make, Deliver and Return process. The details of these steps are given below (Supply-Chain Council, 2006):

Plan – a strategic part of SCM. The aim is to develop strategies for managing resources and balancing demands and supplies. A set of metrics to monitor the SC efficiency has to be proposed.

Source - the aim is to choose a set of suppliers for producing goods and services.

Make- goods and materials are transformed to final products. This step is the manufacturing portion of the supply chain. Production scheduling, testing, packaging, etc. are the activities that take place at this step.

Deliver - coordination of orders from customers, developing a network of warehouses, distribution and transportation of products to customer, invoicing system to receive payments from customers. This part is known as "logistics"

Return - deals with the problematic of defective products, how they can be returned to producer and how customers are dealt with to satisfy their requirements on problematic products. A "help desk" application is used in this part.

The basic scheme of SC is shown in Figure 1a, Figure 1b and Figure 1c. Production gets customers' demands and purchases material from suppliers on the basis of these demands. Products are delivered to distributors where they are for sale for customers. This scheme is also shown in Figure 2 with a ontology language (Protégé).

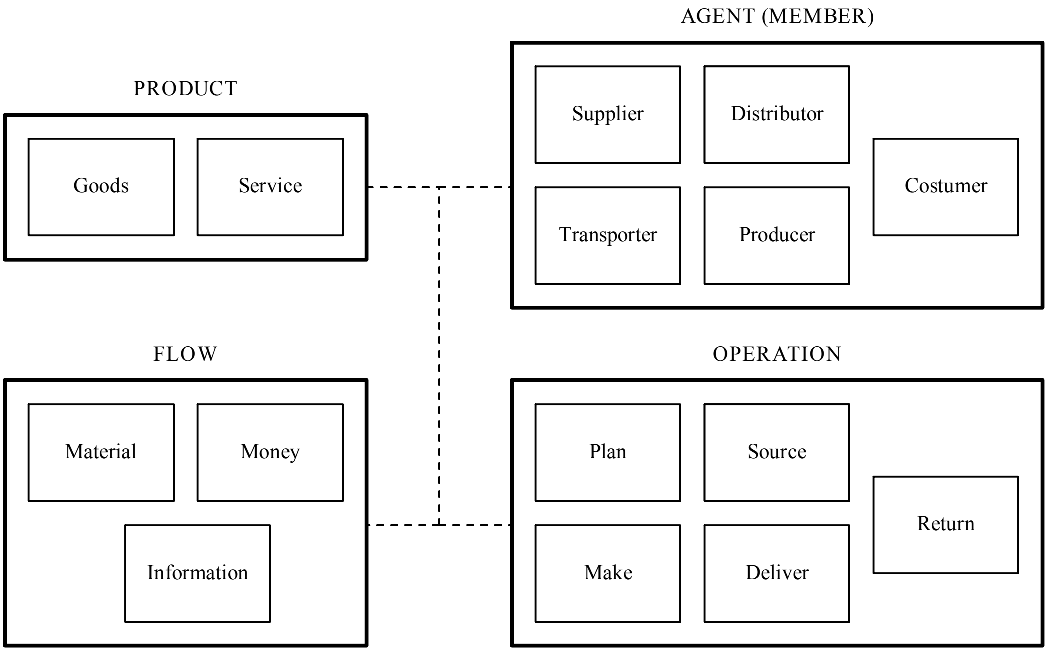


Figure 1a. Ontology-Based SCM Model

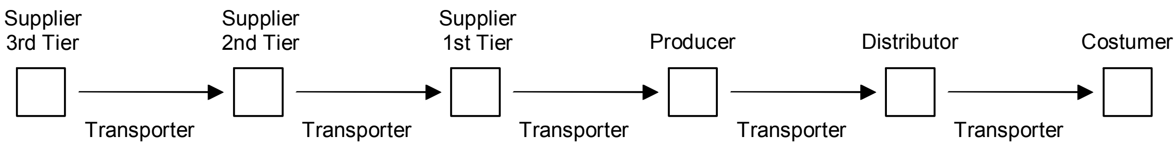


Figure 1b. Products and Agents Layer of Ontology

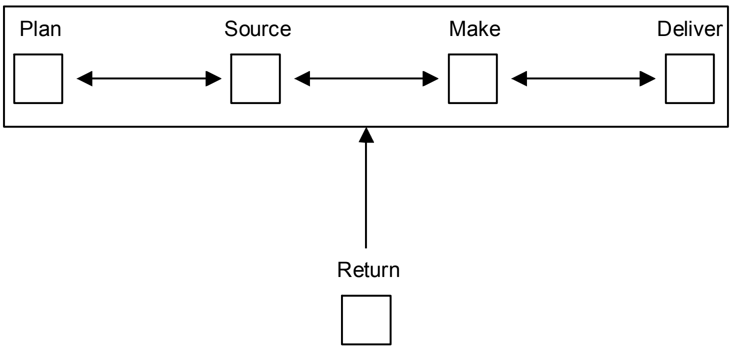


Figure 1c. Flow and Operation Layer of Ontology

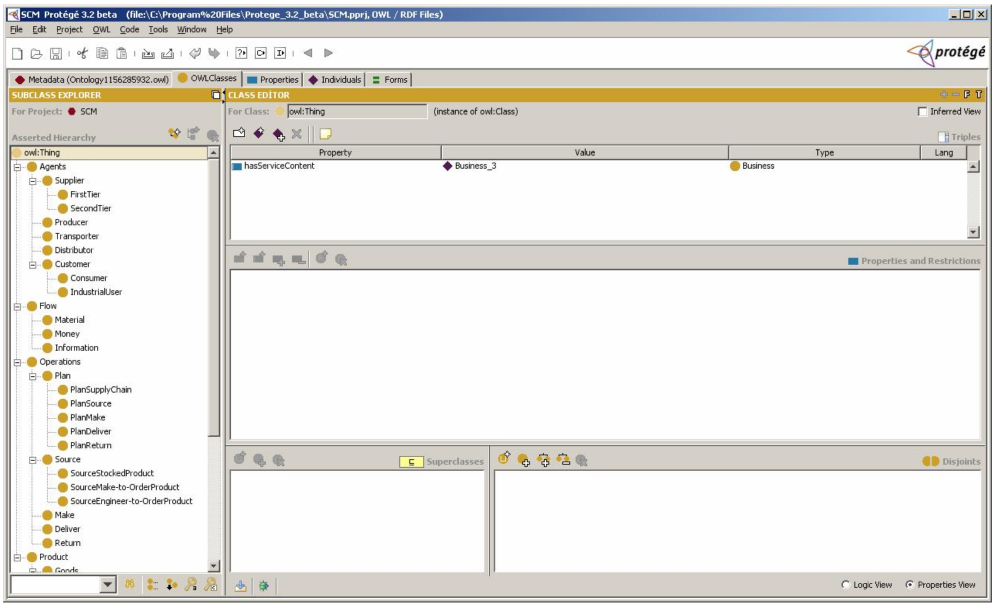


Figure 2. SCM Ontology in Protégé

## 5. Conclusion

A brief literature survey indicates that quite a lot of efforts have been devoted to ontology studies in different areas such as medicine, telecommunication, biology, botany etc. This stems from the need to standardize and formalize languages to ensure a common understandability among agents, humans and computers. In designing and managing supply chains which are complex and dynamic networks, it is important to share a common language among the constituents. The supply chain management ontology has the goal of providing a framework to better formulate, understand, analyze and share a company's supply chain management model. Therefore ontologies can be regarded as precious tools that can be used to increase the efficiency of supply-chains. But literature survey indicates that there is not much work devoted to this area. This was the reason for deciding to make an ontology study on SCM systems. The aim of this paper is to create a better understanding of supply chains by identifying the basic notions used through the chains. The methodology used for constructing a general-purpose ontology for supply chain management is presented along with the resulting ontology and an ontology based SCM model.

This study can be used as a framework for further studies. The ontology may be enhanced by including supply chain performance drivers and by including other concepts such as forecasting, warehouse location, aggregate planning, etc. More effort can be devoted to synchronizing the ontology with the SCOR (Supply Chain Operations) model in which the operations of supply chain is classified as plan, source, make, deliver and return, as is used in our ontology. Further research can also include computerizing the SCM ontology or extending the general-purpose SCM ontology into various application areas.

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# DATA MINING AND MODELLING AS A SOLUTION FOR CRITICAL ISSUES IN FOOD DISTRIBUTION

Tülin Çavuş [1]and Dr. Gülgün Kayakutlu[2]

## Abstract

*Data mining has become an indispensible need for enterprises which integrate data extracted from business applications and market resources. This study aims to provide a solution for defining the number of stops and load/unload durations for heat sensitive products. The problem presents a conflict amongst the goal of delivering maximum amount of orders on time and preserving the food at the quality requested. Analysis is performed on data accumulated by order management and customer complaint handling in the light of regional road and weather conditions. Goal programming is one of the data mining methods that allows defining a common pattern for combining the internal and external data, as well as solving conflicting goals. A mathematical model is developed and tested in the case of an ice-cream production company, based on the target variables of number of pallets and duration of stop and predicting variables of truck capacity, number of orders, delivery distances, and temperature. The results achieved from this study lead the distribution scheduling.*

*Keywords:* Data Mining, Food Industry, Goal Programming

## 1. Introduction

Knowledge based decision making is inevitable in the current management processes, which is enriched by the knowledge discovered in the accumulated data (Eker, 2002; Cheng-Liang & Wen-Cheng 2004). Data mining is used to make the discovery and transformation of data into useful knowledge (Laudon& Laudon, 2000; Gehrke & Ramakrisman, 2000) . Hence, data mining has become a crucial tool for the logistic activities as any function it is used for.

This study aims to provide a solution for defining the number of stops and load/unload durations for heat sensitive products using data mining techniques. The problem presents a conflict amongst the goal of delivering maximum amount of orders on time and preserving the food at the quality requested, that is why goal programming model is developed.

This paper is so organised that a brief review of the data mining literature will given before the presentation of the mathematical model and the case study. The achievements and further recommendations will be given in the conclusion finalising the paper.

## 2. Review of the Data Mining History

Data analysis starts with Aristotle, Bacon and Galileo, yet, the statisticians started ‘data hunting’ only in 1960’s when decision analysis has become important in all the industries (Frawley, Shapiro and Matheus, 1992). In 1989, JCAI Knowledge Discovery in Databases workshop has been accepted as the starting point of the Data Mining Concept (Fayyad & Simoudis 1998). Since then, it has become a tool to extract the useful knowledge from the mass of data.

In the second part of 1990’s, integration of the data analysis with the the machine learning has become quite an attraction of interest on the data mining (Holshemier & Siebes 1994). Clustering, neighbourhood analysis, genetic and neural network techniques have accompanied the decision trees and decision analysis methods.

In the twenty-first century, after the widespread and web sharing of the databases, data mining has evolved to locate and extract knowledge in the integration of multiple data resources (Alataş, Akın , 2004). Data pattern analysis, concurrent clusters, time series analysis help managers to avoid the risk in decision making (Kantardzic, 2002).The most current developments in the data mining can be summarised as integration with the simulation methods.

## 3. The Logistics Problem Cited

For the food with the expiration date, problems are faced in the delivery plans and the transportation. “Breaking the Cold Chain” is one of the most popular problems, which can not be avoided unless all the effective factors are under control. This is one of the major reasons to cause the need for the fleet and the product distribution plans to be prepared in accordance (Aouni, Kettani, 2001). In order to avoid the loss in products without avoiding the delivery on time a decision system is designed in Figure 1. In such a system, the fleet capacity and the distance

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travelled can be planned in accordance with the required number of loading and unloading. The system can give the opportunity to minimise the unload time while maximising the allowance for the temperature differences.

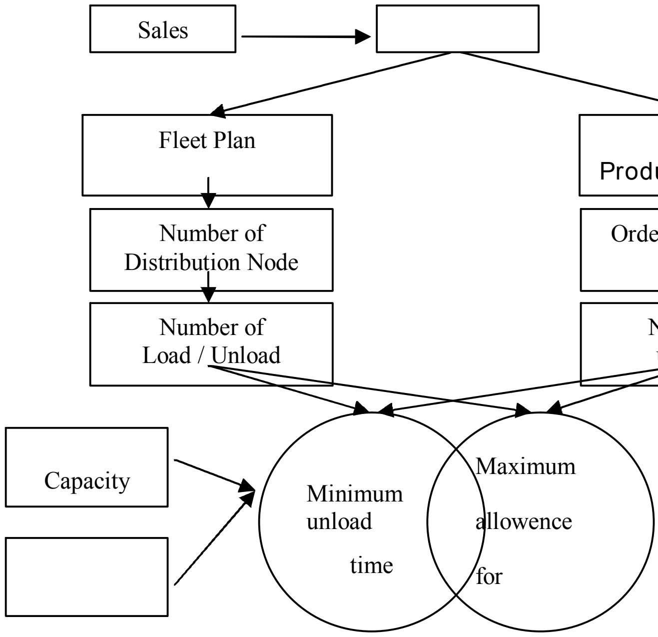


Figure 1. System diagram

## 4. Solutions and Results

### 4.1. The Goal Programming Model As a Solution

One of the methods to avoid the defined "Breaking Cold Chain" problem, is to minimize the extra waiting time while unloading at the delivery nodes. The time spent at each node might be because of the human negligence or the number of palettes to be unloaded, that the climate in the vehicle is effected negatively. The waiting duration and the number of palettes are effective factors when the environmental temperature is assumed to be constant during the delivery process, which is negligibly small due to the closed systems in the cold food trucks. The goal of the study is making the unload time minimum, while allowable maximum temperature changes. Since these are conflicting, the goal programming method is chosen for the solution.

Hence, the decision variables can be defined as the number of unloading nodes ($x_1$) and unloaded palettes ($x_2$) in one distribution plan from warehouse to the determined delivery nodes. At any node, both the time spent for delivery extra waiting ($t_1$) and unloading one palette ($t_2$) are the time based variables in effect. Besides, truck capacity (K) and distance (M) depend on the fleet distribution plan, and can be determined by solving a goal programming model. Moreover, fleet distribution plan helps to define ultimate loading time (ULT) for different distribution groups. A distribution group includes one warehouse and several nodes, which are planned ahead. The truck loads the palettes from the warehouse and continues visiting the delivery nodes. In order to construct a model, an average distance (d) must be defined between two nodes.

Cold Chain is under control depending on the lower and upper temperature limits. Upper temperature limit (UTL) and lower temperature limit (LTL) help to define the allowable temperature difference (ΔLTEMP) in the system. Therefore, the temperature change must be between lower temperature difference limit ($\Delta LTEMP_1$) and upper temperature difference limit ($\Delta LTEMP_2$) in order not to break Cold Chain. In the transportation system, temperature difference is by the palette unloading ($\Delta h_1$) or extra waiting time period ($\Delta h_2$).

After having defined the variables of the models, the objectives and the constraints are to be defined. Since there are several transportation distribution groups and trucks with different capacities via two goals, as temperature and loading effects it requires multiple objective goal programming. Therefore, a model, which is shown below, is constructed to evaluate optimum logistic distribution plan to avoid "Break of the Cold Chain".

$$\text{Min. } Z = w_1 * d_1^+ + w_2 * d_2^+ + w_3 * d_3^- + w_4 * d_4^+ + w_5 * d_5^+ \qquad (1)$$

s.t..

$$t_1 * X_1 + t_2 * X_2 - d_1^+ + d_1^- = ULT$$

$$\Delta h_1 * X_1 + \Delta h_2 * X_2 - d_2^+ + d_2^- = \Delta LTEMP_2$$

$$\Delta h_1 * X_1 + \Delta h_2 * X_2 - d_3^+ + d_3^- = \Delta LTEMP_1$$

$d*X_1 - d_4^{+} + d_4^{-} = M$

$X_2 - d_5^{+} + d_5^{-} = K$

$X_1, X_2, d_1^{+-}, d_2^{+-}, d_3^{+-}, d_4^{+-}, d_5^{+-} \geq 0$

$d_i^{+-}$ i = 1, 2, 3, 4, 5 is deviation from the constraint limits. Importance level of the deviations is different and the difference is effective on objective.

## 4.2. Data Mining Applied

The model is applied in an ice cream factory, where the data for all the variables and the limits are collected by data mining.

The existing data is cleaned by deleting the irrelevant values and then they are used for the calculation of the mean and the confidence tests. data is used for average For the confidence, Cronbach Alpha (Helberg, 2002). test is applied to the data set as in the equation 2 and estimate α value.

$$\alpha = \frac{N * \bar{r}}{(1 + (N - 1) * \bar{r})} \qquad (2)$$

Last step was to estimate the average values for the company by applying the central limit theorem.

As mentioned before, there are several regions and truck types in logistic distribution model. Two different trucks and 3 different regions bring six $ULT_{ij}$, $M_{ij}$ and $d_{ij}$ in the system (Table.1). The calculated mean values of $t_1$, $t_2$, $\Delta h_1$ and $\Delta h_2$ are used to determine the for finding mean values of $ULT_{ij}$, $M_{ij}$ and $d_{ij}$.

Table 1. The 6 Cases Analysed

| | Region - 1 | Region - 2 | Region - 3 |
|---|---|---|---|
| Truck - 1 | $ULT_{11}$<br>$M_{11}$<br>$d_{11}$ | $ULT_{12}$<br>$M_{12}$<br>$d_{12}$ | $ULT_{13}$<br>$M_{13}$<br>$d_{13}$ |
| Truck - 2 | $ULT_{21}$<br>$M_{21}$<br>$d_{21}$ | $ULT_{22}$<br>$M_{22}$<br>$d_{22}$ | $ULT_{23}$<br>$M_{23}$<br>$d_{23}$ |

The weighting to be used in the objective function is determined by using the Analytical hierarchy process (AHP) method (Saaty, 1980). The hierarchy is defined as in Figure 2 and the questions for comparing the couples are prepared. Interviews using the Likert scale of scoring with ten managers allowed to define the priorities of the four decision variables.

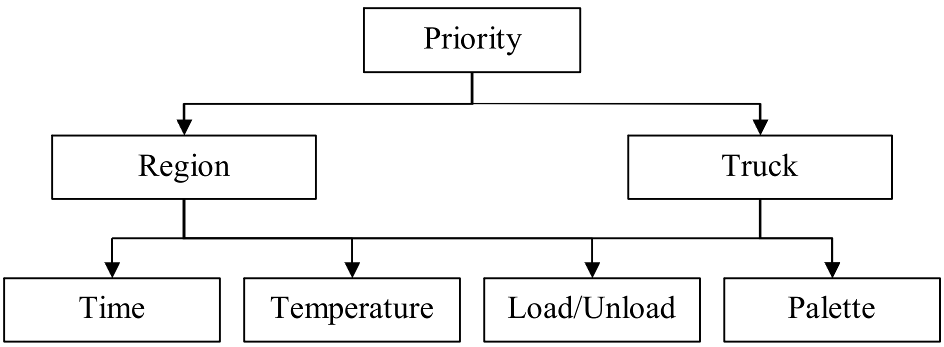


Figure 2. Hierarchy of Decision Variables

Data mining lead the numeric values of $t_1$, $t_2$, $\Delta h_1$, $\Delta h_2$, $ULT_{ij}$, $M_{ij}$ and $d_{ij}$ as shown in Table 2.

