



**SUPPLY CHAIN CHALLENGES AND STRATEGIES OF  
A GLOBAL PAPER MANUFACTURING COMPANY**

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Valajärvi, my weekend home, May 2009

Pekka Koskinen

## **ABSTRACT**

This research work describes a supply chain strategy and its implementation in a global paper producing company with a strong presence in Finland. The overall research work consists of four individual articles, which have been published in three international journals.

The starting point of the research was based on real life observations of the case company's supply chain's operational challenges. After the real life observations the strategic aspects of the supply chain management in the case company were analyzed. Special attention was devoted to the interaction between the corporate and supply chain logistics strategies. The supply chain strategy implementation was then measured by the lead times of the case company's four supply chains. A new lead time performance measurement system was developed based on individual supply chain processes. Each supply chain process has its own lead time component and the sum of the lead time components comprise the total lead time for the analyzed supply chains. The length of the lead time was then explained by some selected parameters, such as, the number of produced reels and number of production lots. After the analysis of the supply chain, a conceptual analysis between non-containerized and containerized supply chains was conducted, as the case company's supply chains are currently based on non-containerized supply chains.

The findings, which support the lead time measurement system, can be summarized by four main observations: 1) Information sharing plays a very important role in managing supply chain operations. Joint and real time supply chain information improves the overall efficiency of the supply chains, and thus does not leave space for logistics service companies' individual sub-optimizing; 2) the interaction between the case company's corporate and supply chain logistics strategies could be improved by defining more precisely the organizational responsibilities of the business divisions and the logistics organization in the area of supply chain management. The key performance indicators of the case company should be developed in order to allow supply chain management's specific indicators to play a more important role in the strategy implementation; 3) the number of production lots has a higher explanatory value for the length of lead times than the number of produced reels. Developing new supply chain rules, based on this observation, would improve the efficiency of the case company's supply chains, especially when seen from the working capital point of view and 4) the four analyzed supply chains are based on a non-containerized supply chain model, which means that customer orders are shipped in break bulk. Based on this

analysis of different modes of transport, it was noticed that the longest waiting times occurred at those points, where customer orders are moved from one transport mode to another. When using containerized supply chains such waiting times could be minimized, as there is normally a better supply chain discipline in containerized supply chains.

The contribution to general supply chain management theory includes four different types of contributions: 1) The supply chains processes can be analyzed individually so that each process has its own lead time; 2) supply chain strategy should be one element in the corporate strategy; 3) the lead time can be explained by parameters, which are controlled by the production and not only by logistics parameters and 4) there exist obvious differences between the containerized and non containerized supply chains.

The results of this research are based on observations made of the case company and from, mainly, within the Finnish market. The lead time performance measurement system can be generalized for other paper producing companies, however, their supply chains are very individual and dependent on the geographical location of the mills and customer locations. This statement is due to the fact, that other paper producing companies use the same logistics service providers. The other four main observations can be partly generalized to other Finnish paper producing companies as they have a similar governance model in corporate and supply chain strategies.

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## THESIS ARTICLES

### **ARTICLE ONE**

Koskinen Pekka – Hilmola Olli-Pekka (2008) Supply chain challenges of North-European paper industry. *Industrial Management & Data Systems*, Vol. 108, No: 2, 208-227.

Available at: <http://emeraldinsight.com>

### **ARTICLE TWO**

Koskinen Pekka (2009) Supply chain strategy in a global paper manufacturing company: a case study. *Industrial Management & Data Systems*, Vol. 109, No: 1, 34-52.

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### **ARTICLE THREE**

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### **ARTICLE FOUR**

Koskinen Pekka - Chistokhvalova Oksana – Hilmola Olli-Pekka (2009) Intermodal and Non-Containerized Supply Chain Connecting Northern Europe to North America. *World Review of Intermodal Transportation Research*. Special Issue on the “Northern Dimension of European Logistics”. Vol. 2, No:4, 311-325.

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## List of attached articles and author's contributions

### List of attached articles

<b>Article</b>	<b>Publication</b>	<b>Authors</b>	<b>Acceptance</b>
Supply Chain Challenges of North-European Paper Industry	Industrial Management & Data Systems (IMDS)	P Koskinen O-P Hilmola	Vol. 108, No: 2, 208-227, 2008
Supply Chain Strategy in a Global Paper Manufacturing Company – A Case Study	Industrial Management & Data Systems (IMDS)	P Koskinen	Vol. 109, No: 1, 34-52, 2009
Production Lots as Determinant of Paper Production Lead Time Performance	International Journal of Information Systems and Supply Chain Management (IJISSCM)	P Koskinen O-P Hilmola	Article accepted 02.02.2009
Intermodal and Non-Containerized Supply Chain Connecting Northern Europe to North America	World Review of Intermodal Transportation Research, Special Issue on the “Northern Dimension of European Logistics”,	P Koskinen O Chistokhvalova O-P Hilmola	Vol. 2, No: 4, 311-325, 2009

## Author's contributions

The supply chain management of a global paper industry is a challenging area for scientific research. The idea for this research work came out from the industry itself.

The first article describes supply chain challenges of North European paper producing company. The author highlights several disturbance areas, which are based on real life data from the case company. The author also describes the lead time behaviour of four different supply chains. Co-author professor Olli-Pekka Hilmola contributed in streamlining the structure and content of the first article by writing partly selected sections of the article.

The second article describes the supply chain strategy of the case company. The author had access to the strategy and supply chain strategy of the case company. The author analyzed the strategies of the case company and summarized the results to the manuscript independently.

The third article seeks explanations to the lead time behaviour of the case company. Production lots were used as explaining parameter. The author used the case company's real life data as basis for the analysis. Regression analysis was used for explaining the lead time behaviour. Co-author professor Olli-Pekka Hilmola assisted in the data structuring and in analyzing the results. The author prepared the manuscript independently.