Table 2. Numerical values of $t_1$, $t_2$, $\Delta h_1$, $\Delta h_2$, $ULT_{ij}$, $M_{ij}$ and $d_{ij}$.
Numerical values of $t_1$, $t_2$, $\Delta h_1$ and $\Delta h_2$.

| Parameter | Numerical value |
|---|---|
| $t_1$ | 10 min. |
| $t_2$ | 0,75 min. |
| $\Delta h_1$ | 0,32 °C |
| $\Delta h_2$ | 0,025 °C |

b) Numerical values of $ULT_{ij}$, $M_{ij}$ and $d_{ij}$.

| $ULT_{ij}$ (min.) | | | |
|---|---|---|---|
| | Region – 1 | Region - 2 | Region - 3 |
| Truck - 1 | 85 | 100 | 110 |
| Truck - 2 | 50 | 70 | 80 |
| $M_{ij}$ (km) | | | |
| | Region – 1 | Region -2 | Region - 3 |
| Truck - 1 | 25 | 40 | 65 |
| Truck - 2 | 10 | 18 | 36 |
| $d_{ij}$ (km) | | | |
| | Region – 1 | Region -2 | Region - 3 |
| Truck - 1 | 5 | 6 | 8 |
| Truck - 2 | 3 | 4 | 6 |

Temperature limits are parameters between 2°C and 4°C. As a result of this, upper and lower bound for the temperature difference can be write down $\Delta LTEMP_1$ = 0 °C and $\Delta LTEMP_2$ = 2 °C. Besides these parameters, Analytical hierarchy process (AHP) $w_{ij}$ values must be also identified as numerically (Table 3).

Table 3. Weights of the Effective Factors

| | Time | Temperature | Load/Unload | Palette | $w_j$ |
|---|---|---|---|---|---|
| Time | 0,38 | 0,71 | 0,27 | 0,06 | 0,35 |
| Temperature | 0,13 | 0,24 | 0,63 | 0,56 | 0,39 |
| Load/Unload | 0,13 | 0,03 | 0,09 | 0,31 | 0,14 |
| Palette | 0,38 | 0,03 | 0,02 | 0,06 | 0,12 |

Data mining is allowed the construction of six different model as $R_1T_1$, $R_1T_2$, $R_2T_1$, $R_2T_2$, $R_3T_1$ and $R_3T_2$. One of them for $R_1T_1$ is shown below:

$\text{Min } Z = 0{,}35 * d_1^+ + 0{,}39 * d_2^+ + 0{,}39 * d_3^- + 0{,}14 * d_4^+ + 0{,}12 * d_5^+$
$10 * X_1 + 0{,}75 * X_2 - d_1^+ + d_1^- = 85$
$0{,}32 * X_1 + 0{,}025 * X_2 - d_2^+ + d_2^- = 0$
$0{,}32 * X_1 + 0{,}025 * X_2 - d_3^+ + d_3^- = 4$
$5 * X_1 - d_4^+ + d_4^- = 25$
$X_2 - d_5^+ + d_5^- = 48$
$X_1, X_2, d_1^{+-}, d_2^{+-}, d_3^{+-}, d_4^{+-}, d_5^{+-} \geq 0$

## 4.3. Solution Results

The model is solved by using EXCEL Solver and the results for six different cases are listed below (Table 4).
Table 4. EXCEL Solver results
a) Palette and unloading node number results

| | $K_1B_1$ | $K_1B_2$ | $K_1B_3$ | $K_2B_1$ | $K_2B_2$ | $K_2B_3$ |
|---|---|---|---|---|---|---|
| Unloading node | 5 | 6 | 8 | 3 | 4 | 6 |
| Palettes | 46 | 48 | 40 | 26 | 30 | 26 |

b) $Z_k = \Sigma(d_i * w_j)$ results for six different cases

| | $K_1B_1$ | $K_1B_2$ | $K_1B_3$ | $K_2B_1$ | $K_2B_2$ | $K_2B_3$ |
|---|---|---|---|---|---|---|
| $Z_k$ ($\Sigma(d_i * w_j)$) | 1,77 | 3,03 | 2,60 | 1,98 | 4,24 | 2,02 |

Since the minimum Z value gives the optimum result for logistic distribution model, it is clearly seen that $K_1B_1$ must be chosen which allows the plan for visiting 5 nodes and unloading a maximum of 46 palettes at each node.

## 5. Conclusion

Data mining is used to determine a solution model for an important issue in food distribution, "Breaking the Cold Chain". The conflicting goals of maximising the delivery volume and minimising the defects in the food due to temperature changes are combined by using the goal programming method. The deficiencies of the goal programming, determination of the weights of the effective factors are solved by using an AHP application. The results achieved gave the lead for the distribution plans.

In this study the model is defined by simplifying the decision variables, as in the assumption of taking a fixed the environmental temperature. This model can be improved by considering more factors, removing the assumptions and covering all the regions. It would then allow the utilisation of a data-warehouse and some data mining software like SPSS.

This study allows the decision makers in food distribution to visualise modelling and solution of the issues by using data mining techniques.

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# FINANCIAL BENCHMARKING OF TRANSPORTATION COMPANIES IN THE NEW YORK STOCK EXCHANGE (NYSE) THROUGH DATA ENVELOPMENT ANALYSIS (DEA) AND VISUALIZATION

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## Abstract

*In this paper, we present a benchmarking study of industrial transportation companies traded in the New York Stock Exchange (NYSE). There are two distinguishing aspects of our study: First, instead of using operational data for the input and the output items of the developed Data Envelopment Analysis (DEA) model, we use financial data of the companies that are readily available on the Internet. Secondly, we visualize the efficiency scores of the companies in relation to the subsectors and the number of employees. These visualizations enable us to discover interesting insights about the companies within each subsector, and about subsectors in comparison to each other. The visualization approach that we employ can be used in any DEA study that contains subgroups within a group. Thus, our paper also contains a methodological contribution.*

*Keywords: Financial benchmarking, Data Envelopment Analysis, Data Visualization, Logistics, Transportation, Delivery Services, Railroad Transportation, Marine Transportation, Trucking, New York Stock Exchange*

## 1. Introduction

Logistics is often considered as "movement of goods", a definition which is not totally wrong, but has to degree of limited meaning. In fact, with its growing field of operations, including transportation, planning, warehousing and many more disciplines, logistics has become an indispensable part of the business world especially in recent decades. The statistics covering many sectors point out this fact: 10 to 35% of gross sales of companies are spent on logistics costs (Projects Monitor).

Logistics is a component of the value chain which can bring significant competitive advantage to the firm. A well known example of this fact is the great success of Wal-Mart in the retail industry (Stalk, Evans, & Shulman, 1992). Wal-Mart is reported to achieve its phenomenal success thanks to its efficient logistics operations and specifically to its successful implementation of crossdocking. Companies may prefer to carry out the logistics operations within their own structure or may prefer to outsource it to companies that are specialized in logistics, namely "logistics companies". The main cost component in logistics is typically transportation. So we have decided to focus on the industrial transportation sector, and analyzed industrial transportation companies.

Financial benchmarking makes it possible to compare companies in an industry based on their financial statements. Companies can compare their financial statements and managerial strategies with those of their competitors, and can identify suitable strategies to prevail in their industries. Financial benchmarking is a subject which is commonly examined in the academic environment. There are some visualization approaches such as Self Organizing Maps (SOM), and some mathematical methods such as Stochastic Frontier Approach (SFA), Distribution-Free Approach (DFA), Data Envelopment Analysis (DEA), etc. In this paper, we prefer to employ DEA since it has some eligibility among all other methods besides the advantage that it is a nonparametric technique which requires fewer assumptions (Weill, 2004). Furthermore, Weill's (2004) study proves that DEA is also consistent with standard measures of performance such as DFA and SFA. In addition to its consistency, DEA can reveal the reason for a company being inefficient, and shows how to restore the fund to its optimum of efficiency (Galagedera & Silvapulle, 2002).

In this study, we gathered the financial statements for 2005 of the industrial transportation companies traded in New York Stock Exchange (NYSE), and carried out a benchmarking study among them through DEA. The results of DEA were visualized by Miner3D (Miner3D) in order to detect patterns and derive useful insights.

## 2. Methodologies

### 2.1 Data Envelopment Analysis

*Data Envelopment Analysis (DEA*) is an approach which is used to measure efficiency (or productivity) of an activity or entity (named Decision Making Unit, DMU). Measuring total productivity is difficult with multiple inputs and outputs since it requires choosing weights for inputs and outputs. The most useful property of DEA is the fact that it does not make any assumptions to choose these weights: Instead, the weights are directly derived from

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the data. The "best" weights, which have the most adequate properties to be used for benchmarking of the DMUs, are chosen by the model itself. Thus, these weights are not fixed but they are defined as variables. Since the weights of the inputs and outputs are determined from the data, their units do not need to be congruent. In other words, the units can be of different types (ex: workers, machines, dollars, units). The DMUs which have the highest rank of efficiency levels all together determine the *efficient frontier* and the other (inefficient) DMUs' scores are calculated according to this efficient frontier. The efficient DMUs that reside on the efficient frontier and have efficiency equal to 1 are same as or superior than the inefficient DMUs (that have efficiency less than 1) in all productivity dimensions. However, they can not be superior to each other in every dimension, i.e., they are inferior to each other in at least one dimension. Thus, the efficiencies measured in DEA can be alternatively defined as the relative efficiencies.

The properties explained above are illustrated in the example below. If there is one input (in this case, number of employees) and two outputs (sales and number of customers); a given data of 7 DMUs can be visualized as in Figure 1. The DMUs B, E, C and F create the efficient frontier and they all are efficient, whereas the DMUs A, D and G form the set of inefficient DMUs. The efficiencies of the DMUs on the frontier are all equal to 1, since they have the perfect efficiency compared to others. The inefficient DMUs' efficiencies are calculated by taking the efficient frontier into account. For instance, the efficiency of D is |OD| / |OP|.

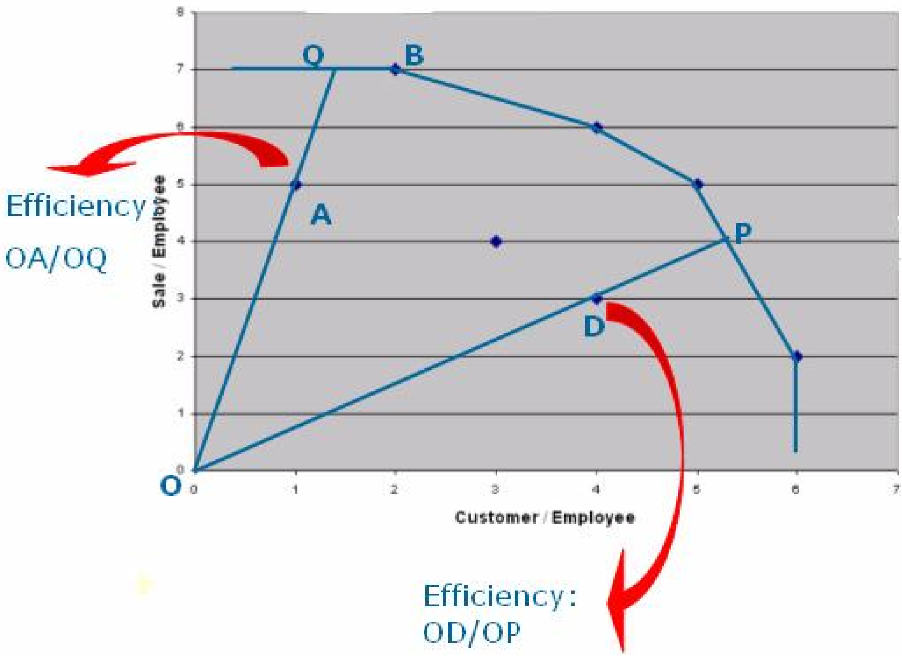


Figure 1. One input & two output case of DEA

The example above is a very simple one, and it is *not* possible to figure out the components of the graph such easily when there are multiple inputs and outputs (which is the usual case in real world problems). Thus, a mathematical modelling approach is devised in order to deal with the more complex problems.

One of the best known models generated to cope with this difficulty is the *CCR Model*, developed by Charnes, Cooper & Rhodes (1978). CCR assumes that there is *constant-returns-to-scale*, which possibly is not the case in a large number of real life problems. There are two variations of the CCR model, one of them is the *input-oriented model*, and the other one is the *output-oriented model*. The input-oriented model is given below (Cooper, Seiford, & Tone, 2006), with $\theta$ denoting efficiency (virtual output/virtual input), X and Y denoting matrices formed composed of sets of $x_j$ and $y_j$ vectors for the variables, i.e., X=($x_j$), Y=($y_j$).

$$(DLPI_o)\ \min \theta$$

$$\theta x_0 - X\lambda \geq 0$$

$$\mathrm{Y}\lambda \geq y_o$$

$$\lambda \geq 0$$

In this model, the objective is to minimize the input by concurrently keeping the output at least the same. In the output oriented CCR Model below, the objective is to maximize the output level by making use of at most the same amount of input:

$$(DLPO_o)\ \max \eta$$
$$x_0 - X\mu \geq 0$$
$$\eta y_0 - Y\mu \leq 0$$
$$\mu \geq 0$$

These two variations do not change the DMUs on the efficient frontier, but calculate the projections of the DMUs differently.

Another known DEA Model is the *BCC Model* which is developed by Banker, Charnes, & Cooper (1984). Almost all of the characteristics of the CCR Model also prevail for BCC Model. However, unlike the CCR Model, BCC Model enables the problem to be *variable-returns-to-scale*. This property is assured through a convexity constraint which makes the production frontier to be spanned by the convex hull of the DMUs. The mathematical model of input-oriented BCC Model (Cooper, Seiford, & Tone, 2006) can be written as:

$$(BCC_o)\ \max \quad \theta_B$$
$$\theta_B x_0 - X\lambda \geq 0$$
$$Y\lambda \geq \mathrm{y}_0$$
$$\mathrm{e}\lambda = 1$$
$$\lambda \geq 0$$

where X=($x_j$) is the matrix of input variables and Y=($y_j$) is the output matrix of variables, λ is a column vector and e is the raw vector of 1's. (See Appendix -Section 7.1- for further mathematical explanation of the models.)

In this study, the BCC Model is utilized since it can accommodate variable-returns-to-scale, without the restriction of constant-returns-to-scale. Also, the input-oriented model is found to be more appropriate for this study since it is much easier to set actionable goals for the input values in shorter time periods (Culliane, Song & Wang, 2005).

### 2.2 Data Visualization

Data visualization is a fundamental component of data analysis, and especially helps the analyst with detecting outliers, finding patterns that are not suggested by standard statistical techniques, and coming up with new hypotheses. The book by Chambers et al. (1983) is the classic source of reference for data visualization carried out within the context of statistics. The visualizations (referred to as "graphical methods") include quantile plots, histograms, box plots, symmetry plots, scatter plots, quantile-quantile plots, etc., and could be generated by the computers of 1980's. However, these visualizations focused mostly on supporting statistical analysis, could display a very limited number of data points, and did not make effective use of colors.

The field of computer science known as *information visualization* has emerged in the 1990's and extends the graphical methods of 1980's to new dimensions. In information visualization, the idea is to detect undiscovered patterns, come up with actionable insights, and generate maximum benefit out of –typically large scale– data. Information visualization is built on ideas from data mining, statistics, and computer graphics; and compensates for the shortcomings of graphical methods of 1980's. Well-known sources on information visualization include books by Spence (2001) and Soukup & Davidson (2002), web sites such as Olive (Olive), IV (IV), and review papers including Keim (2002) and Hoffman & Grinstein (2002).

The visualization method that we employ in this paper is the "colored scatter plot" developed in the 1980's, and is referred to as "starfield display" in the information visualization literature. This visualization method is very simple, yet can enable a great understanding of the visualized data. We carry out our visualizations using the Miner3D software (Miner3D).

## 3. Related Literature

We believe that the work most related to our research is the one by Min and Joo (2006), where the authors carry out a benchmarking study of six third party logistics (3PL) providers using DEA. They use financial data of accounts receivables, salaries & wages, operating expenses and property & equipment as inputs in the model and operating income as the output. Their study spans the years 1999-2002. The authors discovered that the strength of companies' service performances and the diversity of their 3PL services are correlated to their operational efficiencies. The authors suggest several survival strategies based on their observations from the DEA.

DEA has also been employed in studies related with logistics and transportation, for comparing container ports' efficiencies (Turner, Windle, & Dresner, 2004; Cullinane et al., 2006), estimating productivity of the trucking industry in U.S. states with respect to fatalities (Weber, & Weber, 2004), deriving efficiency scores of urban rail firms (Graham, 2006) and urban transit systems (Boame, 2004), evaluating performances of airlines (Chiou, & Chen, 2006), and measuring operational pruductivity of warehouses (Hackman et al., 2001).

Scatter plot visualizations similar to the ones in our paper can be found in Frazelle (2002, pages 61-63), where efficiency scores of warehouses (referred to as "Warehouse Performance Index") are plotted against warehouse sizes and material handling systems investments. These visualizations provide warehouse and logistics managers with critical insights on strategic warehouse design issues.

## 4. Analysis and Results

### 4.1 Data Collection

The data for benchmarking is obtained from New York Stock Exchange (NYSE) and company websites: The marine transportation, transportation, trucking, delivery and railroad subsectors of the industrial transportation sector are selected for the study (NYSE Industries). There are 19 marine transportation, 9 transportation, 2 trucking, 3 delivery and 10 railroad companies listed under this sector. The annual reports of these companies for the year 2005 are compiled from their SEC (The Securities and Exchange Commission) filings. A company from marine transportation (K-Sea Transportation Partners L.P.) and two companies from transportation (PHH Corporation, Air castle Limited) have no annual reports available on the Internet for the year 2005; so these companies were not considered. Also, Southeast Airport Group was eliminated from the transportation companies list since its business includes mostly transportation of people. As a result, there are a total of 39 industrial transportation companies that were benchmarked in this study and this number provides a very suitable working atmosphere for DEA. Boussofiane et al. (1991) suggest that the number of DMUs to include in DEA should be at least equal to the number of inputs multiplied by the number of outputs. In our study, this translates into at least 9 DMUs during the analysis of each subsector.