The findings from the third article conducted the research to benchmarking the non-containerized supply chains with the containerized supply chains for intermodal transports. The author describes the supply chain from Finland to the USA. Co-author Oksana Chistokhvalova contributed to the article by her knowhow on the intermodal transports by writing the special sections describing the intermodal transports. Professor Olli-Pekka Hilmola, as second co-author, contributed to the article by simplifying the structure and substance of the fourth article. However, due to two co-authors, the manuscript represents an independent research work of the author.



# 1 INTRODUCTION

The strategic role and competitive advantages of supply chain management as part of business process development are widely recognized (Cooper and Ellram, 1993, 13-24; La Londe and Masters, 1994, 25-47; Mentzer et al., 2001, 5-24). Supply chain management is often referred to within the holistic view of the value creation process from producers to end customers, and trust and co-operation are considered to be its corner stones (Christopher and Ryals, 1999; Lambert and Cooper, 2000, 65-83).

Globalization is one of the driving forces that helps make supply chains more efficient. (Zhenxin Yu et al., 2001, 114, Holmberg 2000, 847). Working cooperatively in global supply chains is an argument advanced for creating competitive advantage for companies in supply chain development. Manufacturing industry was characterized for more than 30 years ago by stable and predictable environments, where manufacturers could push their products on the markets. The global market has changed so that the customers demand more value and better operational performance from manufacturers. Customers require high quality products and services at a reasonable cost and delivery at the requested time. These components lead to customer satisfaction, which can be partly achieved by more efficient supply chain solutions (Gattorna and Walters, 1996; Griffiths and Margetts, 2000, 155-159; De Souza, et al., 2000, 348).

Having the right products delivered in the right quantities and at the right time has become a critical success factor for companies. Sellers and buyers realize that by working together, they can provide a better service to the end customers and at the same time there is the possibility to improve the profitability of the seller and buyer. This type of collaboration strategy is one of the key elements of supply chain management that is used to improve the competitive advantage of the seller and buyer. Bommer et al., (2001, 11-25), Christopher and Jüttner (2000, 117-127) argue that the seller and buyers compete through their capabilities and competencies (competitive strategy). The fundamental aspect of the competitive strategy is how well the companies manage the basic business processes. Sterling and Lambert (1987, 1-30) have identified the role of supply chains as belonging on the bottom line of companies. They found that the physical distribution of products

consistently contributed more to market share than price and promotion, as supply chains create value by linking the producer closer to the customers.

According to Stabenau et al. (1996) the global market contains three basic elements, product quality, product price and product supply. These three elements are crucial elements in supply chain management. Stabenau et al. (1996) define a company's capability to react to market changes as being an element of product quality. The market changes lead to new products, which generate new demands for supply chain services. Product prices are again affected by the cost of supply chains.

The share of supply chain costs is between roughly 10 and 60 percent depending on the total product value. For high value electronic equipment the share of supply chain costs is approximately 10 percent and for fresh dairy products the share of supply chain costs to the total value of the product is approximately 60 percent. Hence, reorganizing supply chains may in optimal cases lead to a cost reduction of 20 percent of the supply chain costs. The reduced supply chain costs can lead to lower product prices of between two and 12 percent (Stabenau, et al. 1996, 9). According to A.T. Kearny's report (2004) the share of the logistics costs in European companies' turnover was approximately six percent in 2003. The logistics costs have shown a declining trend since 1987 when the share of the logistics costs of the companies' turnover was 12 percent.

Supply chain management and logistics have a very important role in the global economy. Rodrigues et al. (2005, 1-16) have estimated, that logistics costs globally were, in 2002, approximately 6,450 billion EUR. This is 13.8 percent of the global gross national product. It is to be noted, that these logistics costs do not include the in-house logistics costs of the companies. In developed countries the share of the logistics costs, of the gross national product, vary between 10 and 15 percent.

The estimated national logistics costs vary between 11 percent and 20 percent of the gross national product, Japan has the lowest rates (10.1 percent). The average is 11.7 percent of the gross national product. These figures show how much money is involved in the global supply chains (Bowersox et al. 1999, 128). There are several national development programs that aim to decrease their national supply chain costs in order to improve the competitiveness of their national companies. However, few companies have achieved total and successful supply chains. There is only a relatively small group of EU companies who have adopted supply chain management techniques, tools and incorporated advanced ICT (European Union Trilog-Europe Summary Report, 2004, 4).

Paper products are one part of the global trade. The total global consumption of paper and paper board products was 339 million tons, in 2003. Asia was the biggest consumer of paper and paper board products in 2003, and Asia consumes 36 percent of the annual production capacity. The USA and Canada consume 28 percent of the global paper and board production capacity. Western Europe is the third largest consumer of paper products with 27 percent. Latin America consumes six percent, Africa two percent and Oceania one percent of the global paper and paper board production capacity (FFIFF 2005, 27).

Finland has always been considered one of the paper making nations. The paper production capacity of the Finnish paper mills was 11.2 million tons in 2004. In total, 92 percent of that production was exported. Paper was produced at 28 paper mills. Finland's paper board production capacity was 2.8 million tons and 89 percent of the paperboard products were exported. The pulp and market pulp production capacity was 15.1 million tons. A major part of the pulp was consumed by the domestic market. Finland's sawn timber production was 13.5 million cubic meters and 62 percent of the sawn timber products were exported. Plywood production amounted to 1.4 million m<sup>3</sup> and 86 percent of that was exported (FFIFF, statistical web-service 2006).

The paper industry with its global presence meets all the customer and collaboration requirements for supply chain management. This research work concentrates on supply chain strategy and its implementation within a global paper industry company that is among the five biggest paper producers globally.

In several discussions with logistics professionals from the Finnish paper industries over the last fifteen years a constant question has been; which parameters actually have the biggest influence on supply chain behavior? Several questions have been asked in the resulting discussions: 1) What influence does the customer order size have on the lead time? 2) What influence does the number of production lots have on the lead time? 3) Do the company's internal supply chain management rules have an influence on the lead time and, thus, on the logistics performance of the paper producing companies? Further questions, which have been asked, are: 4) What is the role of the logistics organization? 5) What is the role of the production units? 6) What is the role of the business divisions and sales offices in the supply chain management?

All these discussions and questions have been asked, and not really answered, based on analyses of research conducted during the last fifteen years. A desire to find answers to those questions provided me with the motivation to start this research project with the assistance of a case company. Applying research methodologies to practical business life and then trying to find out fact based

explanations for the case company's supply chain behavior was the biggest challenge for this research work.

The evolution of the research work started in a simple way; three problem or disturbance areas of the current supply chain management were analyzed. The analyzed supply chains to the UK and USA markets gave very clear signals that the supply chains should be analyzed more broadly. The three disturbance areas are very typical of the daily operational character and their corresponding lead times are reported in the first individual research article. The second step was analyzing how the supply chain strategy is implemented in the case company. The supply chain management organizational roles of the case company were also analyzed. The supply chain organizational roles in the case company are described in the second research article.

The lead time aspects of the analyzed supply chains are discussed in the first and second article. The third article analyzes the behavior of the lead times of the case supply chains as a measurement tool for supply chain strategy implementation including selected explanatory parameters for the length of the lead times. Based on the findings in the first, second and third article, the fourth article discusses a conceptual change from the current non-containerized supply chain to a containerized supply chain.

## 1.1 Research questions

In order to understand the research environment from a theoretical point of view, the supply chain management and lead time definitions and implementations are firstly described in a generic way in the theoretical frame of reference section. According to this theoretical background knowledge regarding supply chains and lead times, the research questions deal mainly with the empirical case study including a lead time analysis for the four supply chains of the case company.

Van Hoek (1998, 187–192) states in his article that supply chain measurement systems are still fragmented and not well developed. Holmberg (2000, 11) supports Van Hoek's statement and at the same time he argues that supply chain measurement activities have a positive influence on supply chain integration between companies. Tan et al. (2004, 233-244) describe supply chain measurement by stating, that in several cases, measurement is made based on historical data and not on process based measurements, which are observed in real time.

This research has been completed with the assistance of a Finnish, global paper manufacturing company. The case company offered the opportunity to make a case study of their supply chain data for the research work.

Supply chain and lead time data analysis, including interviews with key persons from the case company, provide the basis for the research work. The four research questions have been structured so that each of the research question has been discussed in an individual article, which has been published in an international refereed journal.

This research is based on the implementation of the logistics strategy of the case company. The logistics strategy implementation has been measured by the total lead times and by the individual supply chain management process phase lead times. This research work gives answers to four main research questions.

#### *Research question 1*

The first research question is: What is the actual lead time performance for the case company's selected four supply chains? The aim of this research question is to identify areas of improvement for the new supply chain context of paper production, and possibly give further support for the general development of the business area. Research question one is discussed in detail in article number one.

#### *Research question 2*

The second research question aims to analyze the relationship between corporate and supply chain strategy, and study how it is implemented in a multinational paper producing company. Traditionally paper producing companies have had a strong interest in developing a physical infrastructure for their customer deliveries. However, supply chain thinking is still an unstructured issue in the case company. Research question two is discussed in detail in article number two.

#### *Research question 3*

The third research question tries to give answers for two detailed research questions: (1) 'To what extent do the number of produced reels explain the length of the production lead time?', and (2) 'What is the role of the used production lots (as entire production batch is split into smaller lots to enable the transfer of the lots) concerning lead time?' Research question three is discussed in detail in article number three.

#### *Research question 4*

The fourth research question tries to give answers to the following detailed research questions. (1) What are the special features of a supply chain involving intermodal and non-containerized transports? (2) Which main factors determine the success of a non-containerized intermodal transport solution? (3) How can the performance of an analyzed supply chain be improved in the future? Research question four is discussed in detail in article four.

### 1.2 Research objectives

During the last few decades there has been a growing understanding of the strategic importance of integrating suppliers, manufacturers and customers in order to achieve higher efficiency and effectiveness in managing an entire supply chain (Reck and Long 1998, 2-8; Christopher, 1992; Clinton and Closs, 1997, 19-44). Supply chain management is not only a tool for lowering the logistics costs of a company, but also a tool for improving profits for all partners in the supply chain.

The global paper industry, including the case company represented, has been selected as the object of the research work. The case company's head office is located in Finland and the case company has production in 15 countries. Thus, supply chain management for the global paper industry is a vital element in selling their products to their main markets globally.

In this thesis supply chain management will be analyzed from the case company's strategic point of view. Supply chain management offers a strategic insight into a company's way of working. The scope of the supply chain management covers the cross-functional, intra-firm and inter-firm operations of a company (Stabenau, et al., 1996, 44).

The objective of this research is to contribute to both academia and industry. The likely contribution to academia is theory development or the new application of an existing theory within a business environment or the pinpointing of new kinds of theoretical problems. The theoretical framework for this research lies in developing a real life process based measurement system for lead time management. The specific objective of this research regarding its contribution to academia is to:

*Develop a conceptual measurement system for the lead time measurement of supply chains, which are managed by several actors.*

In order to contribute to the industry and to the case company, the findings should add value to the case company and at the same time improve their daily performance. One way of adding value to the case company is to communicate the results of the lead time analysis in such way that they lead to new supply chain management principles for the case company. The specific objective of this research regarding the contribution to the case company is to:

*Provide a measurement system for the total lead time and for the individual supply chain management process phases of the supply chains. The target of the new measurement system is to assist the case company in lowering the supply chain cost structure.*

The four individual research questions can be summarized in following way: The first research question describes the phenomena to be analyzed, what is the actual lead time performance; the second research question analyzes the relationship between corporate and supply chain strategies, which are governing the analyzed phenomena. In the third research question production lots are analyzed as a new explaining parameter for the length of the lead time. The fourth research question compares a non-containerized supply chain (case company) with a containerized supply chain.