In compiling the data from the annual reports, the income statements and the balance sheets were used. The total revenue, total operating expenses, net income values were taken from the income statement, and total assets, total liabilities and total shareholders equity data were taken from the balance sheet. All values were taken in millions of US $. The reason for the selection of these values were the facts that it was possible to obtain them for all companies and in their usage as inputs and outputs in DEA can be considered as simpler compared to other potential data. The data that we used in DEA can be downloaded from the internet (Ertek). The inputs and outputs in the DEA analysis were selected as follows:

- Inputs: Total operating expenses, Total assets, and Total liabilities
- Outputs: Total revenue, Net income, and Total shareholders equity

We have not been able to find a standard scheme for the selection of input and outputs in financial benchmarking literature and thus have made the selections in the light of the fact that in DEA achieving more amount/quantity of an output with less amount/quantity of an input is always preferred.

### 4.2 Visual Analysis

By feeding these inputs and outputs to the DEA-Solver software (Cooper, Seiford, & Tone, 2006), the efficiencies of each DMU were determined. According to the results that were achieved, there are 12 transportation companies that were found to be efficient. Efficiency scores of these companies and the inefficient ones are provided in the Appendix - Section 7.2. These efficiency scores were then visualized by the Miner3D software (Miner3D) to search for the possible patterns. The first graph plots the efficiency scores against the subsectors (Figure 2):

In Figure 2, the x-axis and also the colors indicate the subsectors under the industrial transportation sector. Blue stands for delivery services (D), dark green stands for marine transportation (M), light green stands for railroad (R), yellow stands for transportation (T) and red stands for trucking (U) companies.

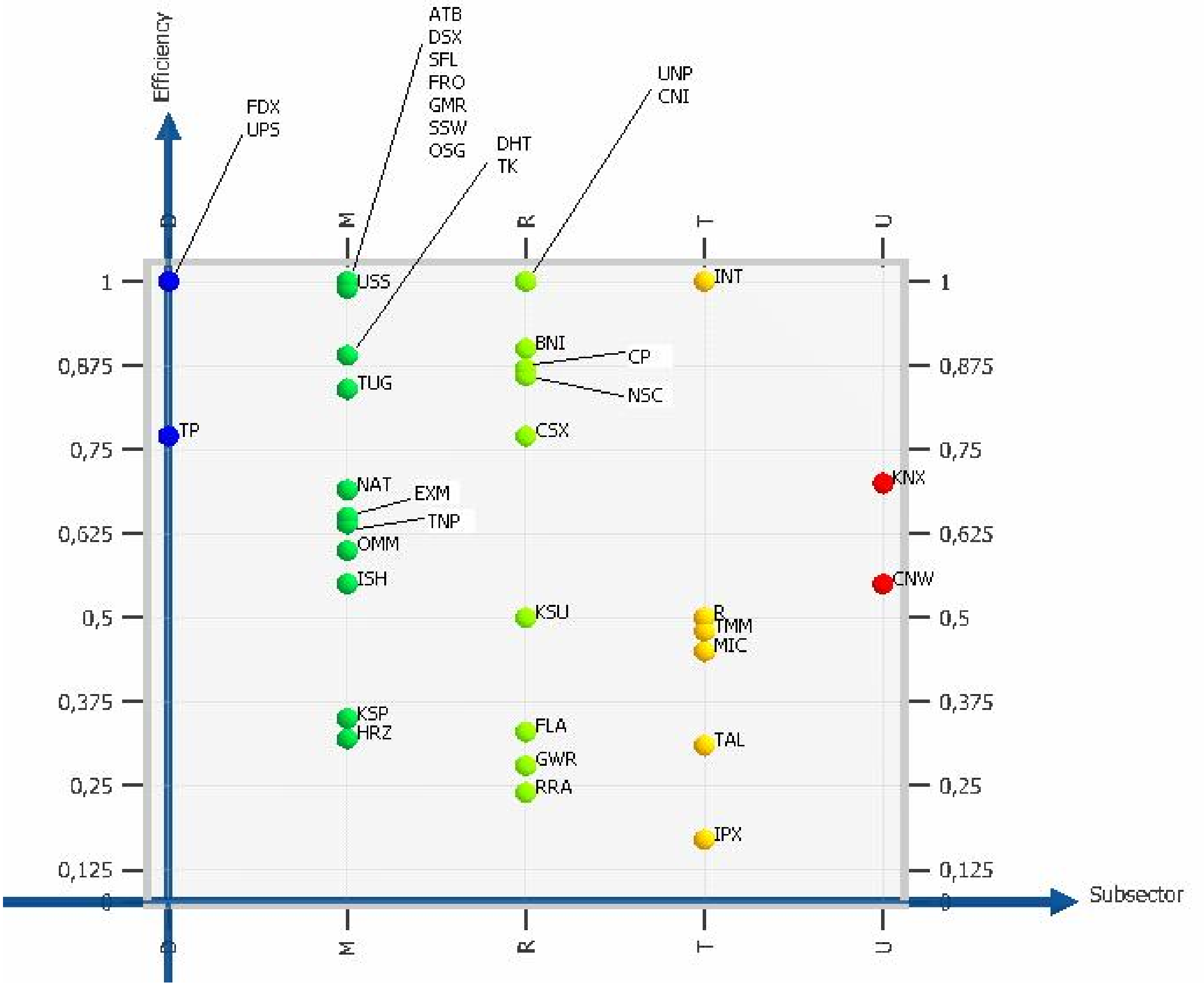

Figure 2. Efficiency related with the subsectors

By examining Figure 2, one can discover the following insights:

Seven from among the 18 marine transportation companies are fully efficient, i.e. they all have efficiency scores of 1. These companies are Arlington Tankers Ltd. (ATB), Diana Shipping Inc. (DSX), Ship Finance International Ltd. (SFL), Frontline Ltd. (FRO), General Maritime Corp. (GMR), Seaspan Corp. (SSW) and Overseas Shipholding Group Inc. (OSG). Also, there are four additional companies in this subsector, having a score greater than 0.80 and these are U.S. Shipping Partners L.P. (USS), Double Hull Tankers Inc (DHT), Teekay Shipping Corp. (TK), and Maritrans Inc. (TUG). When these 11 most efficient companies were investigated in detail, it was found out that most of them focus on transportation of oil and petroleum. Among these 11 companies only DSX and SSW are not operating in this subsector of marine transportation. One of these companies, DSX, transports coal, iron ore, grain and dry cargoes. The other one, SSW, provides charter services to container liner companies. It can be said that both of the services that these companies are involved in have the property of being unique among the marine transportation companies in NYSE. Furthermore, in marine transportation subsector there are only two companies having low (less than 0.5) efficiencies. These are Kirby Corp. (KSP) and Horizon Lines Holding Corp. (HRZ). Both of them do not serve in the field of petroleum and oil transportation but they focus on different kinds of services. KSP is a barge operator and HRZ is involved in transport of cargo such as building materials, consumer goods, and food to and from the continental US and Alaska, Hawaii, Guam, and Puerto Rico.

In the field of transportation services, only one firm, World Fuel Services Corp. (INT), is fully efficient and the rest of them have efficiency scores less than or equal to 0.5. The success of INT can be explained by the fact that it is the only transportation firm that runs its business through integration of both marine and aircraft modes. This company holds more than 10% of the global marine fuels market, and provides 24-hour fueling service to aircraft at 1,500 airports in more than 160 countries. It is possible to state that the considerably higher ranking marine transportation sector in our research channel a significant portion of their financial resources to INT and this may be the explanation behind its success. Meanwhile, we were amused to observe that the value of 0.5 acts much as a border in all the subsectors (except delivery services) that separates the “leaders” and the “laggards” of that subsector.

It is not so easy to see a definite pattern in the subsector of railway transportation. The graph gives the impression that almost half of the companies are above the rank of 0.50. Considering the only two companies that have efficiency scores of 1, namely Union Pacific Corp. (UNP) and Canadian National Railway Co. (CNI), it can be possible to discover an interesting insight. UNP is involved in the business of transporting coal, chemicals, industrial products, and other freight by using a system of more than 32,000 route miles in 23 states in two-thirds of the western of US. On the other hand, CNI is recognized as Canadian's top railroad operator. Both spread their services over a wide network, a characteristic which is not possessed by the other companies in this subsector. A detailed search on these "laggard" companies' websites revealed that they mostly operate regionally.

In the subsectors of delivery and trucking services, it is difficult to see a pattern since there are too few companies. Although it is not statistically appropriate to make generalizations, one can observe that delivery services have much higher efficiencies compared to trucking services for the companies that we considered. The trucking subsector has no companies having a score of 1; all the companies in this subsector have medium ranks of efficiency.

The second graphical analysis from the results of the DEA shows the relation between the number of workers and the efficiency scores (Figure 3).

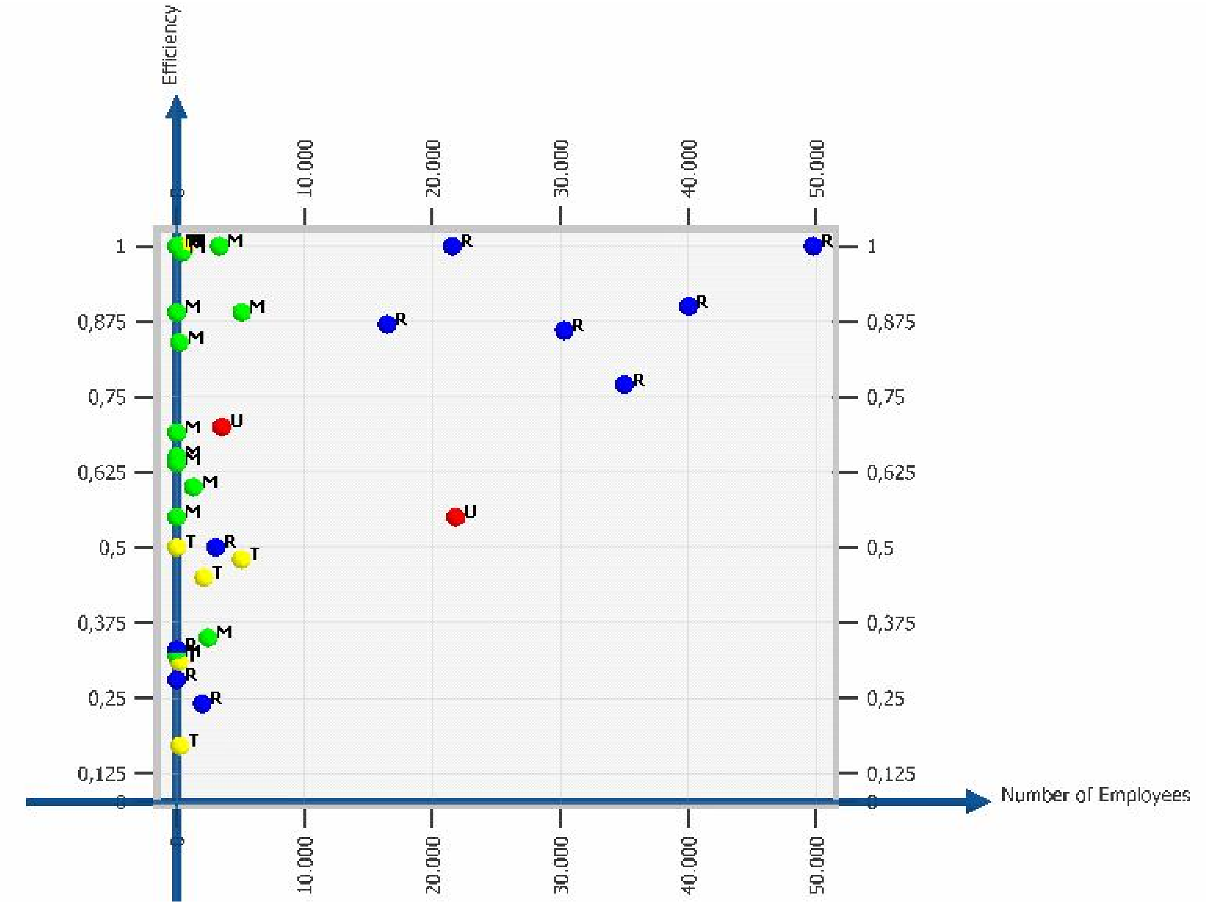

Figure 3. Efficiency related with the number of employees

The first and obvious pattern in Figure 3 is the bimodal distribution of the railroad companies (indicated by the label "R"). There are two major groups: One with small number of employees and low efficiency scores, and other with large number of employees and high efficiency scores. These two groups are clearly separated. Although the companies in each group have no clear patterns, the existence of two disconnected sets can lead one to hypothesize that the railroad companies benefit from economies of scale.

When the marine transportation and transportation companies are examined, no clear pattern can be detected. There companies all operate with less than 10,000 workers.

It is also not possible to identify a definite pattern about the trucking subsectors by considering the two trucking companies that exist in NYSE.

Companies from the delivery subsector were not included in Figure 3. The reason for this was the fact that all of the companies that belong to this industry have employee numbers between 40,000 and 407,000. Those numbers would stand as clear outliers in the graph, and would cause a cluttering of the other companies in the graph. If we sort the delivery companies amongst each other (Appendix – Section 7.2) it can be concluded that FedEx Corp. (FDX) and United Parcel Service Inc. (UPS), which were the largest two delivery companies, have perfect efficiency score of 1. Meanwhile, the considerably small TNT N.V. (TP) has significantly lower ranking in DEA results. However, despite all these differences, all delivery companies have efficiency scores greater than 0.75, which leads one to believe that this subsector of industrial transportation is more efficient than the other subsectors.

### 4.3 Marine Transportation

From marine transportation subsector in NYSE, 18 companies were considered. This number is sufficient to carry out an independent analysis for this subsector. Thus we benchmarked these companies and found out a new ranking amongst them. This new analysis gave a better understanding of this subsector's own boundaries for being efficient and made it possible to see the companies that should be taken as role models by the inefficient companies. The reference sets found by DEA enable us to identify such patterns.

When the DEA is done for marine transportation subsector only, the most important change that can be observed is the increase in the number of companies with efficiency score of 1 (Table 1).

Table 1. DEA results of the marine transportation subsector

| Rank | SYMBOL | DMU | Score |
|---|---|---|---|
| 1 | ATB | Arlington Tankers Ltd. | 1 |
| 1 | DSX | Diana Shipping INC. | 1 |
| 1 | FRO | Frontline Ltd. | 1 |
| 1 | GMR | General Maritime Corp. | 1 |
| 1 | HRZ | Horizon Lines Holding Corp. | 1 |
| 1 | OSG | Overseas Shipholding Group INC. | 1 |
| 1 | SSW | Seaspan Corp. | 1 |
| 1 | SFL | Ship Finance International Ltd. | 1 |
| 1 | TK | Teekay Shipping Corp. | 1 |
| 10 | USS | U.S. Shipping Partners L.P. | 0.99 |
| 11 | DHT | Double Hull Tankers Inc. | 0.90 |
| 12 | KSP | Kirby Corp. | 0.87 |
| 13 | TUG | Maritrans Inc. | 0.84 |
| 14 | NAT | Nordic American Tanker Shipping Ltd. | 0.70 |
| 15 | EXM | Excell Maritime Carriers Ltd. | 0.68 |
| 16 | OMM | Omi Corp. | 0.68 |
| 17 | TNP | Tsakos Energy Navigation Ltd. | 0.64 |
| 18 | ISH | International Shipholding Corp. | 0.55 |

The independent analysis of the marine transportation subsector enables two companies (HRZ and TK) which did not have perfect efficiencies to reach the ranking of 1. This result is meaningful because in the first analysis the more efficient companies from other subsectors took place in efficient frontier instead of them. One of these two companies, HRZ, became one of the most efficient companies; while in the analysis of whole data it was the worst among the marine transportation subsector. This may seem strange however, it is possible that the efficient frontier may differ dramatically for a subset of the DMUs compared to the complete set of DMUs. An example of such a situtation for "one input & two outputs case" is illustrated in the Appendix - Section 7.3.

Table 2 involves the reference sets for the companies in the marine transportation subsector, which are not on the efficient frontier. In our DEA for all companies, we did not made a research on reference sets, since the suggested companies involved the companies from different subsectors, which would make the given set inadequate, due to the difficulty of taking the policies of an other business subsector. Consequently, the table above gives only references from the marine transportation sector, which would make the study more clear and meaningful. The weights given on the right side of the reference DMUs sum up to 1 and if the firm is on the efficient frontier its only reference is itself (with the weight of 1).

Table 2. Reference sets for the marine transportation companies

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| USS | DSX | 0.34 | SFL | 0.66 | | | | | | |
| DHT | ATB | 0.20 | DSX | 0.77 | SFL | 0.03 | | | | |
| KSP | GMR | 0.35 | HRZ | 0.46 | SFL | 0.17 | TK | 0.02 | | |
| TUG | DSX | 0.40 | SFL | 0.60 | | | | | | |
| NAT | DSX | 0.79 | SSW | 0.08 | SFL | 0.13 | | | | |
| EXM | DSX | 0.93 | GMR | 0.04 | SSW | 0.03 | | | | |
| OMM | FRO | 0.06 | GMR | 0.14 | OSG | 0.08 | SFL | 0.66 | TK | 0.06 |
| TNP | DSX | 0.34 | GMR | 0.47 | SFL | 0.19 | | | | |
| ISH | DSX | 0.08 | SFL | 0.92 | | | | | | |

### 4.4 Railroad Transportation

In this section we repeat the results of an independent DEA for the railroad transportation subsector, because it is the remaining candidate in the industrial transportation sector which has sufficient data for the study. Again for this subsector, there is an increase in the number of companies which have efficiency scores of 1. BNI, CP, FLA and GWR BNI, CP, FLA and GWR which are found inefficient in Section 4.2, are now found to be efficient in their subsector. The reason for this increase in the number of efficient companies within this subsector is the same as the reason for the marine transportation sector. The reference sets for the railroad transportation are shown in Table 4.

Table 3. DEA results of the railroad transportation subsector

| Rank | SYMBOL | DMU | Score |
|---|---|---|---|
| 1 | BNI | Burlington Northern Santa Fe Corp. | 1 |
| 1 | CNI | Canadian National Railway Co. | 1 |
| 1 | CP | Canadian Pacific Railway Ltd. | 1 |
| 1 | FLA | Florida East Coast Industries Inc. | 1 |
| 1 | GWR | Genese & Wyoming Inc. | 1 |
| 1 | UNP | Union Pacific Corp. | 1 |
| 7 | RRA | RailAmerica Inc. | 0.94 |
| 8 | NSC | Norfolk Southern Corp. | 0.92 |
| 9 | CSX | CSX Corp. | 0.91 |
| 10 | KSU | Kansas City Southern | 0.79 |

Table 4. Reference sets for the railroad transportation companies

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RRA | BNI | 0.00 | CP | 0.01 | GWR | 0.99 | | |
| NSC | BNI | 0.20 | CNI | 0.73 | CP | 0.03 | UNP | 0.04 |
| CSX | BNI | 0.36 | CNI | 0.30 | CP | 0.31 | UNP | 0.02 |
| KSU | BNI | 0.05 | CNI | 0.02 | CP | 0.17 | GWR | 0.76 |

## 5. Conclusions and Future Research

We have carried out a financial benchmarking of industrial transportation companies using DEA and visualized the results using Miner3D software. To the best of our knowledge, the colored scatter plots have not been used before to visualize the results of DEA, thus we have made a methodological contribution. Our analysis revealed the characteristics of companies within the subsectors of the industrial transportation sector, and compared the efficiencies of different subsectors with each other.