As there are four separate research questions, which are discussed in four individual articles the following question arises: How do these articles support the overall research objectives of the research work? The interaction between the research questions (RQ) and research objectives is summarized in Table 1.

Table 1: Interaction between research questions and research objectives

	RQ 1	RQ 2	RQ 3	RQ 4
Research objectives	Phenomena description, What is the actual lead time performance?	What is the relationship between corporate and supply chain strategy in the case company?	To what extent do production lots explain the length of the lead times?	What are the special features of a supply chain involving intermodal and non-containerized transportation?
<i>Develop a conceptual measurement system for the lead time measurement of supply chains, which are managed by several actors.</i>	The lead time performance of the four selected supply chains of the case company are analyzed. The research phenomena and environment are described in the first article.	The corporate strategy and the supply chain strategies are analyzed in order to identify the organizational responsibilities and models. Generic bottlenecks areas also identified for supply chain management	Production lots and batch sizing have been analyzed in other industries. Production lots have not been analyzed earlier in the paper industry as explanatory parameters for the length of lead times.	Paper industry's supply chains to the European and USA markets are mainly shipped in break bulk, so called storo shipments. The fourth research question analyzes differences between intermodal and non-containerized transports.
<i>Provide a measurement system for the total lead time and for the individual supply chain management process phases of the supply chains. The target of the new measurement system is to assist the case company in lowering the supply chain cost structure.</i>	Based on the findings of the first research question, a new measurement system has been developed for the case company.	The findings of the second research question should recommend new organizational responsibilities and working models for the case company.	The findings of the third research question should recommend new decision making criteria (production lots) for the case company's supply chain management.	The findings of the fourth research question should identify the benefits and disadvantages of intermodal and non-containerized transportation from the case company's supply chain management's point of view.

The interaction between the research objectives and research questions can be concluded as follows: The strategic objective is to increase the understanding of the paper industry's supply chain and lead time management based on the case company's analysis. The expected result of the research work is to develop a method for analyzing lead times for the paper industry's supply chain management. The method will be tested by using the four selected supply chains of the case company.

Lead time measurement is not a commonly used supply chain management measurement tool in the paper industry. The method of lead time performance analysis should then be tested against and implemented in other supply chains in the paper industry and, consequently, bring new benchmarking criteria to the whole industry.



### 1.3 The generic scope of the empirical research work

The paper producing industry is known to be very much production oriented. The optimization of the paper machines is made according to signals received from the sales network. The weekly optimization is carried out by using advanced production planning, which is one main feature of the paper mills IT applications. Keskinok et al. (2002, 249-259) have been researching the scheduling solutions for the paper industry. In their article the researchers state that “scheduling the production and distribution of paper products in real-world manufacturing environments is an extremely complex task that requires the consideration of hundreds of constraints and objectives.” The production optimization and distribution planning of the paper industry has several external and internal factors, which have to be taken into consideration both in long term capacity planning and in daily operations planning. The authors make a further statement, which says that existing paper industry software and literature for paper mill production and distribution planning has focused on production and distribution planning stages independently, without taking into consideration the overall production and distribution planning.

Carlsson and Rönnqvist (2005, 590-616) have analyzed the supply chains in a pulp producing industry in Sweden. The authors state that the forest industry, in general, has relatively few decision support systems and puts less funding into research and development. On the other hand, the supply chain management for other industrial areas has been described by other authors from an operations research point of view (Shapiro, 2001).

Supply chain management for the paper industry has not been very well optimized, due to the fact that the paper industry’s logistics organizations mainly have a facilitator’s role. This means, in practice, that the logistics organizations make the contracts with the logistics service providers (LSP). Different types of key performance indicators (KPI) are agreed with the logistics service providers. These key performance indicators are used only between the logistics organizations and the logistics service providers. The logistics organizations do not normally provide the paper mills with adequate supply chain performance reporting, such as lead time reporting.

Christopher and Jüttner (2000, 117-127) have stated that “whilst the need to develop strategic approaches to managing supply chain relationships is commonly accepted, there appears to be a void of empirical research.” Existing supply chain frameworks and managerial guidelines are mainly of conceptual and theoretical

character and lack empirical observations of the state of practice (Olsen and Ellram, 1997, 221-231; Ellram 1991, 2-8; Andersson and Narus 1991, 95-113).

There is an obvious difference between the supply chain management terminology in the research literature and how the terminology is implemented in the case company. In order to get a joint understanding between the research literature and the case company, the following terminology and definitions will be used in this research work. Supply chain management for ready made paper products is, in the case company, generally understood as part of the business scope of the business division including the sales network and the mills. The supply chain management philosophy in the case company is divided into three main supply chain management processes. The first process is order taking and order placing from the sales network to the mills, the second process includes production planning and production and the third main process is delivery to the customers.

The case company defines the supply chains as geographical routes. These geographical routes and respective logistics service providers on the routes execute the case company's supply chains. Lead time measures the total time used from production to customer delivery. The lead time corresponds to the number of days in the supply chains.

Four geographical supply chains have been selected for the case study analysis. These supply chains start from the main production units, paper mills and from the biggest paper machines in the selected mills. Production is situated in two different locations in Finland, and the mills are called A mill and B mill, respectively. The analyzed four supply chains end at the case company's biggest market areas in the United Kingdom (UK) and the United States of America (US).

The selection of these four supply chains was made by the logistics management of the case company. Both the UK and US markets are of strategic importance for the business activities of the case company. The supply chains to the UK market have had in recent years a major bottleneck in their warehouse operations in the discharging ports of UK. The case company has by far the highest stock values in the UK port warehouses (interview with the Senior Vice President of Logistics, 25<sup>th</sup> September 2005). The business motivation for selecting the USA market as the other market can be explained by the long distances from the place of production to the customers. The distance has actually two components. The first component is the long sea transport time from Finland to the US and the second component is the local distances with the US. The transport time from the USA discharging ports to the customers takes an additional

several days (3-7 days). The respective transport times from the UK ports to the customers can be measured in hours.

The warehousing capacity at the mills was another selection criterion for the analyzed mills. The B mill has actually no warehousing capacity at the mill and the A mill has a warehousing capacity of 10,000 tons at the mill's premises. The transport routes to the markets partly pass through the same ports in Finland and thus a comparison of the lead times can be easily made.

The first analyzed supply chain starts from paper machine number 2 (PM2) in Eastern Finland ("A" paper mill). The first supply chain for the A mill goes via an Eastern Finnish port to Tilbury (UK) and the second supply chains go via a Western Finnish port to Baltimore in the US. The third supply chain starts from paper machine number 6 in Central Finland ("B" paper mill). The third supply chain goes via Western Finnish port to UK markets. The fourth supply chain starts from the B mill and goes via a Western Finnish port to the US.

The analyzed supply chains and their main operational and geographical points are illustrated in Figure 1. No separation is made between the two discharging ports per market area in order to make the analysis more streamlined. In both markets there is one dominant port, which handles the majority of the volumes and the other port handles a minority of the transported volumes.

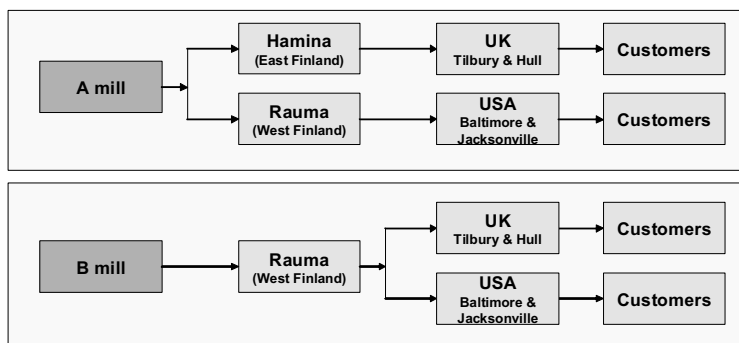


Figure 1: The geographical scope of the case study supply chains

The scope of the case study analysis contains data analysis for four supply chains. The data is derived from the order handling and from the logistics IT applications of the case company. The objective is to analyze selected parameters in each of the seven supply chain process phases. The main parameters are the number of handled reels and how many lots the reels have handled in each of the

supply chain process phases. The lead time for individual customer orders is analyzed for each of the supply chain process phases.

#### 1.4 Structure of the thesis

This research is balanced between a theoretical and empirical approach, where, first of all, the theoretical issues are discussed. The empirical issues are then discussed in the second part of the research work. The conclusions and recommendations are presented in the third part. The structure of the thesis contains eight major sections, which are described below (from Section 1 to Section 8).

##### *Section 1: Introduction*

The main elements in the introduction section are the changes in global trade and the global development of supply chains. The research questions and objectives are described in the introduction section. The introduction section also explains the business based motivation behind the research work. The scope of the case study is presented on a general level. The structure of the thesis including the content of the sections is described in the introduction section. Also the limitations of the case study are presented in this section. Section 1 presents the research questions and objectives of the case study with reference to the four supply chains that flow from Finland to European and American markets.

##### *Section 2: The research process*

The research process describes how the research starts from its theoretical paradigm and then later on discusses the research design, method and approach. The reasons for using case studies are discussed in Section 2. Then the physical and geographical scope of the case study is described. The data collection method is discussed and described as well as the method of statistical analysis.

##### *Section 3: Theoretical frame of reference*

Based on previous research literature Section 3 presents a detailed picture of the evolution of supply chain management. The characteristics of supply chains and paper industry supply chains are compared with each other. The lead time

definitions are also discussed in this section. The role of supply chain planning information will be discussed on a theoretical basis. The supply chain and logistics management as an organizational issue and the supply chain integration components will be discussed in this section.

#### *Section 4: Case study description*

Section 4 includes a short description of the case company including its basic financial and production figures. The characteristics of the four selected supply chains to the UK and US markets and the methods used for analyzing the lead time are described in research Section 4.

#### *Section 5: Summary of the published articles*

Section 5 highlights the main findings of the four published articles, which also gives answers to the four research questions.

#### *Section 6: Discussion*

The findings and results from the four published articles are discussed as one entity in Section 6. The discussion section includes practical recommendations for improving the supply chain management of the case company.

#### *Section 7: Conclusions and recommendations for future research work*

Section 7 presents conclusions and areas for future research activities. The conclusion section presents new findings for supply chain management, from the case study, on a generic level. New areas for future research work are discussed in this section.

## 1.5 Limitations of the research work

The lead time analysis covers four selected supply chains to markets in the UK and US. The domestic supply chains in Finland are excluded from the study as they are based on truck and rail transport located just a few hours from the mills. Other market areas and other paper producing mills of the case company have been excluded from the research work, because the selected supply chains are considered to be volume wise representative enough of the case company. The supply chain management for the overseas markets has a totally different structure based on containers, and overseas supply chains were excluded from the research (interview with the Senior Vice President of Logistics, 25<sup>th</sup> September 2005).

In this research work the supply chains are defined so that the harvesting, transportation of logs and the storage of logs and other types of raw materials are excluded from the study. This research work deals only with ready made products, which are to be transported to the UK and USA.

The analysis of the transport costs are excluded from this research work as the research work concentrates on lead time management. The transport costs are not directly influenced by the daily supply chain management as the transport costs are contracted on an annual or longer term basis.