There are two important future research areas that can be pursued as a continuation of our work. One is to carry out formal statistical tests to prove or disprove the hypothesis formed by observing the visualizations. The other area is the investigation of what other types of visualizations can be developed or adopted for analyzing the DEA results.

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## 7. Appendix

### 7.1 Further Explanation for the Models in Section 2.1

The objective of the CCR model is to maximize the efficiency θ (virtual output / virtual input) for each DMU, in order to obtain the values for the input "weights" ($v_i$) and the output "weights" ($u_r$) as variables. Also, the ratio of virtual output to virtual input should not exceed 1 for any DMU. Thus, the fractional model can be written as:

$$(FP_o)\ \max\theta = \frac{\sum_{i=1}^{s} u_i y_{io}}{\sum_{j=1}^{m} v_j x_{jo}}$$

$$\frac{\sum_{i=1}^{s} u_i y_{ik}}{\sum_{j=1}^{m} v_j x_{jk}} \le 1 \quad k = 1,\dots,n$$

$$u, v \ge 0$$

The fractional model can be transformed into the linear model shown below.

$$(LP_o)\ \max\theta = \sum_{i=1}^{s} u_i y_{io}$$

$$\sum_{j=1}^{m} v_j x_{jo} = 1$$

$$\sum_{i=1}^{s} u_i y_{ik} \le \sum_{j=1}^{m} v_j x_{jk} \quad k = 1,\dots,n$$

$$u, v \ge 0$$

Finally, when the dual of the linear model is taken according to the variables shown in Table 6, the input oriented CCR Model ($DLPI_0$) is obtained as written in Section 2.1.

Table 6. The dual variables of CCR Model

| Multiplier form Constraint ($LP_0$) | Envelopment form Variable ($DLP_0$) | Envelopment form Constraint ($LP_0$) | Multiplier form Variable ($DLP_0$) |
|---|---|---|---|
| $Vx_0=1$ | $\theta$ | $\theta x_0 - X\lambda \ge 0$ | $v \ge 0$ |
| $-vX+uY \le 0$ | $\lambda \ge 0$ | $Y\lambda \ge y_0$ | $u \ge 0$ |

The output oriented CCR Model is obtained similarly. Instead of maximizing the efficiency, the objective of the fractional model minimizes the inverse of efficiency (1/θ = virtual input / virtual output =η). While taking the dual for the linear model which is obtained from the fractional one; μ stands for the dual variable of the second constraint. By following these steps one can easily find the output oriented CCR Model given before.

The BCC Model presented in the body text is obtained by a very similar way of obtaining the input oriented CCR Model. The only difference is the convexity constraint (eλ = 1) which allows the variable returns to scale.

7.2 Results of BCC input-oriented DEA for all industrial transportation companies in NYSE

Table 5. Results of BCC input-oriented DEA

| Rank | DMU | Symbol | Industry | Efficiency |
|---|---|---|---|---|
| 1 | World Fuel Services Corp. | INT | Transportation | 1.00 |
| 1 | FedEx Corp. | FDX | Delivery | 1.00 |
| 1 | Union Pacific Corp. | UNP | Railroad | 1.00 |
| 1 | United Parcel Service Inc. | UPS | Delivery | 1.00 |
| 1 | Arlington Tankers Ltd. | ATB | Marine | 1.00 |
| 1 | Diana Shipping Inc. | DSX | Marine | 1.00 |
| 1 | Canadian National Railway Corp. | CNI | Railroad | 1.00 |
| 1 | Ship Finance International Ltd. | SFL | Marine | 1.00 |
| 1 | Frontline Ltd. | FRO | Marine | 1.00 |
| 1 | General Maritime Corp. | GMR | Marine | 1.00 |
| 1 | Seaspan Corp. | SSW | Marine | 1.00 |
| 1 | Overseas Shipholding Group Inc. | OSG | Marine | 1.00 |
| 13 | U.S. Shipping Partners L.P. | USS | Marine | 0.99 |
| 14 | Burlington Northern Santa Fe Corp. | BNI | Railroad | 0.90 |
| 15 | Double Hull Tankers Inc. | DHT | Marine | 0.89 |
| 16 | Teekay Shipping Corp. | TK | Marine | 0.89 |
| 17 | Canadian Pacific Railway Ltd. | CP | Railroad | 0.87 |
| 18 | Norfolk Southern Corp. | NSC | Railroad | 0.86 |
| 19 | Maritrans Inc. | TUG | Marine | 0.84 |
| 20 | TNT N.V. | TP | Delivery | 0.77 |
| 21 | CSX Corp. | CSX | Railroad | 0.77 |
| 22 | Knight Transportation Inc. | KNX | Trucking | 0.70 |
| 23 | Nordic American Tanker Shipping Ltd. | NAT | Marine | 0.69 |
| 24 | Excell Maritime Carriers Ltd. | EXM | Marine | 0.65 |
| 25 | Tsakos Energy Navigation Ltd. | TNP | Marine | 0.64 |
| 26 | Omi Corp. | OMM | Marine | 0.60 |
| 27 | Con-Way Inc. | CNW | Trucking | 0.55 |
| 28 | International Shipholding Corp. | ISH | Marine | 0.55 |
| 29 | Kansas City Southern | KSU | Railroad | 0.50 |
| 30 | Ryder System Inc. | R | Transportation | 0.50 |
| 31 | Grupo TMM SA | TMM | Transportation | 0.48 |
| 32 | Macquarie Infrastructure CO Trust | MIC | Transportation | 0.45 |
| 33 | Kirby Corp. | KSP | Marine | 0.35 |
| 34 | Florida East Coast Industries Inc. | FLA | Railroad | 0.33 |
| 35 | Horizon Lines Holding Corp. | HRZ | Marine | 0.32 |
| 36 | TAL International Group | TAL | Transportation | 0.31 |
| 37 | Genese & Wyoming Inc. | GWR | Railroad | 0.28 |
| 38 | RailAmerica Inc. | RRA | Railroad | 0.24 |
| 39 | Interpool Inc. | IPX | Transportation | 0.17 |

7.3 Example for a dramatic change in efficient frontier

The example of a dramatic change in efficient frontier can be shown on the graph of the “one input & two output case” example from section 2.1. If F and G are removed from the DEA analysis, the efficient frontier moves to its new position shown by the red line in Figure 4 and the efficiency of D (which used to be less than 1) now becomes 1.

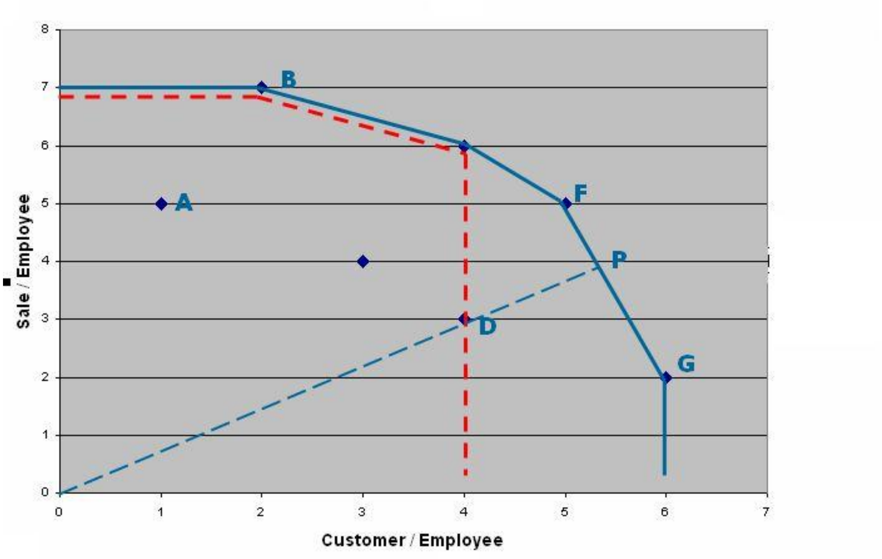

Figure 4. The change in efficient frontier when DMUs F and G are removed.

# COORDINATION OF PRICING AND PRODUCTION-SCHEDULING DECISIONS IN SUPPLY CHAIN SYSTEMS

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## Abstract

*Coordinating the independently made decisions of parties in a two-stage supply chain has gained a lot of interest in recent supply chain research. The major pursuit of the studies in this area has been to identify the inefficiencies in the system, and to determine the contractual terms of the relationship between the parties to improve their individual incentives. In view of this trend, much of the previous research effort has been spent developing coordination mechanisms and evaluating their effectiveness in different settings. However, the existing literature in this area overlooks production capacity considerations at the vendor. In this study, we consider a single period, stochastic demand environment with one vendor and multiple buyers, and we model the production capacity at the vendor explicitly. Through a numerical analysis, we show that considerable savings can be achieved by the vendor by quoting a price schedule that is a function of delivery time and order quantity.*

*Keywords: Supply chain coordination, Production capacity, Price discounts*

## 1. Introduction

The analysis of multi-echelon systems within the context of inventory theory dates back to 1960s. Clark and Scarf (1960) studied a serial multi-echelon inventory system with stochastic demand. Federgruen (1993) provides an excellent review of the relevant literature on multi-echelon inventory systems. One common property of all these studies is that suppliers and retailers make their inventory and production decisions jointly in a centralized fashion. However, it is not practical in real life for independent parties of the supply chain to make their decisions according to a centralized model unless they belong to the same corporation, or the supplier manages the inventory for the whole system (i.e., Vendor Managed Inventory).

An alternative to the centralized modeling is the decentralized approach in which supply chain players make independent decisions with limited information sharing. However, the solution of the decentralized model results in a reduction of the total system profits when compared to the corresponding centralized model. In other words, independent actions of one supply chain member may make the others worse. This concept is referred to as "Double Marginalization" (Spengler, 1950) in the literature. Goyal (1976) is one of the early studies in the operations research literature that quantifies the gap between the two solutions and proposes a mutually agreeable way to share the savings from the centralized approach. Other researchers followed Goyal (1976) in investigating ways to implement the decentralized models that achieve benefits of centralized models leading to an increasing trend in this particular area called *channel coordination*. Channel coordination, essentially aims to align individual incentives of both parties with those in the centralized solution through manipulation of the system parameters. These parameters are usually determined either by the supplier or the buyer and are communicated to the other party in terms of a contract.

Much research has been conducted in developing various types of contracts for different supply chain settings. It may be possible to classify the proposed contracts in six major categories, namely, quantity discount contracts (e.g., Monahan, 1984; Banerjee, 1986; Lee and Rosenblatt, 1986), wholesale price contracts (e.g., Lariviere and Porteus, 2001; Cachon, 2004; Bresnahan and Reis, 1985), sales rebate contracts (e.g., Taylor, 2000a; Krishman et al., 2001), revenue sharing contracts (e.g., Cachon and Larivierre, 2005), buyback contracts (e.g., Pasternack, 1985; Emmons and Gilbert, 1998; Padmanabhan and Png, 1997; Taylor, 2000a), and quantity flexibility contracts (e.g., Tsay, 1999; Tsay and Lovejoy, 1999).

It is important to note that although there is a growing body of research that analyzes the effectiveness of different contractual agreements under various conditions, there is no study that integrates the scheduling decisionswith supply chain coordination. We believe that significant savings can be achieved when contractual agreements are designed to consider scheduling related costs as well. This is specifically important when one or more of the parties have limited production capacity. In this research, we consider a system with a single supplier

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and multiple buyers. We model the supplier's production capacity explicitly, and we illustrate that through a carefully designed price schedule, the supplier can increase his/her savings while keeping the buyers no worse than their uncoordinated decentralized profits. This price schedule differs from what the classical literature proposes in that, it depends on both time and quantity. That is, through this price schedule, the supplier not only affects the buyers' order quantities but also he/she manipulates the due dates of deliveries asked by the buyers. This way, he/she achieves the savings inherent in better scheduling through coordination. A similar system to ours is studied by Charnsirisakskul et al. (2005) within the context of leadtime flexibilities.

The contribution of this study is twofold. First, to our best knowledge, there is no other study that quantifies the savings due to coordination under the consideration of scheduling costs. Secondly, this study leads to a unique type of pricing scheme where the wholesale prices not only depend on the order quantities but also on the time of delivery. We note that time dependent price schedules have been investigated within the context of revenue management, however, this is new for the coordination literature in multi-echelon inventory systems.

## 2. Problem Definition

We consider a two-stage supply chain with one supplier and multiple buyers operating in a single period stochastic demand environment. At the beginning of the period, each buyer decides on his/her order quantity to maximize his/her expected profits. After the supplier collects the orders from all buyers, he/she makes the production schedule. Since the supplier has limited capacity, some orders may be rejected. We assume that in the current setting, all selected orders must be delivered to the buyers before the single period during which demand is realized. We also assume that the *production period* of the supplier extends through the *demand period* of the buyers, and the buyers are willing to receive their orders during the demand period as long as their maximum single period expected profits do not change. Figure 1 illustrates the supplier's production period and the buyers' demand period. All orders are received by the supplier before time $t_1$. In the current setting, the supplier selects the orders that maximize his/her profits subject to limited capacity over $[t_1,t_2]$, where $t_1<t_2$. The transportation times from the supplier to the buyers are negligible, therefore, all selected orders are received by their buyers before time $t_2$. Demand is realized at the buyers within $[t_2,t_4]$.

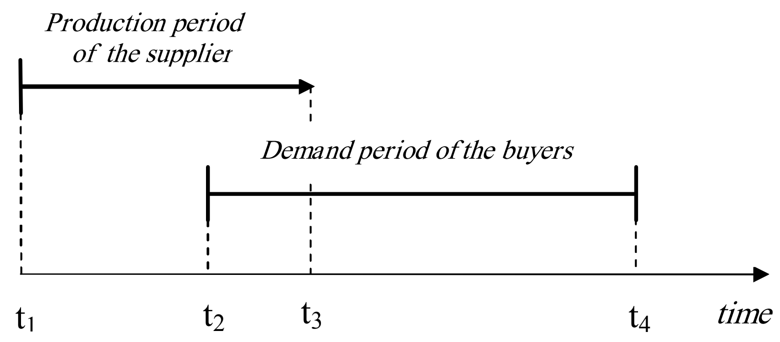


Figure 1. Illustration of the supplier's production period and the buyers' demand period ($t_3 \leq t_4$)

This research proposes the use of a time-dependent pricing mechanism to improve the efficiency of the decentralized supply chain. This mechanism will be referred to as the "price menu" in the remainder of the paper. It enables the supplier to utilize its production capacity more efficiently and decrease the number of rejected orders. In short, the purpose of the price menu is to align the individual incentives of the supplier and the buyers to a more profitable decentralized system solution.

With the aid of price menus, the supplier has an opportunity to affect the retailers to make their ordering decisions in a way that increases his/her own profit. The buyers decide on their order quantities based on the options on the price menus. The price menu consists of three different types of information, namely, a wholesale price corresponding to each (delivery time, quantity) pair. This information is created based on the competitive strengths in the market. Therefore, the problem is the formation of the price menu by the supplier to implicitly manipulate the quantities and the delivery times of the buyers' orders such that the supplier's capacity is used more effectively and his/her profits are increased through more sales.

The price menus are created through a routine that has two separate procedures and is based on the assumption that the supplier has all system information. The first procedure is the preparation of the triples. A triple is composed of a wholesale price, a due-date and a corresponding purchasing quantity. Note also that, we assume there is a finite number options ($K_i$) as a delivery time and a finite number of feasible prices ($J_i$) for each order *i*. The second procedure solves the supplier's optimization problem. Having prepared the triples, we use the second procedure to decide which triple/triples are to be accepted for production. Therefore, the production schedule is also obtained through this routine.

Along with the production costs, inventory holding costs and tardiness costs, triples are an input to the supplier's problem. They are created by considering demand distributions and competitive strengths in the market. The former factor accounts for the demand distribution from the delivery date of an order to the end of the demand season for that particular order. For the latter, we will use two market types namely, the competitive and monopolistic markets. In a competitive market, price menus should be prepared such that each triple provides at least same expected profit for buyers as in the solution of the system without proposed price mechanism, whereas, in monopolistic market the supplier is free to manipulate the wholesale prices as long as the buyers are willing to place orders.

Once the buyers give their orders, the supplier's problem turns out to be a deterministic problem. The supplier's objective is to maximize his/her total profits while satisfying the capacity and delivery time constraints. The total profit is the sum of revenues received from all accepted orders less the inventory holding, tardiness and production costs.

## 3. Model Formulation

The model has two submodels, the supplier's optimization problem and the preparation of the triples. We first present the procedure by which the triples are generated. Then, we discuss the second stage where the production schedule is generated (i.e., supplier's optimization problem).

### 3.1 The Preparation of Triples

The notation, including the indices and the parameters is defined below.

*Indices:*

$i \in \{1,2,...,N\}$ : Order index, where $N$ is the total number of orders.

$j \in \{0,1,2,...,J_i\}$ : Price index. For order $i$ there are $J_i$ feasible prices. If $j=0$, then price option gives the current wholesale price of order *i*.

$k \in \{0,1,2,...,K_i\}$ : Due-date option index. For order $i$ there are $K_i$ possible due-dates. If $k=0$, then due-date indicates the start of the demand season for order *i*.

*Parameters:*

$p_i$ : Unit retail price of order $i$

$g_i$ : Unit salvage value of order $i$

$B_i$ : Unit lost sale value of order $i$

$c_i$ : Unit production cost of order $i$

$d_{ij}^k$ : $k^{th}$ due-date for order $i$ at price option $j$.

$v_{ij}^k$ : Unit wholesale price of order $i$ at price option $j$ for delivery time option $k$. If $j=0$ and $k=0$, then it indicates the market price for order *i*.

$Q_{ij}^k$ : Order quantity of order $i$ at price option $j$ for delivery time option $k$.

$F_i^k(x)$ : Cumulative demand distribution of order $i$ for delivery option $k$. It has mean $\mu_i^k$, standard deviation $\sigma_i^k$ and probability density function $f_i^k(x)$.