Such forest industry products as timber, pulp and plywood are excluded from the research work, because the supply chain management of these product groups is controlled by other IT applications than the paper products, and because the logistics routes are different from the paper industry logistics routes, meaning that the loading ports, shipping lines and discharging ports are different in comparison with the case supply chains.

## 2 THE RESEARCH PROCESS

What are the driving forces needed in order to make research work? The motivation and answers can be found in the expected results. This can be called the research ambition. The expected research results may aim to increase knowledge of the analyzed phenomenon by describing the phenomenon in detail or by explaining solutions to the analyzed problems.

The research approach always requires an understanding of the analyzed phenomenon mixed with academic knowledge. Generally speaking, knowledge and understanding can be gained from existing books, articles and from the Internet, but scientific research requires methods, which are more rigorous and disciplined and make the whole research process more transparent for other researchers. It is very difficult to define, what is good research and which methods suit the research subject best. The selected research method has to bring together the research questions, the research objectives and the analyzed problem.

This research will be judged mainly from a scientific point of view; however, it is also based on a real life case study and thus aims to be practical. For this reason it is important to describe the research process in detail.

### 2.1 Theoretical paradigm

All researchers are individuals that have their own basic beliefs, which influence their way of working, and especially decision making during the research process. The used methods, techniques of analysis and other tools are influenced by these basic beliefs. A combination of the basic beliefs, methods used and techniques of analysis is required in order to answer the research questions.

Basic beliefs or assumptions are crucial elements of paradigms. These elements represent a world of views that defines, for its holder, the nature of the world, an individual's place within it and the range of possible relationships to that world (Denzin and Lincoln, 1994). Denzin and Lincoln (1994) argue that basic beliefs can be summarized in three fundamental questions. The first question covers the area of ontology (metaphysics): What is the form and nature of reality and what

can we know about that reality? The second question covers the area of epistemology: What is the nature of the relationship between the knower or would-be knower and what can be known? The third question covers the area of methodology: How can the inquirer go about finding out whatever he or she believes can be known?

According to Holmberg (2000, 21) the paradigms are human constructs and accepted only on faith, which means that there are no real tools for determining the ultimate truthfulness of the paradigms. It is also impossible to value which is the best paradigm as there are no real measurement tools for measuring the accuracy of the paradigms.

Kuhn (1970) has defined scientific research as a devoted attempt to force nature into conceptual boxes supplied by professional education. There are some significant differences between scientific research and non scientific research. Scientific research has a goal, an objective to increase knowledge and solve problems and it is also a logical, rigorous and controlled process (Ackoff et al., 1968). One typical feature for identifying a field as science is that scientific studies are guided by paradigms, which are generally understood as a theoretical framework.

Kuhn (1970, 10) defines paradigm as: “Some accepted examples of scientific practices, including law, theory, application and instrumentation that provide models from which spring particular coherent traditions of scientific research.” Denzin and Lincoln (1994, 99) define the term paradigm as: “a basic set of beliefs that guide action. Paradigm deals with first principles, or ultimate. They are human constructions. They define the world-view of the researcher.”

Holmberg (2000, 23) states that even a logistics system is a socio economic system, which does not only deal with tangible things, but also deals with abstract things such as an individual’s beliefs, thoughts, ideas, attitudes and values.

The theoretical paradigm is constructed on the personal beliefs of the researcher. The next step in the research process is the research design, which guides the method for seeking answers to the research questions.

## 2.2 Research design

Denzin and Lincoln (1994, 199-200) have defined the role of research design as a road map for the researcher that concerns four basic questions: 1) How will the design be connected to the paradigm being used? In other words the question is, how will empirical materials be informed and interact with the paradigm in



question? 2) Who or what will be studied? 3) What strategies of inquiry will be used? and 4) What methods or tools will be used for collecting and analyzing data?

Yin (1994, 19) describes and defines research design as follows: “The research design is a logical sequence that connects the data to a study’s initial research question and, ultimately to its conclusions”. It is an action plan for getting from here to there where here may be the initial set of questions and there is the set of conclusions (answers) about these questions. Between here and there a number of major steps may be found, including the collection and analysis of relevant data.

Guba & Lincoln (1994, 105) have stated that: “The questions of method are second to questions of paradigm.” In practical terms this is understood as the decisions regarding the research study naturally follow the identification of the scientist’s paradigm.

The research design of this work starts from the identification of three specific disturbance areas and the corresponding lead times. The second step covers the supply chain strategy implementation in the case company. The third step covers lead time as a measurement tool for the supply chain strategy implementation and the fourth step covers a conceptual discussion between non-containerized and containerized supply chains. The fifth step places the findings from the four independent articles within a set of conclusions based on a conceptual discussion.

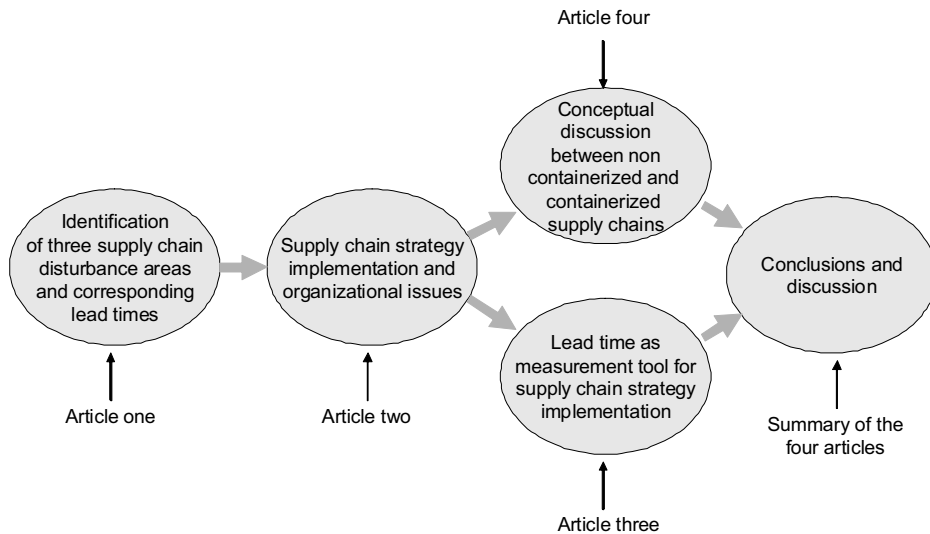


Figure 2: Research design

Figure 2 also highlights the sequence of the four published articles and the conclusion and discussion summary of the four articles.