The expected profit of a buyer at the optimal quantity for his/her order $i$ to be delivered at due-date option *k*, is given by

$$EP_{ij}^k = (p_i - g_i)\mu_i^k - (p_i - g_i + B_i)\int_{Q_{ij}^{k*}}^{\infty} x f_i^k(x)dx \quad (1)$$

and the optimal quantity is obtained from

$$F_i^k(Q_{ij}^k*) = \frac{p_i - v_{ij}^k + B_i}{p_i - g_i + B_i} \quad (2)$$

Triples are created according to two different market types based on the market strength for competition. We will give an algorithm to create triples for competitive and monopolistic markets. The algorithm uses the following two facts:

The manufacturer's profit function is concave in wholesale price (Lariviere and Porteus, 2001).
Eq. (1) is increasing in order quantity $Q_{ij}^k*$.

Define $w_{i0}^k$ as the wholesale price corresponding to order $i$ at due date option $k$ in a monopolistic market.

*Algorithm (Competitive and Monopolistic Markets)*

Step 1: Set $i$ to 1.
Step 2: Set $k$ to 0.
Step 3:
Set $j$ to 0
If the market is competitive
Find $Q_{ij}^k*$ from Eq. (2).
Find the values of $d_{ij}^k$ from due-date option $k$ for order $i$
Store the triple $\left(Q_{ij}^k*, v_{ij}^k, d_{ij}^k\right)$.
If the market is monopolistic
Solve the following problem and obtain the values of $v$ and $Q_{ij}^k*$.

$$\begin{aligned}
&\max\ v\\
&s.t.\\
&(p_i-g_i)\mu_i^k-(p_i-g_i+B_i)\int_{Q_{ij}^{k*}}^{\infty} x f_i^k(x)dx \ge 0\\
&F_i^k(Q_{ij}^k*)=\frac{p_i-v+B_i}{p_i-g_i+B_i}\\
&Q_{ij}^k*\ge 0
\end{aligned}$$

Set $w_{i0}^k$ to $v$.
Find the values of $d_{ij}^k$ from due-date option $k$ for order $i$
Store the triple $\left(Q_{ij}^k*, v_{ij}^k, d_{ij}^k\right)$.
Set $j$ to 1.
Step 4:
Set $Q_{ij}^k*$ to $Q_{ij}^k*+1$.
Find the values $v_{ij}^k$ (By using Eq. (2)).
If $v_{ij}^k > c_i$, then store the triple $\left(Q_{ij}^k*, v_{ij}^k, d_{ij}^k\right)$. Otherwise go to next Step 5.
Increase $j$ by 1 and repeat Step 4.
Step 5: Do one of the following:
If $k=K_N$ and $i=N$, then stop the algorithm.
If $k=K$ and $i<N$, then increase $i$ by 1 and go to Step 2.
If $k<K$, then increase $k$ by 1 and go to Step 3.

Having obtained all triples we can reduce the number of indices. The two subscripts of the triples imply the superscripts. The reduction is due to the fact that there is a unique demand distribution, equivalently due-date option, satisfying Eq. (2) for a given order $i$ with an order quantity and a corresponding wholesale price. Thus, we can drop the superscripts and let $\left(Q_{ij}^k*, v_{ij}^k, d_{ij}^k\right)$ be the triple corresponding to order $i$ at price option $j$.

### 3.2 The supplier's optimization problem

Let $h_i$ be the inventory holding cost for order $i$ per unit/unit time and $T_i$ be the tardiness cost of order $i$ per unit time. Supplier aims to maximize the following function

$$P=\zeta((Q_{ij}, v_{ij}, d_{ij}, h_i, T_i), i=0,1,...,N, j=0,1,...,J_i) \qquad (3)$$

Let $y_{ij}$ be a decision variable where it is equal to 1, if the supplier accepts order $i$ at price option $j$, otherwise 0. Hence, the total profit in the decentralized supply chain can be written as in Eq. (4).

$$SCVT=\zeta((Q_{ij}, v_{ij}, d_{ij}, h_i, T_i), i=0,1,...,N, j=0,1,...,J_i)+\sum_i\sum_j y_{ij}EP_{ij} \qquad (4)$$

For a fair comparison we use the triples, created for competitive market, whose price indices are 0. These triples are fed into Eq. (4) and the result is the total profit of the decentralized supply chain without coordination. Let *SCV* denote this value. The difference (*SCVT-SCV*) is the improvement over the decentralized system.

## 4. Example

We illustrate the model described above in a numerical study for all possible capacity values at the supplier. We consider a supply chain with a supplier and two identical buyers in the sense that they have the same system parameters and demand distributions. The supplier produces a single product and the unit production time is 1.

There are at most $C$ time units for production. Deliveries can be made at two different points in time, those are $C/2$ and $C$. For simplicity, assume that the tardiness cost is big enough to prevent any late delivery, the unit inventory holding cost is 1 and the production cost is negligible. The demand season starts just after the first delivery time. Two buyers have the same system parameters and the demand distributions. The retail price is 10 and there is no salvage value or lost sale cost. The demand for each delivery is normally distributed. For the first delivery, we have a mean of 120 and a standard deviation (STD) of 80, whereas for the second one, the mean and STD are 105 and 75, respectively.

While we calculate the total value of the decentralized system, we focus on the supplier's profits. The results are given in Table 1 and 2 for competitive and monopolistic market types, respectively. The intervals for the capacity are obtained from the profit graphs of the supplier. We have two identical orders coming from each buyer. Each order has two different profit graphs corresponding to the two delivery times.

Table-1

| Competitive Market | | | |
|---|---|---|---|
| Capacity Range | SVCT | SVC | Improvement |
| $C \geq 440$ | 1659 | 1188 | %39.6 |
| $440 > C \geq 292$ | 1530 | 1188 | %28.8 |
| $292 > C \geq 220$ | 1530 | 594 | %157.6 |
| $220 > C \geq 192$ | 1530-1448 | 594 | %157.6-143.7 |
| $192 > C \geq 146$ | 1448-1188 | 594 | %157.6-100 |
| $146 > C \geq 96$ | 702 | 0 | - |
| $96 > C \geq 70$ | 702-503 | 0 | - |
| $70 > C$ | 0 | 0 | - |

Table-2

| Monopolistic Market | | | |
|---|---|---|---|
| Capacity Range | SVCT | SVC | Improvement |
| $C \geq 440$ | 1659 | 1188 | %39.6 |
| $440 > C \geq 292$ | 1530 | 1188 | %28.8 |
| $292 > C \geq 220$ | 1530 | 594 | %157.6 |
| $220 > C \geq 192$ | 1530-1448 | 594 | %157.6-143.7 |
| $192 > C \geq 146$ | 1448-1188 | 594 | %157.6-100 |
| $146 > C \geq 104$ | 1157-852 | 0 | - |
| $104 > C \geq 96$ | 654 | 0 | - |
| $96 > C \geq 42$ | 654-315 | 0 | - |
| $42 > C$ | 0 | 0 | - |

## 5. Conclusions

This paper proposes a time dependent pricing mechanism to improve the performance of a system with a single supplier and multiple buyers where the supplier has a limited capacity. The supplier has all the system information, and generates the price menu through a two-stage procedure. The first stage is the preparation of triples for a competitive or a monopolistic market. These triples and the other system parameters are fed into the second stage as inputs. The supplier solves an optimization problem and prepares the price menu. A numerical example indicates that there is a strong opportunity to improve the profits of the supply chain. Furthermore, both parties can improve their profits in some cases leading to a win-win situation. As a further research, we plan to conduct a detailed experimental study to identify the potential savings under different problem characteristics and to develop an efficient solution method for the supplier's optimization problem.

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# APPLICATION OF THE BALANCED SCORECARD CONCEPT TO A LOGISTICS COMPANY

Adil Baykasoğlu[1], Vahit Kaplanoğlu[2]

## Abstract

*In this paper, an application of balanced scorecard methodology to an international logistics company is presented. Because of the complexity of work processes of the logistics company business performance can not be evaluated easily. In this application the balanced scorecard methodology is used to represent performance indicators of the logistics company from a number of perspectives such as financial side, customer side, internal business processes side and innovation and learning side and a business strategy map is developed accordingly. Activity based costing and business process modeling is used as the key techniques to initiate performance improvement actions. The implemented approach clarifies the vision and strategy of the company and paves the way for successful management actions of the company by giving feedback from internal business processes and external business effects.*

Keywords: Strategic Planning, Logistics, Balanced Scorecard

## 1. Introduction

In today's business environment companies compete with their business knowledge beside the financial forces and the amount of tangible assets. A few decades ago the amount of tangible assets and financial conditions of the companies were used to determine power. Companies are now shifting from industrial age competition to information age competition. No longer can companies gain sustainable competitive advantage just by rapidly deploying new technology into physical assets or by excellent management of financial assets and liabilities (Kaplan, & Atkinson, 1998). Due to the volatile nature of today's global businesses it is becoming imperative that organizations monitor their process performance, the performance of their supply chains and then align their processes to the strategic goals of the company (Fernandesa, et al., 2006). However, recent data suggests that only 5% of the workforce understand their company's strategy, only 25% of managers have incentives linked to their organizational strategy, 60% of organizations do not even link budgets to strategy, and 85% of executive teams spend less than one hour per month discussing strategy (Kaplan, & Norton, 2001). Because of inadequate understanding of business vision and strategies, new management techniques appeared during the last decades. The new techniques do not only include financial indicators of the companies, it also includes some other performance measures such as product and services quality, customer relationships, information technology usage, business process management, level of skills of employees etc. In other words the financial indicators have become one of the performance indicators among other performance indicators. These performance indicators highlight the objectives and strategies of the companies.

Logistics organizations pose to same conditions mentioned above. Usage of information, innovation and improvement has become unelectable concepts that must be given importance during the logistic organization management. Logistic organizations should use new management techniques in order to have an effective strategic management. Because of the complexity of logistics processes, applying new management tool and techniques is not a straight forward task. Balanced scorecard can be considered as an appropriate management tool which can be applied to logistics companies to formulate their strategic management plans. Phillips (2004) presented an application of balanced scorecard to public transportation for the appraisal of public transit system performance. Gehlen de Leao (2005) proposed a performance evaluation system for business logistics which is based on balance scorecard. Balanced scorecard has already been applied to several organizations such as hospitals (Atkinson, 2004; Sioncke, 2005), manufacturing companies (Gumbus, & Lussier 2006; Fernandesa et al., 2006) in the literature. However, there are not many reported application on logistics organizations. In this study balanced scorecard is applied to an international logistic company located in Gaziantep. In the following sections of the paper first an overview of balanced scorecard approach is given then the case study is briefly explained.

## 2. A brief overview of balanced scorecard methodology

Kaplan and Norton first introduced the balanced scorecard methodology in 1990 through one-year study of 12 companies (Gumbus, & Lussier, 2006). Balanced scorecard is a framework that measures a company's performance

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in an integrated way. It provides a formalized mechanism to achieve a balance between non-financial and financial results across short-term and long-term horizons and is based on the notion that companies have to aim at a true integration of marketing, production, purchasing, sales and logistics (Brewer, & Speh, 2000). The balanced scorecard translates mission and strategy into objectives and measures, organized into four perspectives: *financial*, *customer*, *internal business process*, and *learning and growth* (Kaplan, & Atkinson, 1998). The focus on only four areas forces managers to concentrate on the most critical measures. The balanced scorecard is a management system (not only a measurement system) that enables organizations to clarify their vision and strategy and translate them into action. It provides feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results. When fully deployed, the balanced scorecard transforms strategic planning from an academic exercise into the nerve center of an enterprise. (Arveson, 1998). In Figure one components of balanced scorecard are given. Each component (*financial*, *customer*, *internal business process*, and *learning and growth*) in Figure 1 has *objectives*, *measures*, *targets* and *initiatives*. Objectives define what the strategy is trying to achieve. Measures are used to monitor success or failure (performance) against predefined objectives. Targets define the level of performance or rate of improvement. Initiatives are key action programs required to achieve targets.

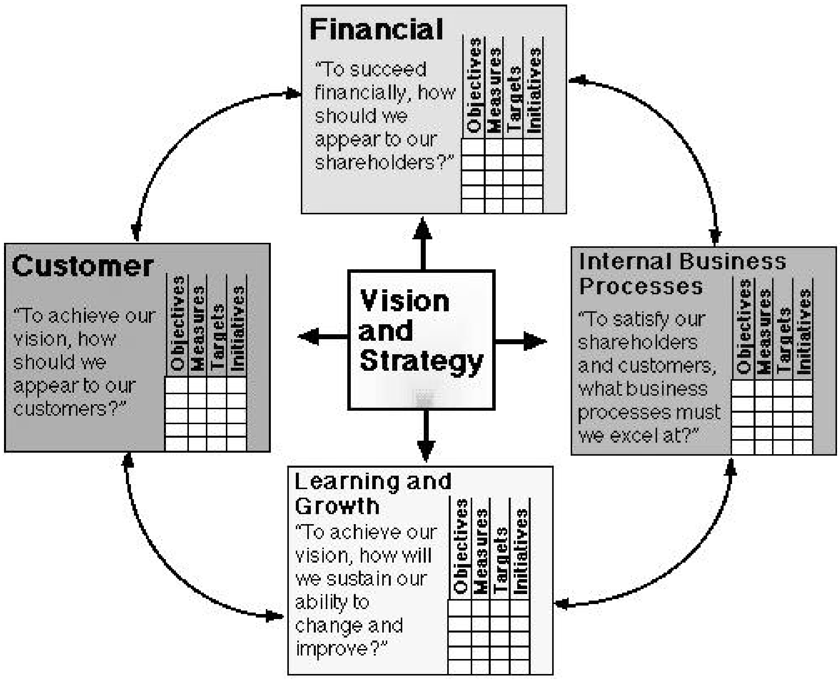



Figure 1. Balanced scorecard framework (Arveson, 1998)

## 3. The case study

A brief overview of the company: The logistic company which is the subject of the present case study is delivering logistical services to international markets. The main services of the company consist of export services from Gaziantep to European countries and import from European countries to Turkey. Transit services are also given by the company. The company is established at 1936. The company presented a sharp growth rate after year 2000. The company owns 122 trucks presently and it is presently one of the biggest logistics company in the south east of Turkey. Company's main operations consist of planning (truck assignment and organization, route planning, load consolidation etc.), customer relations/marketing, transportation (import, export and transit), warehousing, accounting, maintenance and support services.

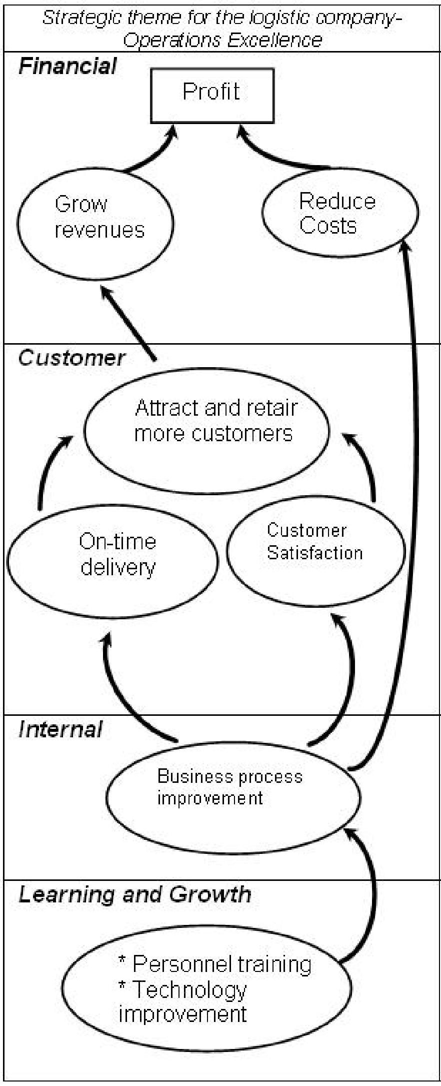
Vision and mission: The mission and vision statements of the company are reviewed with company management in order to better shape the companies strategies. The company management stated their vision and missions as follows:

Vision and target statements of the company: Logistics is one of the most important sectors in modern business environment. It is becoming more important with the increase of production and requirements on transportation of products to desired areas. With increased production and work improvement of our customers, we aim to enlarge and develop our service capacity. We aim sustained customer satisfaction by supplying online vehicle control service. We know what our customers will demand from the logistics sector in the future. Therefore, we aim to develop our work and be able to make competition with European companies. We also aimed to be the leader in the logistics sector by supplying integrated logistic services (warehouse, distribution, custom, insurance etc.) all over the world, giving better services than customer desires.

Mission statements of the company:

- Satisfying the changing needs of customers
- Providing new processes and optimizing the existing services
- Being leader at the logistics activities of international transportation in the region
- Increasing the variety of services provided to the customers (like warehousing, distribution, custom clearance, insurance)
- Providing sustained customer satisfaction by supplying safe, economic and fast

Based and the vision and mission of the company a strategy map which is based on the balance scorecard is developed by management after determining and over viewing the issues which are important to the company. A simplified abstract version of the strategy map for the company is shown in Figure 2.




| Perspective | Objectives | Measures | Targets | Initiatives |
|---|---|---|---|---|
| Financial | • Profitability<br>• Grow Revenue<br>• Reduce Costs<br>• Increase variety of services | • % Increments<br>• % Increments<br>• % Reduction | • 20 % Increase<br>• 30 % Increase<br>• 5 % Decrease | • Activity based costing<br>• Business process modeling |
| Customer | • Attract more customers<br>• On-time delivery<br>• Competitive prices<br>• Giving integrated services (insurance, loading-unloading, packaging etc.) | • Number of customers<br>• Lateness<br>• Competitor's prices<br>• Usage of internet services | • 15% growth<br>• No late delivery<br>• Lowest price in the region<br>• Increase number of customers who is served through internet | • Advertisement and more customer contacts<br>• Improving truck and related systems planning<br>• Better cost management through activity based costing<br>• Investing on network facilities<br>• Technology upgrade |
| Internal | • Eliminate non-value adding activities<br>• Better work assignment and balance | • Reduction of time for activities<br>• Labor utilization profiles<br>• Amount of overtime | • Reduce cycle time 25%<br>• Reduce amount of overtime 25% | Business processes modeling, process mapping and simulation |
| Learning and Growth | • Personnel training<br>• Adapting new technologies | • Training time per employee per month<br>• Time taken to finalize an accepted customer order | • Increase training time 20%<br>• Improve service time 20% | • Improving training programs<br>• Business process modeling |

Figure 2. Strategy map of the logistics company

Financial view: The financial perspective of management is mostly based on the profitability of the company. The prices in transportation are almost standardized. Target costs are almost known with certainty. There are some cost drivers which are mostly based on distance and target country. Therefore setting up prices is straightforward and they are mostly determined by business. In order to increase profits it is decided to focus on costs and customers. After many discussions and company audits it is figured out that the company has no detailed knowledge and control on its costs. It is decided to analyze service costing in detail in order to reduce costs which will probably lead to profit improvements. Activity based costing is accepted as the costing methodology. In order to implement activity costing based efficiently business process modeling is also carried out. The details of activity based costing which is also carried out by authors is reported and can be found in the following reference Baykasoğlu and Kaplanoğlu (2006). The results of activity based costing study has presented that there are many mistakes in setting up service costs and many improvement opportunities are realized. In order to increase profits the second concentration was on the customers. It is decided to increase variety of services given (like carrying parcel loads, giving special transportation services to different sectors like carpet sector etc.). A customer relations department is also formally established in order to professionally contact with customers. In order to achieve financial objectives activity based costing and business process modeling are considered as initiatives.