### 2.3 Research method

Merriam (1998, 21) has argued that the selection of the research method is decision making between adapting a naturalistic (non-experimental) or experimental inquiry method. Quinn (1987, 14) describes the differences between the two methods: “A naturalistic inquiry strategy is selected to describe naturally unfolding program progress and impacts. Experimental designs are selected to test the effects of controlled treatments, reduce variation in extraneous variables, and focus on a limited set of predetermined measures.”

Holmberg (2000, 25) explains the Quinn definition by stating that the naturalistic (non-experimental) inquiry approach has a mainly qualitative, holistic nature. This approach is focused on the processes, meaning and understanding of specific events. The naturalistic approach is described as inductive as it includes the collection of empirical data and generates new ideas, hypothesis or theories rather than testing existing ones. This approach aims at describing the analyzed phenomena in detail. The experimental inquiry method is hypothetical-deductive

and mainly quantitative in nature. The experimental inquiry method verifies or rejects predefined hypothesis or theories.

Such terms as research strategy, method or approach are often used interchangeably. Denzin and Lincoln (1994, 202) define research strategy as follows: “The strategy of inquiry comprises the skills, assumptions and practices used by researcher, when moving from a paradigm and research design to collection and analysis of data. Strategies of inquiry connect researchers to specific approaches and methods for collecting and analyzing empirical materials.” The main target for the research strategy is to lead the researcher from the research questions to useful and meaningful results.

Researchers are often confronted with questions of what, when and why in the course of using research strategies. According to Yin (1994) research strategy has specific advantages and disadvantages depending on three conditions: 1) the type of research questions asked; 2) the extent of control an investigator has over actual behavioral events and 3) the degree of focus on contemporary as opposed to historical events.

Previous studies on supply chains have often been reliant on the transactional cost economics background (Sako and Helper 1998, 387-417, Dyer 1997, 535-556). The transaction cost theory is powerful in explaining existing relationship patterns in single relationships, but transaction cost theory is less suited to identifying the problems of complex interactions with both customers and suppliers in a supply chain environment. In contrast, general systems theory is more feasible for analyzing complex relationships (Ackoff 1971, von Bertalanffy 1973). The core of systems thinking is that a system needs to be analyzed within its environment and through the adoption of a holistic perspective. The concepts of response or responsiveness in manufacturing and supply chains originally stem from the initial principles of systems theory.

Theory building research normally combines multiple data collection methods. The advantage of using several types of data collection methods is that they provide a stronger substantiation for constructs and hypotheses (Jick, 1979). Quantitative evidence can indicate relationships, which may not be derived from pure qualitative data, which is useful for understanding the relationships in the analyzed case. Data collection, data analysis and theory building are closely linked to each others in this research and form an iterative process.

Iterative triangulation is considered to be a feasible method for combining different types of research methods. Lewis (1998, 456) describes the functionality of iterative triangulation as a combination of systematic iterations between literature review, case evidence, and intuition. With iterative triangulation, a

rigorous process and explicit techniques for comparing diverse case settings and incorporating varied research perspectives aid the development of creative, useful, and valid operational management theory.

Inductive case research typically employs triangulation, using multiple data sources and analytical techniques to improve the representational accuracy of the resulting theory. Iterative triangulation expands the traditional notion of triangulation by utilizing existing case studies to enhance representational diversity. According to Lewis iterative triangulation employs numerous inductive techniques, such as the comparison of case study data with literature reviews.

Lewis (1998, 456) has structured the iterative triangulation according to five main steps. The first step covers the selection of relevant and usable cases. The second step covers the searching for patterns among these cases and the third step covers iteration between the case evidence. A review of the relevant literature is the fourth step. The final step includes intuition, which extends and links conjectures into a cohesive theory. Lewis also defines the limitations of using iterative triangulation. The quantity of available cases restricts the use of iterative triangulation. Using multiple case sources and search strategies can increase case quantity and diversity and lessen case selection bias (Lewis 1998, 458). Another limitation is that the existing cases often provide incomplete information and even when a case covers all constructs of interest, case write-ups do not include field notes.

According to Ellram (1996, 93) and others (Bonoma 1985, 199-208; Flynn et al. 1990, 250-284; Hamel et al. 1993 and Yin 1981, 58-65) the case study method is one of the least understood research methods. Ellram and Siferd (1993 and 1994) and Mentzer and Kahn (1993) have noticed that the majority of empirical research in logistics, operations and material management is focused on quantitative research methods. The quantitative methods include simulations, model building as well as the testing of survey data. The survey method is based on the quantitative analysis of a few selected variables across a large number of observations. Mentzer and Kahn (1993) point out that the qualitative methods have only been implemented infrequently in logistics, operations and material management research. Häkkinen and Hilmola point out in their article (2005, 239-256), that logistics case studies currently use more and more qualitative research approaches. The authors have analyzed approximately one hundred research articles on logistics.

Ellram (1996, 96) classifies research methodologies according to type of source data and according to the type of analytical method used. The empirical data is collected from real life via surveys or empirical studies. Another type of data is

modeled data, which means that the data is either hypothetical or real world data, which has been manipulated by a model.