Customer view: Costumer satisfaction is critical in logistics sector. Based on the interviews in the company it is figured out that customer are very sensitive to on time delivery. The other parameters that directly effects customer satisfaction are cost, on time feedback to the customer about the status of his/her commodity, ability to give integrated services (insurance, loading-unloading, packaging, custom etc.). In order to attract more customers and improve customer satisfaction the company started to give several of its services through internet by enabling its customer to control their commodity on-line. All the trucks are equipped with modern vehicle control systems. New advanced logistics ERP software is implemented in the company and it is planned to run all business activities through this software in very near future. Several other software for route planning, truck loading etc. are also implemented. A local computer network within the company is also set up. All these investments improved the operations of company and in last two year company has doubled its number of customers and size.

Internal business process view: Internal business processes directly affect the cost structures of the services provided. For the present study it is figured out that internal business process has a direct impact on all other views. After discussions with management it is also figured out that new employee having lots of difficulties in understanding the work flow and work practices. Moreover the amount of overtime in the company was very high and employees were always complaining about long working hours. As internal business process has a critical role it is decided to develop a detailed business process model. A team which is composed of members from different departments and authors is formed to develop a business process model. A business process modeling software is used for this purpose the selected software has abilities for process mapping, discrete event simulation and process costing. The process modeling study is also reported in somewhere else can be found from the following references Baykasoğlu and Bartık (2005). A simplified version of the process map of the study company is presented in Figure 3. The process model gives us the opportunity to test alternative process configurations for cost reduction. After altering and improving some part of process chains some cost reductions are observed after simulation an example outcome is shown in Table 1.

Table 1. Process cost improvement

| | | | Present Process Simulation Results | | Modified Process Simulation Results | |
|---|---|---|---|---|---|---|
| *Periods* | *Resources* | *Activity Names* | Capacity Cost $ | Absorption Cost $ | Capacity Cost $ | Absorption Cost $ |
| Quarter1 | Personnel 7 | Submissions of Truck Documents for Import | 46 | 782 | 48 | 761 |
| Quarter1 | Personnel 11 | Customs Clearance Doc. Prep. for Export | 75 | 1.308 | 76 | 1.284 |
| Quarter1 | Personnel 9 | Preparation of Vehicle Bag for Export | 19 | 1.525 | 19 | 1.441 |
| Quarter1 | Personnel 2 | Vehicle and Driver Scheduling for Export | 58 | 1.695 | 58 | 1.634 |
| Quarter1 | Warehouse Costs | Warehousing for Export | 25 | 700 | 25 | 695 |
| Total | | | 223 | 6.011 | 227 | 5.815 |

Learning and growth view: The fourth perspective of balanced scorecard is based on the long-term growth and improvement of the transportation services of the company. Learning and growth perspective of balanced scorecard directly affects the internal business process view of the company. It is critical for the company that the employees can effectively used the software and hardware effectively in order to realize the benefits of its investments. Moreover the employees need to have all the necessary knowledge for business regulations as they change frequently. For that purpose a training program is established in the company. The benefits of the training program are realized very soon. After two months employee become very efficient in using the ERP software. The mistakes and rework in document preparation are decreased considerably.

## 3. Conclusion

In this paper an application of balanced scorecard to a logistics company is presented. It is figured out balanced scorecard can help to company in formulating its business strategy systematically. Activity based costing and business process modeling is also used during the study to better analyze cost and work flow within the company. The simplified versions of process model and strategy map are also presented in this paper. The work is still under progress and detailed results will also be presented some where else.

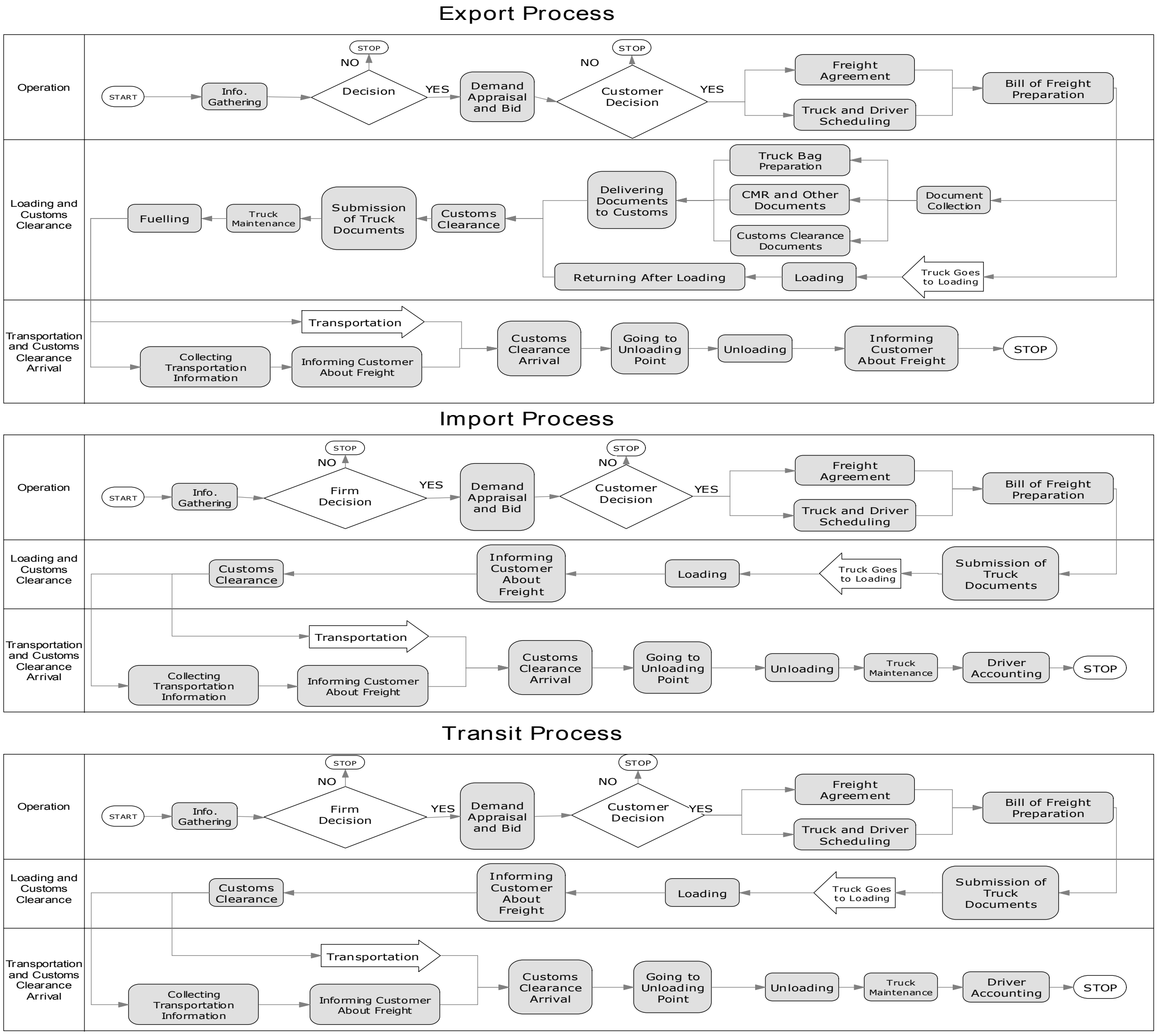



Figure 3. Business process model of the case study company

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# A LOOK AT THE STUDY OF SPACE TECHNOLOGY APPLICATIONS ON HEIGHTENED SECURITY NEEDS – AS PROJECTED WITHIN UNIVERSITY COURSE OFFERINGS ON LOGISTICS AND SUPPLY CHAIN MANAGEMENT

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Ayça CEZAYİRLİ[4], and Frank BATES[5]

## Abstract

*From the origin of man's study of space comes guidance on today's security matters – particularly as they impact and place burdens creating challenges for effective logistics and supply chain management activities. There is evidence that observations and experiences from space throughout the millenniums have inspired ways to enhance security and to minimize vulnerabilities while facilitating the teaching of logistics and supply chain management. Security issues that are being dealt with today strategists and planners responsible for the transport and safe-keeping of goods and the well-being of logistics services providers include that of the threat and response; global positioning systemization for remote sensing capabilities within passive and active RFID systems; software algorithms capabilities built into equipment to allow "intelligent" or "smart" decisions to be made in remote areas of operation; observation of earth for the forecasting and monitoring of natural disasters and of organize crime, as well as the armed threat of forces from an adversary; new communication techniques, small satellites for facilitating surveillance and communications; design and construction of logistics support structures; solar panel energy power generation; international cooperation in space activities through global sourcing processes and other such space-influenced initiatives.*

*Today as Turkey embarks on the procurement and contracting with satellite manufacturers for the oversight of the building and launching of its first military/defense satellite "priority program", there is the recognition that an opportunity may exist for university students to become familiar with important methodological processes dealing with the acquisition by Turkey of certain aeronautical and space technologies – the bases of which can include a look at such applications and their connection to security needs within logistics and supply chain management activities. With this relatively late focus on Turkey's expansion into space, there may exist an opportunity to capture further the students' imagination into another dimension – that of the exploration of space as a source of tools for dealing with security issues. Recognition of this opportunity may be the initial step toward the inclusion of these issues into the development of the university course offering.*

*Such a course would serve as a tool for teaching/training students to become familiar with the methodology for the appreciation of the global impact of space technologies as part of the logistics and supply chain program of study. It may further allow the student to gain insight about such programs and also may help to create more robust discussion and innovative thinking about development of the logistics and supply chain infrastructure. Such educated and trained students, during the course of their chosen career fields, may contribute by their seeking to be included in the planning sessions for collaboration on the security aspects of related projects – the objective being to find new ways to strategize Turkey's participation in the various logistics and supply chain management programs and thereby maximize returns to the country.*

Key Words: Educational Courses, Logistics Strategies, Innovation strategies, Technology transfers

## 1. Introduction

Globalization has brought about tremendous variations of interconnecting supply chains and their attendant logistics support systems that tie suppliers, customers and nations together. Unfortunately with this spread of diverse business relationships have also come an age of growing security threats and vulnerabilities to the chains and networks (Alexander and Gupta, 2004).

The attack on the World Trade Center towers on 9/11 brought about a tremendous growth of the technical security market. With concerns about dangerous material in passenger luggage to contents in the global

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transportation of containers, there have been significant and dramatic security improvements throughout the supply chain. Expenditures on security measures are expected to exceed $58 billion in 2007, a significant increase over that of the level of $17 billion spent in 2001 (Bates and Izmirli, 2006). The resulting security systems and tools were facilitated by technology-based computers, cell phones and other network connections.

These security measures have taken the form of secure identification cards for certain groups (federal employees and defense contractors) with a focus on law enforcement and surveillance at airports, sea ports and ground transportation centers (railway, bus and such). They also include: x-ray machines with smart complicated algorithms capabilities that constantly recalibrate during an interrogation and examination process to detect certain behaviors detected through observations and in response to subsequent questioning, and that are programmed as well as for the detection of weapons and components; equipment systems that incorporate the use of biometrics (face-recognition); machine-readable passports for border control to identify those with criminal histories or to detect immigration violations with access-control technology; explosion detector devices, radiation monitors, satellite capabilities tied to emergency alert systems; improved communication systems and networks for information sharing; data-mining programs; chemical, biological and radiological sensors, with the attendant global sourcing for members within the supply chain to achieve industrial participation and transfers of technology; and systems for analyzing intercepted communications and video surveillance.

Various technologies have been developed and deployed in support of threat reduction and minimization of risks. Many of these technologies were developed as part of earth-bound man's observations of space, dating back from 4000 years ago when, inspired by what they saw in the Heavens (outer space), Egyptian rulers built the Giza pyramids to protect and instill security for the 'afterlife' (http://news.bbc.co.uk/1/hi/sci/tech/1024779.stm).

Moving forward from the development of these security measures as influenced by space technology, there is an opportunity to look at the subsequent impact on logistics support systems and supply chain management; this may be reflected, in a novel but illustrative manner, by a look at certain social fabric and media outlets which may serve as a guide for demonstrating an origin from space-derived technology concept development – namely by looking at TV, movie cinemas and books that serve as part of the current popular culture.

For instance, illustrating the development of voice recognition software, in the Stanley Kubrick movie, "2001: A Space Odyssey", HAL, the human-sounding voice, seems to foretell the advent of sophisticated security access capabilities, using natural-sounding computer-synthesized voices for the security access to high-value storage of goods (Rice and Caniato, 2003).

In the movie, "Fahrenheit 451", a television addict considers the TV actors to be her family relatives. Today, people use TV screens and computer monitors for online video chats, video conferencing, and webcams. Military and security personnel use this technology to maintain communications through the use of video conferencing for command and control logistics dispatch centers (Flynn, 2005).

The 1980s TV show "Knight Rider," shows an actor driving a 'talking' automobile named "KITT" capable of performing defensive and security tricks. Today we are using talking GPS systems in our vehicles for vehicle guidance and real time decision support systems. Such portable devices make driving safer for transport operators (Finkenzeller, 2003).

The movie, "Minority Report" features a detective who is monitored by computers that scan the eye's retinas to ensure that his needs and wants are met. Biometrics can identify criminals and travelers. Fingerprint and eye iris scanners are being used by some security officials at airport security systems; cellphones and PDAs contribute to threat recognition to minimize vulnerabilities (Wong, McFarland, Zaharudin, and Agarval, 2002).

The 1976 movie "The Man Who Fell to Earth," shows a space alien on earth who develops new technologies, like that of today's digital cameras for instant images using memory cards and LCD displays and memory cards (Alien Technology, 2006).

In the 1971 Stanley Kubric film "A Clockwork Orange", the actor uses small cassette tapes while listening to the big sound of music. Today big sound and small media comes to us with the handheld MP3 players with great storage capacity for our favorite songs, videos and sounds with equipment that has been miniaturized due to the weight sensitivities of space travel (Hickman, Geradi and Feng, 1991).

Finally, "Doctor Who", the science fiction TV show has an actor that has a talking robotic dog that uses lasers in support of mobile and remote decision making requirements under difficult circumstances. This was commercially produced in a reality product by Sony's AIBO – a computer canine capable of reacting to human actions, and able to appear and act as a real dog (Penttila, Engels, Kivikoski, 2004).

Subsequently with the early day's of the space age beginning half a century ago and with a simultaneous impact of security needs upon globalization and the supply chain, there is a need to review the applications of the growing capabilities of space technologies that are dramatically changing how vulnerabilities of the logistics and supply chain management functions are being influenced and how risks can be managed (Anderson and Norman, 2003). Various media reporting and space-engaged organizations and nations have produced related studies showing new security issues and concepts that take note of the vulnerabilities and threats and the forecasting and monitoring of natural disasters and of organize crime, as well as of the armed threat of forces from an adversary. The propitious timing of the coming focus on such issues and concepts is now occurring when Turkey itself is embarking on the procurement and contracting with satellite manufacturers for the oversight of a priority program for the building and launching of its first military/defense satellite, whose main functions will be those of surveillance and communications (Arslan, 2005).

However, a review of both the academic and technology-oriented business literature reveals that very little has been written on the use or participation by the academic researcher on the deployment of space technologies attendant to the security needs of supply chains and logistics support systems (Blanchard, 2004). Given increasing pressures to maximize the returns to the recipient supply chain, academic and technical institutions and acquisition planners and personnel need to be creative and find new ways to aggressively achieve the security goals of information, equipment and training/know-how for starting up new production/manufacturing activities and for vital on-going logistics support (Brindley, 2004).

Thus the rationale for this research work is to provide an input to the growing need for the better understanding of how recent developments in space technologies are being adapted to address the dimensions of security needs that involve communication and observation, early warning and surveillance, threat definition, interdiction and risk management within the supply chain. A further goal of this paper is to explore the academic institution offering logistics and supply chain management studies as a supporting player for the technology transfer program. It is suggested that academic management professionals can utilize these features within the teaching of the university courses as part of their educational commitment to their students to add value to their service offerings. And as strategic managers observe some of those issues facing security program planners within the globalized business environment, they more interestingly in class may better understand how space technologies have and will continue to contribute to the challenges of the 21st century supply chain.

## 2. Regional Security and Defense Planning

In 2004, the General Director of the Turkish Aeronautical Association (THK) announced that Turkey could launch a spacecraft on its own if the necessary coordination were provided, and that a launch site with an embarkation platform could be stationed in Turkey's Mediterranean region. Informing the public on renovations and improvements taking place at the THK institution, the General Director indicated the intention for on-going planning to focus on space research. It was also noted that, at the time as recently as 2003, a Turkish-made satellite had been sent into orbit by the Russians; Turkey only needed a launch pad to send a Turkish-designed spacecraft into space: "Our personnel are well trained. The THK could launch a spacecraft into orbit within 10 or 15 years with good coordination and preparation…". The announcement further indicated "…that the launch site should be established in the south of Turkey to save energy costs during a launch. The mission of such a launch would be in the areas of security and communications" (Arslan). Today, Turkey is engaged in significant national procurement activities and is being courted by the largest names in space technologies (Boeing, Lockheed Martin, Northrup Grumman Corp, LM Ericsson, Raytheon, etc.) – an opportunity may exist to impress upon planners the role of security and space technologies in these activities

There would appear to be movement for the subject of space technology transfers to be included in the planning sessions for international industrial projects and for major acquisition and procurement programs involving security within logistics activities and supply chains (Christopher and Lee, 2001). This is being observed in several countries and regional sites that allow an understanding and participation in these processes that may prove to be integral to global industrial programs (Closs, 2004).

How to structure the bases for these perceptions on the study of security issues, space technology and the supply chain could best be approached by studying the nature of such technology transfers and the likelihood for these subjects to be included within the university programs of instruction. One of the most likely areas for the study of technical transfers is that of logistics and supply chain management, where related activities are covered, i.e., make-or-buy, outsourcing, source management, impact of security measures on logistics and supply chain management costs, etc. A description of the technologies to be transferred and the circumstances of the security effectiveness on risk reduction and minimization of vulnerabilities in terms of the market forces at the time can be studied.

Moreover, it is increasingly evident from the literature review that developing successful and productive technical transfers tied to industrial development programs can be help achieve differential advantage for the logistics activities for involved companies and their supply chains.

### 2.1 Space Technologies and Security Issues Fit into the Supply Chain

From the Council of Logistics Management (www.Clm1.org; Cooper, Lambert and Pugh, 1997): Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies.

Supply chains can be generally regarded as the pathway of events and activities reaching from the supplier's supplier or subcontractor to the customer's main customer (Hewit). The members of the chain are required to synchronize efforts, initiate cost and schedule savings through continuous improvement (Lambert, Emmelhainz and Gardner, 1996). Once the supply chain includes a member whose potential for economic development is established, management of the chain, overtime, will result in savings and greater efficiencies (Stevens, 1989).

### 2.2 Technology Transfers Brought About by International Collaboration

The recognition that opportunities may exist for Turkey to engage in certain global networks utilizing space derived technologies for the purpose of advancing its standing and competitive advantage, in the areas of entrepreneurship, innovation and competitiveness, is serving academic interests in the development of university course offerings in logistics and supply chain management, outsourcing and procurement (Christopher and Lee, 2001). Such a course serves as a tool for teaching/training students on the evaluation and achievement of such relationships by illustrating the important role in the continuing development for cross border cooperation – which drives the logistics management student to a working understanding of the need for collaboration, planning, forecasting and replenishment (CPFR) activities within the chain. One of Turkey's universities, the Izmir University of Economics, has undertaken to tie its logistics educational services development activities to the teaching and training of students about certain logistics support strategies – namely enhancement of supply chains in view of changes and challenges being brought about by globalization – in its efforts to build consensus on the acceptance of this strategic study approach. Related issues would also be covered, as the priority placement of infrastructure development projects, regulations/laws, policies, approval processes, build-operate-transfer (BOT) schemes, privatization goals, strategies involving buy back, insurance, outsourcing, make vs buy-back initiatives, targeted space derived technologies, certain industry sectors, status of Turkey's recent industrial issues and related supply chain and logistics management issues (Gershenzon and Gershenzon, 2006).

With this opportunity for using these initiatives, Turkey may seek to achieve further development as a world class technological and innovation center, supported by academic programs that focus on such initiatives that may help build interests and infrastructure for further discussion and innovative thinking about supply chain management issues, as well as provide an early look at how globalism and security threats and vulnerabilities are re-shaping the world. This may be an effective way to provide opportunities and services to the student by demonstrating national efforts to achieve competitive advantage (Geary, Childerhouse and Towill, 2002). Following the lead by other developed countries that have chosen to involve such an academic tool in their study programs, the researchers feel that such educated and trained students may contribute to national objectives by their seeking to be included in the planning sessions for participation and collaboration on such development programs that can be studied via logistics and supply chain management principles – the objective being to find new ways to strategize national goals (particularly Turkey's fit) into such global chains and thereby maximize returns to the country.

At the same time academia and educators are seeking to successfully and realistically integrate (in real time) current events into the class study of globalization and supply chain management; the attention being placed on Turkey's satellite launch program conveniently serves as a learning platform (Gershenzon and Gershenzon).

Long studied as a key to gain competency and efficiency, organizations engaged in supporting industrial technologies are trying to strengthen their supply chains to overcome communications adequacies (Rybeck, 2001). These developments are driven by the needs of the supply chain members to communicate via internet based systems, thereby allowing them to share information, adjust demand projections – almost in real time – in response to demand changes (Wight, 2005). This capability for updating the status of various integral factors, such as inventory levels, demand forecasts, HR development, partner relationships, customer relationship management, service loads, communications and information technology (IT), transportation and freight cost options has allowed the chains' members to gain visibility on the operations, improve turnover, reduce administrative costs, shorten planning cycles, improve customer service, reduce working capital and improve sales and revenues (Hewit, 1994).

In exchange, the members have had to adapt to 'global' systems and to agree to the sharing of once considered sensitive cost data and information, and to understand the IT to be deployed that would make all this possible (Ghisi and da Silva, 2001). This concept has become recognized as "CPFR", i.e., collaboration, planning, forecasting and replenishment (refer to Figure 1 CPFR View).

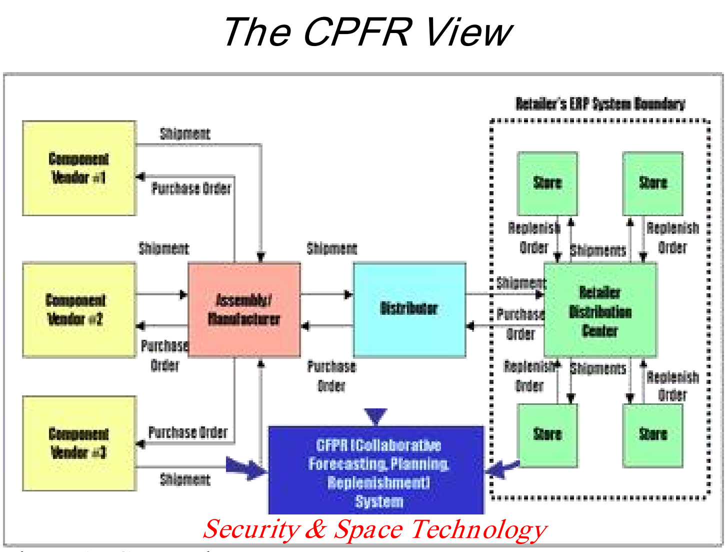


Figure 1. CPFR View
(Source: Adapted from http://www.cpfr.org/ProcessModel.html)

Another version of the CPFR model for supply chain applications may be better portrayed with greater definition of the affected function is portrayed in Figure 2, End-to-End Supply Chain Applications for Space-Derived Security Technology.


Figure 2. End-to End Supply Chain Applications for Space-Derived Security Technology
(Source: Adapted from http://www.cpfr.org/ProcessModel.html)

By these concepts, supply chain members are able to communicate and collaborate via the net system – in response to demand changes and goals for reducing risks, threats and vulnerabilities, thereby having capabilities for updating database networks by use of a common platform (Rybeck; CSI, Container Security Initiative, 2002).

## 3. Academic Program for the Study of Technology Transfers

Much international business is being taught at academic institutions (Lee and Wolfe, 2003; Murphree, 2002). An added feature is the training of procurement and technology staff from both the public and the private sectors on the valuation and acquisition of certain technology transfers (C-TPAT, 2004). From a review of the syllabus for the Logistics and Supply Chain Management courses being offered, the researchers are able to review the elements within the course offering that may lead to an appreciation of the tasks at hand necessary to master dealing with the study of security threats and vulnerabilities in logistics and supply chains with space derived technology transfers (Harland and Benchley, 2001; Haywood, 2002).

Those elements include the definition of space technology transfers, security applications, rationale for using it, how to value it in terms of threats and vulnerabilities, potential challenges and several examples (Monahan and Snow, 1986; Monczka, Trent and Handfield, 1990).

### 3.1 Definition of Space Technology Transfer

A technology transfer is what one does and/or has access to. The transfer is what is given; it is the offering of manufacturing know-how and ability. What does one do? Most likely the activity involves the manufacturing and system integration of aircraft, automobiles, naval ships and major related components. Integrated logistics support, security issues, management of risk and anything that involves any related sectors of the economy (Lindroth and Norman, 2001).

The form of the technology transferred includes computer generated files of:

- blue prints
- drawings
- processes descriptions
- manufacturing routings
- work packages
- systems specifications
- licenses
- training
- education
- operation manuals/books
- suppliers' technologies
- source codes

The recipients maybe in-country partners, allied divisions, colleges or universities, governments and other companies; tech transfers may be directly related or can be unrelated to the product or system being sold and can fall into several categories:

- Training
- Grants to industry or government
- Sub-contracts to customer's industry – added to and become part of the supply chain
- Equity investment in local companies
- Licensing arrangements
- Co-production / co-development
- Marketing assistance
- Anything of value to the customer or to local industry

In efforts to manage the acquisition costs of the programs, there have been movements to contain or otherwise avoid high development costs by using components off the shelf (COTS); this feature of the components is known as dual use, thereby permitting usage on different systems (Niemeyer, Pak and Ramaswamy, 2003).

### 3.2 Examples

To assess the real value of the space technology used in security threat and vulnerability programs, the value can be based on output only – this may cause an increased cost to the domestic company, the recipient of tech transfer (Oliver and Webber, 1982).

One example follows: THY receives tech services from USA/Boeing in exchange for Turkey purchase of airplanes. The seller must provide intellectual property and support THY in export markets. THY accepts and awards the value of, say, 50% of development cost. The transfer may also provide characteristic of "Dual Use" technology for a military defense security program as well.

## 4. Research and Findings

### 4.1. Review Questionnaire Survey Form

The scope of this study is a descriptive study. It is designed to form some general observations for the purpose of this report and to offer new ideas for further researches. The participants of the survey were asked some questions subject to security, supply chain management and space-derived technologies. The samples are chosen from the university academics teaching in Izmir University of Economics. The characteristics of the population were not taken in to consideration while determining the number of the sample; as a result the convenience sampling method is used. The quick survey questionnaires were personally administered to the 30 instructors at the university. 21 of the respondents were female (72.3%), and 9 of the respondents were male (27.7%). The data was collected during the last week of September and first two weeks of October 2006.

### 4.2. Findings

Findings explore that 38.8 % of respondents do not cover any type of security issues in their courses. Only 27.2% of the rest of the respondents that emphasize security problems were related with information safety. Other security subjects mentioned in the classes were about business contracts, military quarrels, job security and security needs. In addition, it is shown that 27.7 % of the respondents were agreed on the security limitations of the school especially at nights, and also the same percentage were concerned about the security of their information gathered in their computers. Moreover, some instructors suggested that new technologies should be transferred to prevent information theft which they have had faced before.

The research also seeks to determine the instructors' knowledge about supply chain management from different specialization areas to be able to ask their opinions about the importance of security in the supply chain process. Related to this, 77.7% of the instructors responded that they have some levels of knowledge about supply chain management. Table 1 below summarizes the levels in terms of knowledge degree. Moreover, it can be said that almost all instructors emphasize the importance of security the flow of network in the supply chain process.

Table 1: Table of knowledge level of SCM – with response rates in groups

| Responses to Survey Questionnaire: | Counts | % |
|---|---|---|
| High | 10 | 33.3 |
| Medium | 5 | 16.6 |
| Low | 11 | 36.6 |
| None | 4 | 13.3 |

Depending on the findings that only 4 of 30 instructors do not have any idea about the supply chain management concept, they were all teaching courses in International Relations and European Union fields.

Furthermore the survey results indicate that 45.4% of instructors who covers security problems in the lessons also mentioned some of the space-derived technology applications on security issues. In addition to commenting on past technical transfer experiences and involvement of academic institutions, the review reflects that a university study course that includes instruction on the transfers of technology can be effective for the student of business and logistics and supply chain management as they become participants in such international deals by understanding and mastering the application of information and services in relation to certain strategies and tactics, as portrayed in Table 2: Risk Avoidance and Minimization of Vulnerabilities – Strategies and Tactics.

Table 2: Risk Avoidance and Minimization of Vulnerabilities – Strategies and Tactics

| Strategies/Tactics | Strategies/Tactics |
|---|---|
| export counseling, international / domestic training activities, marketing information, trade leads, technical assistance | financing assistance, advocacy, coordination with authorities, development of equipment preventative maintenance plan, import/ export issues, tech transfers to candidate partners |

From a macro perspective, the implications for the inclusion of the academic course into the learning process for those dealing with space derived technical transfers and their impact on logistics and supply chain activities may be far-reaching and powerful with a high impact on the nature of cost-benefit analyses involving procurement planning source selection, transportation, material handling decisions and related activities in Turkey.

This research will have some limitations related to the restricted sample size of 30. On the other hand, this study may constitute and serve as a base for further research efforts with larger sample sizes. For instance, ways the space-derived technologies can be transfer and their relative effectiveness on the process may be analyzed in future research work.

## 5. Conclusion

In conclusion, the modeling of the academic course and its benefit to those who will deal with security and threat vulnerabilities in mind to study logistics and supply chains can be a useful and beneficial way to demonstrate how a buyer can acquire needed security and defense equipment and services while gaining important progress in its own security, technological development and industrial development goals (Peck 2005; Peck and Juttner, 2004). Countries that need to gain new market access and shares have the option to achieve them through programs that are influenced by space derived technologies. Security and defense programs are growing in frequency and size yet research shows that many schools have not yet tried to use the academic course training program as an innovative ingredient to their academic research and training programs. Involvement of the academic institution offers a number of advantages, as reflected above (Rustam, 2006). Specifically, it may be a useful process in the technological goals and objectives. To some companies, it may have applications in the providing of information on export counseling, market analyses, modes of transport, material handling procedures, import and export issues and coordination of options taken in these areas with the customer.

Generally, the real purpose of technology-based security systems is to help the company to begin to successfully manufacture and integrate system technology and to grow their business in a threat-free and vulnerability managed environment (Wendel and Norman, 2002). New supply change networks are being developed and are competing against older established value streams in search of competitive advantages and fulfillment of technological acquisitions and performance obligations; with the inclusion of the academic institution into the technical transfer processes, an innovation may be created that will may better prepare the company, going forward, to successfully compete in such risk-managed programs (Svensson, 2002; Zsidisin, 2003).

Specifically, companies with extensive experiences are most apt to benefit from the use of an academic course on the risk management of threats and vulnerabilities (Wilson and Drea, 2002). While not a panacea to every specific difficulty that exists, the results of this approach suggests that there are specific advantages to be gained by the offering of an academic course on the transfer of technology as a facilitative factor within that of a logistics and supply chain management program. Defense and technology planners and strategy managers who have not examined this tie-in involvement may be overlooking an opportunity to engage in more effective and rewarding business operations. Additionally, the business planner – through support from an academic course on technology transfers – and those corporations committed to minimize risks and who are engaged in the reduction of security threats and vulnerabilities will want to carefully coordinate their activities if the country is to derive the greatest benefits from these programs.

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# DETERMINING THE NUMBER AND THE LOCATION OF RETURN CENTERS IN A SUPPLY CHAIN WITH GENETIC ALGORITHM

Ergün Eroğlu[1], Melek Candan Atasoy[2]

## Abstract

*Product returns have been viewed as an unavoidable cost of doing business, losing any chance of cost savings. Due to this reason, a growing number of firms have begun to explore the possibility of managing product returns in a more cost-efficient manner and they have set up their return centers. Return center location decisions represent an important aspect of strategic planning for supply chain management. The problem is to determining the number of return centers and the locations of them. For this problem, a genetic algorithm based heuristic approach has been composed to optimize the number and the locations of return centers and it is tested in a few supply chain network problems.*

Keywords: Genetic algorithms, Location-allocation, Return centers, Reverse logistics

## 1. Introduction:

Companies have to manage their supply chains effectively in order to survive under today's global competition conditions. The movement of goods from sourcing sites to customers through production facilities, distribution centers (DCs), retailers etc. must be done efficiently and effectively in today's competitive environment. And this merely depends on strategic, tactical, operational decision making activities.

Product returns have been viewed as an unavoidable cost of doing business, losing any chance of cost savings. Due to this reason, a growing number of firms have begun to explore the possibility of managing product returns in a more cost-efficient manner and they have set up their return centers. Return center location decisions represent an important aspect of strategic planning for supply chain management. The problem is to determining the number of return centers and the locations of them.

Location decisions have a considerably important place from strategic level to operational level in a supply chain. Location of return centers is one of the key issues of Reverse Supply Chain and a key component of a logistical system. In determining where to locate the return centers, the companies want them to be close to customer locations so as to minimize the transportation and the other costs. The problem is to determine how many return centers to set up, where to locate them, how to serve the customers using these return centers.

A supply chain is a network of facilities and distribution options that perform the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers with warehouses and retailers. Supply chains exist in both manufacturing and service organizations, although the complexity of the chain may vary greatly from industry to industry and firm to firm (Ganeshan & Harrison, 1996).

Reverse logistics is a promising research area in supply chain management and operations management. The American Reverse Logistics Executive Council defines Reverse Logistics as "The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers and Tibben-Lembke, 1998). A reverse logistics supply chain is represented in Figure 1.

Reverse logistic is related to the process of recycling, reusing and reducing the material, i.e. goods or materials that are sent "backwards" in the supply chain. The issues faced in reverse logistics are not just the "reverse" issues of a traditional supply chain; they can be more complex, as for example, aspects related to the transportation and disposal of dangerous materials.

During the last decade, the interest in reverse logistics has grown increasing attention from both academic researchers and industrial practitioners. Especially large-scale businesses are concerned with the optimization of the location and the capacity of their facilities, as well as the product flows between them (Lieckens and Vandaele, 2007). On the other hand, public pressure on reducing the environmental impacts of industrial operations has resulted in setting non-flexible standards and penalties for environmentally intensive industrial operations (Corbett and Kleindrofer, 2001). Additionally; in recent years - mainly due to social concerns for the environment - the term reverse logistics has gained greater relevance in waste management (Bautista and Pereira, 2006).

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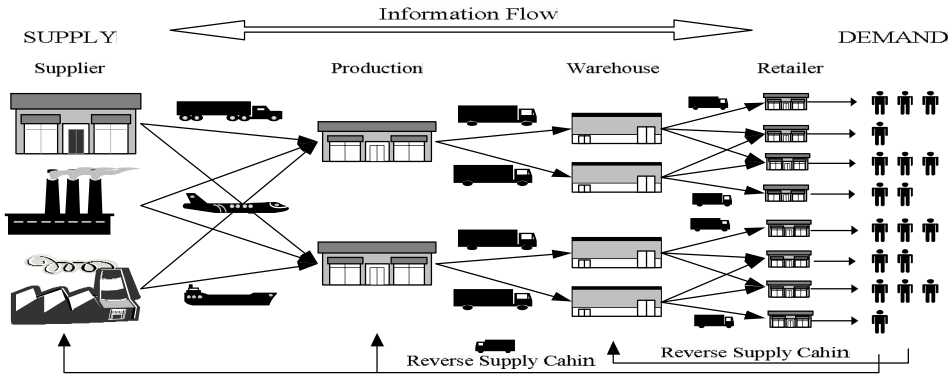


Figure 24. A reverse logistics supply chain

However, one of the main difficulties associated with implementing reverse logistics activities is the degree of uncertainty in terms of timing and quantity of products. Thus, managing return flow usually requires a specialized infrastructure and relatively high handling cost and time (Ko and Evans, 2007). Still, the high level of uncertainty in this field also applies to network design (Lieckens and Vandaele, 2007. That is why, researchers focus on the planning and optimization of reverse logistics systems for an efficient network design.

In this study, our goal is to determine the optimal network design of supply chains. Network design means a geographic outline of the logistics system with capacity, location of the return centers and flows within this system and the system can be submitted as a location-allocation or a facility location problem.

In the published literature, there are several studies about location problems. Factor qualification systems (Eilon, 1982), gravitational methods (Buckley, 1987), linear programming techniques with exact (Sweersey and Thakur, 1995), statistical methods (Fuente and Lozano, 1997; Giddings, Bailey and Moore, 2000) or heuristics (Hansen et al., 1994). Bloemhof-Ruwaard et al.1 present a two-level distribution and waste disposal problem. Barros et al.2 describe a network for recycling sand from construction waste and propose a two-level location model to solve the location problem of two types of intermediate facility (Lu and Bostel, 2007). In the same year, Marin and Pelegrin3 propose a factory location model (Salema and Novais, 2005). Jayamaran et al.4 propose a 0-1 mixed integer-programming model to solve the problem of the location of remanufacturing/distribution facilities and to optimize the quantities of remanufacturing, transshipment and stocking of remanufactured products (Lu and Bostel, 2007). Ammons at al.5 propose a mixed integer-programming model, which is applied to the determination of a reverse production system strategic infrastructure. Fleischmann et al.6 proposed a linear model for the location of reverse logistics facilities (Salema and Novais, 2005). Shih7 proposes a model to tackle a recycling network of electrical appliances and computers in Taiwan (Lu and Bostel, 2007). Le Blanc et al.8 study the problem of redesigning a recycling system for LGP-tanks. Jayamaran et al.9 propose a model for the design of reverse distribution networks. Salema study the problem of designing simultaneously the forward and reverse networks (Salema and Novais, 2005).

## 2. Mathematical Model of the Location-Allocation Problem

Mathematical optimization models are widely used for location allocation problems. These models contain the linear programming, integer linear programming, non-linear 0-1 mixed integer programming. The notation and the mathematical model of the location-allocation problem are given below. The problem in this study is at what places the return centers are to be constructed and from which customer locations (cities) to which centers (cities that have return centers) the out-of-ordered goods are delivered such that the overall costs are minimal. The notations and the mathematical model of the problem can be formulated as follows:

$J = \{1, 2, ..., m\}$, set of customer locations, indexed by $j$

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$I = \{1, 2, ..., n\}$, set of return centers, indexed by $i$

$IC_j$, installation cost of locating a return centers at candidate site $j \in I$

$d_{ij}$, distance from return centers to all cities

$P_j$, population of the cities

$$Z \min \left( \sum_{i=1}^{n} IC_j + \sum_{j=1}^{m} \min_{l=1:n} \{d_{ij} * P_j / 1000\} \right)$$

The objective function minimizes the sum of return center location cost, we say installation cost of locating a return center, and the transportation costs. The customer demands fully assigned to nearest opened return center.

## 3. Genetic Algorithm

Genetic algorithm, based on mechanism of natural selection and natural genetics, is a stochastic search and optimization technique. It was proposed by Holland (Holland, 1975; Goldberg, 1989; Reeves, 1995) and has been successfully applied to solve many combinatorial optimization problems. GAs are adaptive metaheuristic search methods premised on the evolutionary ideas of natural selection by employing a population of individuals that undergo selection in the presence of genetic operators. The biggest difference with other meta-heuristics (e.g., Tabu search or simulated annealing) is that GA maintains a population of solutions rather than only one current solution (Li, Chen, and Cai, Article in Press, Accepted, 2004). GA starts with an initial set of solutions called population. Each individual in the population is called a chromosome, representing a solution of the problem. A population of solutions is evolved to a next set of solutions through genetic operators such as selection, crossover and mutation. In GA, the idea is to get a new population with better desired characteristics than the previous. One of the critical problems in GA is to determine the encoding structure of the problem. The steps of GA are as follows:

```
Step 1. Generation of initial population
Step 2. Evaluation of each individual
Step 3. Selection
Step 4. Crossover
Step 5. Mutation
Step 6. If stopping criteria is not met return to Step 2
Step 7. Select the best individual as a final solution.
```

## 4. Application

In this section; a location-allocation problem, which have 30 candidate cities for return centers, seen in Figure 2, is solved using GA approach. Matlab 7.0 is used for GA coding system. The coordinates of the cities are given in Table 1. The problem is to find the number of return centers and to select the appropriate return center locations out of the candidates, and assign the customers to facilities to minimize the sum of facility installation cost and transportation costs, under the constraint that all customer demands have to be met. A set of customer locations that are also candidate return center locations with known demands are given. Demands of the cities are considered as the demands. To locate a facility at a candidate location requires a fixed installation cost; also there is a unit transportation cost between each candidate facility location and each customer location.

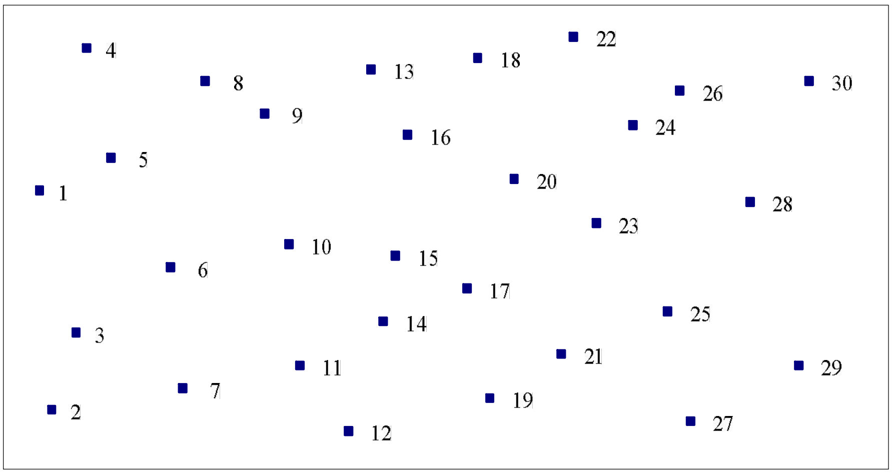


Figure 25. Customer locations (candidate cities) for locating return centers

Table 3. Data related to customer locations

| Cities | C1 | C 2 | C 3 | C 4 | C 5 | C 6 | C 7 | C 8 | C 9 | C 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *x*-value | 4 | 5 | 7 | 8 | 10 | 15 | 16 | 18 | 23 | 25 |
| *y*-value | 27 | 7 | 14 | 40 | 30 | 20 | 9 | 37 | 34 | 22 |
| *IC* | 40 | 40 | 50 | 60 | 50 | 60 | 50 | 40 | 40 | 50 |
| $N(*10^3)$ | 120 | 170 | 320 | 370 | 270 | 520 | 270 | 170 | 120 | 210 |
| Cities | C 11 | C 12 | C 13 | C 14 | C 15 | C 16 | C 17 | C 18 | C 19 | C 20 |
| *x*-value | 26 | 30 | 32 | 33 | 34 | 35 | 40 | 41 | 42 | 44 |
| *y*-value | 11 | 5 | 38 | 15 | 21 | 32 | 18 | 39 | 8 | 28 |
| *IC* | 60 | 60 | 60 | 60 | 60 | 40 | 40 | 40 | 50 | 60 |
| $N(*10^3)$ | 420 | 470 | 370 | 370 | 770 | 120 | 120 | 170 | 320 | 670 |
| Cities | C 21 | C 22 | C 23 | C 24 | C 25 | C 26 | C 27 | C 28 | C 29 | C 30 |
| *x*-value | 48 | 49 | 51 | 54 | 57 | 58 | 59 | 64 | 68 | 69 |
| *y*-value | 12 | 41 | 24 | 33 | 16 | 36 | 6 | 26 | 11 | 37 |
| *IC* | 50 | 50 | 40 | 50 | 50 | 50 | 50 | 60 | 50 | 40 |
| $N(*10^3)$ | 270 | 220 | 170 | 320 | 320 | 180 | 220 | 620 | 270 | 70 |

Generation of initial population

A set of initial solution is the starting point of the evolutionary process. In this study, we use binary encoding to indicate the individuals of the initial population,. The initial population is randomly assigned. To compose the initial population we use mxn matrix, where m shows the number of individuals (population size) and n shows the number of return centers (candidate cities). A chromosome (string) is composed of genes. The structure of the initial population is shown in Figure 3. Here, 1 (one) represents that a return center is located and 0 (zero) represents that a return center is not located (allocated).

| Individuals | 1 | 2 | 3 | 4 | 5 | . . . | 29 | 30 | Number of Ret. Centers |
|---|---|---|---|---|---|---|---|---|---|
| Individual 1 | 0 | 1 | 0 | 0 | 1 | . . . | 0 | 0 | 13 |
| Individual 2 | 1 | 0 | 1 | 0 | 1 | . . . | 1 | 0 | 9 |
| Individual 3 | 0 | 1 | 0 | 0 | 0 | . . . | 1 | 0 | 5 |
| Individual 4 | 1 | 1 | 1 | 0 | 0 | . . . | 1 | 0 | 14 |

Figure 26. The structure of the initial population (four individuals of the initial population)

## Calculating fitness function

Fitness is a criterion of the selection process. The larger the fitness is, the higher the probability of survival in the next generation. Fitness function in our model is considered as minimization of the total cost including installation cost of locating a return center to a city and the costs of transporting goods from customer location to a return center.

Installation costs of locating return centers of candidate cities are accepted different from each other and the distribution costs are defined as the distances from customer locations to return centers. If the population of a city is considered as the demand of the retailer, distribution cost is calculated as the multiplication of distance between the warehouse and city and the population of the city. The code of calculation of the fitness value of each individual is given in Figure 4.

```
function fitness(population,distances,installationcosts);
for i=1:number of individuals '(rows)
   fitness(i)= population (i,:)* installationcost; 'binary chromosomes
   for j=1: number of genes   'warehouses candidates (columns)
      if population(i,j)==1
         fitness(i)=fitness(i);
      else
         fitness(i)=fitness(i)+min(nonzeros(population (i,:)'.*distances(:,j)));
      end
   end
   end
end
```

Figure 27. Calculation of the fitness value

### Selection mechanism

The purpose of parent selection in GA is to offer additional reproductive chances to those population members that are the fittest. One commonly used technique, the roulette-wheel-selection (Ip et al., 2000), is used for this proposed GA.

### Crossover

Crossover is the most important operator in GA applications. The crossover is the main operator used for global searches. The traditional crossover operator by selecting randomly genes from parent chromosomes creates new chromosomes (individuals). Many different types of crossover are mentioned in the literature. These are one, two or multi point crossover. The most useful ones are one point or two point crossover. In our GA approach, we use one point crossover with a probability of 0,5. In this type of crossover, chromosomes of the two parents are split into two (equal or unequal) halves each. Both the chromosomes are cut similarly. The halves are interchanged. Crossover operation is shown in Figure 5.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Individual 3 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| Individual 4 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| Offspring 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| Offspring 2 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |

Figure 28. Crossover operator

### Mutation

Mutation plays decidedly secondary role in the operation of GA. In artificial genetic systems, the mutation operator protects against such an irrecoverable loss (Goldberg, 1989: 14). Mutation arbitrarily alters one or more genes of a selected chromosome, by a random change with a probability equal to the mutation rate. In our model one point mutation is used with a probability of 0,20 and mutation is represented in Figure 7.

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Offspring | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| Mutated | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

Figure 29. Mutation operator-single transposition mutation

## 5. Results of the application

The problem of this study is solved using a genetic evolutionary process for four different case. These cases are as follows:

Case 1, the population of the cities is not taken into account and installation costs are equal to each other,
Case 2, the population of the cities is not taken into account and installation costs are different from each other,
Case 3, the population of the cities is taken into account and installation costs are equal to each other,
Case 4, the population of the cities is taken into account and installation costs are different from each other.

Installation costs of return centers are taken as different from each other for the reason that the rental prices are changing from a city to an other city.

All the results for the cases are given in Table 2. The distribution of the reverse logistic system for the case 1 and 3 is shown in Figure 7 and 8.

Table 4. The results for the cases (The number and the location off return centers)

| Case 1 - Population is not taken into account and installation costs are equal to each other | | |
|---|---|---|
| Installation Costs | Number of Return centers | Location of Return Centers |
| *IC* | 4 | 5, 14, 18, 25 |

| Case 2 - Population is not taken into account and installation costs are different from each other | | |
|---|---|---|
| Installation Costs | Number of Return centers | Location of Return Centers |
| *IC* | 4 | 3, 9, 17, 24 |

| Case 3 - Population is taken into account and installation costs are equal to each other | | |
|---|---|---|
| Installation Costs | Number of Return centers | Location of Return Centers |
| *IC* | 4 | 6, 14, 20, 28 |

| Case 4 - Population is taken into account and installation costs are different from each other | | |
|---|---|---|
| Installation Costs | Number of Return centers | Location of Return Centers |
| *IC* | 4 | 3, 8, 14, 23 |

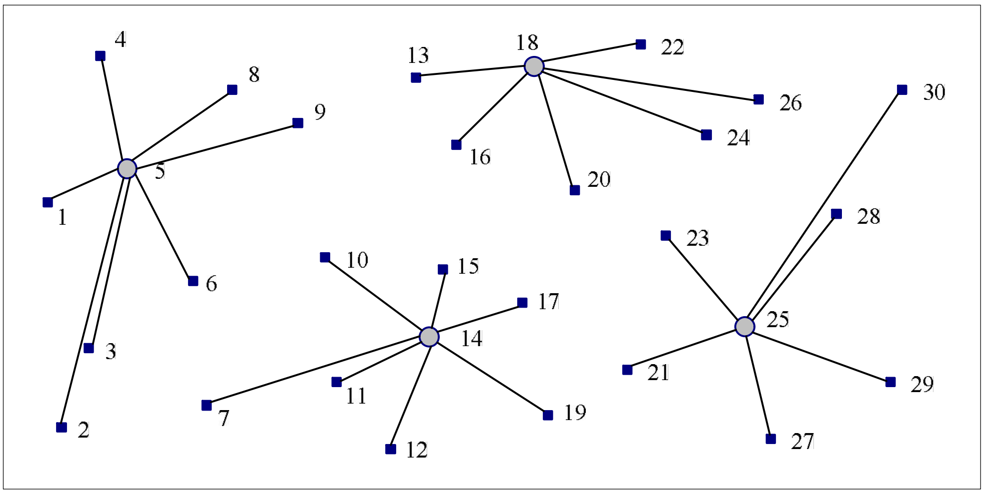


Figure 30. Representation of locations of return centers (for Case 1)

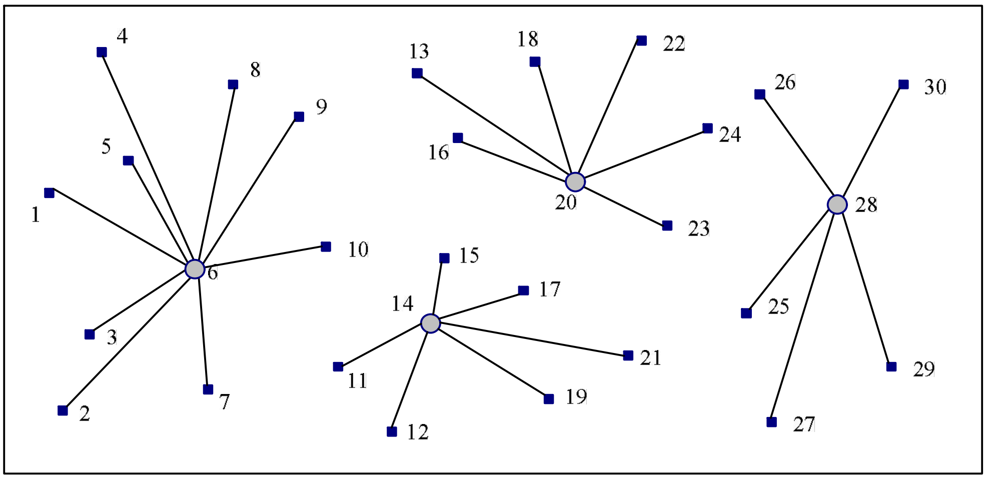


Figure 31. Representation of locations of return centers (for Case 3)

We also find the changes of the number of return centers with respect to different installation costs for the Case 4 using GA approach. If the installation cost for locating a return center to a place changes, the number of return centers change. Table 3 shows the change of the number of return centers with respect to different installation costs for the Case 4. In or GA approach, parameters given in Table 4 are used. The change in fitness value with respect to the number of iteration is seen in Figure 9.

Table 5. The number of return centers (for Case 4)

| Installation Costs | Number of Return centers | Location of Return Centers | Fitness Value |
|---|---|---|---|
| *IC * 4* | 1 | 17 | 757,3183 |
| *IC * 1,5* | 2 | 10, 23 | 549,2657 |
| *IC * 1,1* | 3 | 5, 14, 23 | 506,2743 |
| *IC* | 4 | 3, 8, 14, 23 | 487,9976 |
| *IC/2* | 6 | 3,8,14,20,25,28 | 378,1961 |
| *IC/3* | 9 | 3,5,12,15,16,20,24,25,28 | 314,7106 |

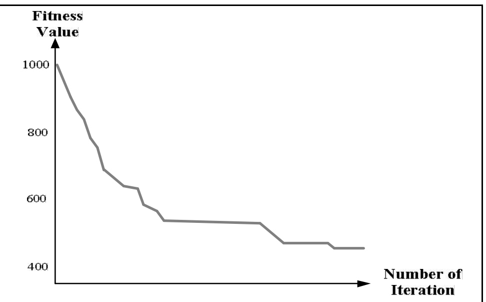


Figure 32. Representation

Table 6. GA parameters used for the problem

| | |
|---|---|
| Crossover rate | 0,50 - 0,75 |
| Mutation rate | 0,10 - 0,20 |
| Number of iteration | 1000 - 5000 |
| Size of the population | 20 or 30 |

## Conclusion

In this paper, we propose a GA approach to solve the location allocation problem. One of the main assets of this research is to explore the use of GA in location allocation problems which has the targets of minimizing total transportation costs. By using this approach, we achieve the results in a little time. But, the larger the problems (the larger candidate cities) the higher total processing time.

If the results are examined you will obtain these information. If the population is not taken into account for equal installation cost, we locate four return centers to candidate cities with number 5, 14, 18, 25. If the population of the cities are taken into account, the location places slides toward the cities that have big populations. On the other hand, if the installation costs are different from each other, the number of return centers change and the location places slides to cities which have lower installation costs (low rental prices).

It has been seen that, the number of return centers are increased as the installation cost is decreased as shown in Table 3. The number of return centers is defined according to the level of installation cost. If the installation cost for locating a return center to a place changes, the number of return centers change. A company may locate more return centers to different customer locations if the installation cost is decreased.

If decision makers obtain more realistic values for the reverse logistics return centers for the real installation costs and the distribution costs this model can be more useful for determining real locations.

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