When positioning this research work next to Ellram's basic research design we can identify the following features. This research work is based on empirical real world data from the case company. The data will be analyzed as a statistical analysis for the case company's supply chain management process phases. This is the quantitative feature of the research work. This research also has the feature of being a qualitative study as the analysis of the quantitative data will be completed by interviewing the key persons in the case company's supply chain management organization.

Table 2: Basic research design, Source: Ellram (1996, 96)

		Types of analysis	
		Primarily Quantitative	Primarily Qualitative
Type of data	Empirical	Survey data, secondary data, in conjunction with statistical analysis such as; factor analysis, cluster and discriminant analysis	Case studies, participant observation, ethnography characterized by limited statistical analysis, often non-parametric
	Modeling	Simulation Linear programming Mathematical programming Decision analysis	Simulation Role playing

According to Ellram (1996, 97) empirical research includes larger risks than modeling research. The main argument is that the use of real world data leads to results, which are not predictable and less controllable. Quantitative results are normally expressed by using numerical and quantifiable terms. The qualitative results are normally expressed by verbal text in order to create an understanding of the described relationships or complex interactions.

Hilmola et al. (2005, 294-311) have analyzed supply chain management articles in the international research journals. They conclude from the articles that supply chain management studies and case study research methodologies are relatively new research disciplines. The authors analyzed a total of 55 international journal papers, using case studies, in the area of supply chain management. The articles were published between the years 1994 and 2002. The main findings from this research work showed that there were a relatively low number of articles that used the case study methodology and most of the articles only dealt with one case

study. The articles also mainly concentrated on describing the supply chain management from an individual company's point of view.

This empirical case study is based on industry specific data; however, there are several logistics service providers, who execute the case company's supply chains. This case study is based on quantitative data from the case company. Two of the published articles (Appendix: articles two and four) and the interviews do have qualitative aspects. The balance between a quantitative and a qualitative research approach could be estimated to be 60/40. Logistics service providers do not provide any data for the case study analysis due to the fact that combining data from several companies' IT applications would have caused several problems in data identification.

Analytical methods are normally used for problem solving especially by using mathematical calculation tools. On the contrary approaches based on system dynamics tries to solve problems by explaining the operational structure.

Analytical simulation model is used, in this thesis, as basis for explaining the lead time measurement concept, which is developed in article number three (Appendix: article three). The early system dynamic simulation models were based on an assumption, that the production capacity never was a bottle neck and thus the capacity utilization was in maximal use (e.g. economic production quantity, developed by Harris 1913 – comprehensive review in Erlenkotter 1990). Analytical production inventory optimization models normally assume that production capacity is available when it is needed and this leads to that the production delivers fixed amount of products. Research article number three analyzes two specific parameters, number of production lots and number of produced quantity, for explaining the lead time. The discussion in article three does not take into consideration the utilization of the production capacity as no data was available for this purpose. One of the most famous developers of the system dynamic approach was Forrester at the end of 1950's when he introduced the Forrester phenomena. This research work analyzes paper industry production, where all orders are produced based on the make to order principle and different types of product qualities are produced by same paper machine. In such market situations, where there is very high demand of paper products, the production capacity can be a limitation, but in normal market situations there is production capacity available.

## 2.4 Research approach

The subject of a study can be approached in different ways. Based on the views and basic assumptions of reality, research approaches are divided into three main categories. Arbnor and Bjerke (1994, 61-77) have structured research work into three different types of methodological approach: analytical, system and actor. The analytical research approach explains different types of analyzed phenomena. The systematic research approach aims to increase the understanding of different phenomena. The actor approach only deals with the increase of understanding in a research area. The basic characteristics of the presented three approaches have different philosophical features. For the analytical approach, the analyzed entity is the sum of the individual observations, reality is considered to be based on objective facts, which are to be verified in the research work. The explanatory role of the analytical approach includes such elements as causality explanations, which explain the reasons for causality. A high level of causality explanations leads to a higher standard of explanation.

For the system approach the analyzed entity is not the sum of the individual observations and reality is objectively accessible. The system approach requires an existing system theory for its basis and the entity is not considered to be equal to the sum of observations. The system approach explains the driving forces behind the analyzed phenomena. The results of system approach research lead to generic classifying mechanisms, where even individual cases can exist. The basic features of the actor approach are based on the assumption that the analyzed entity exists as structures, which are socially created, and that reality is a social construct.

The actor approach tries to understand the interpretations of different actors and the result of actor approach research is different types of descriptions.

The different types of Arbnor and Bjerke's research approaches are summarized in Figure 3.

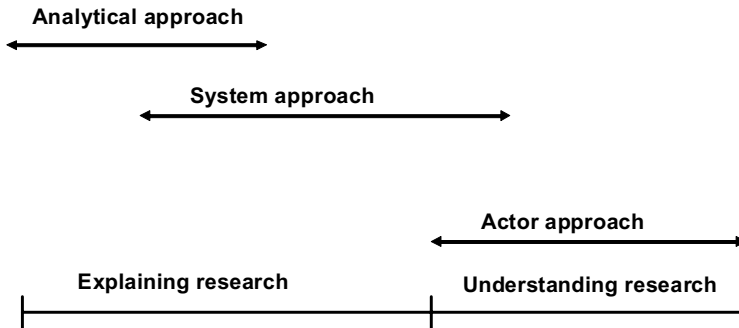


Figure 3: Arbnor and Bjerke, three different types of methodological approach

Arbnor and Bjerke (1994, 107) also present a research circle, which starts with the facts and ends up with the facts. The facts are collected from the empirical world and through induction the facts are analyzed and the results lead to the testing of existing theories. Thus, the combining of real life facts with existing theories leads, via a deduction process, to the building of a new theory, which later on can be verified with real life facts. The Arbnor and Bjerke research circle is described in Figure 4.

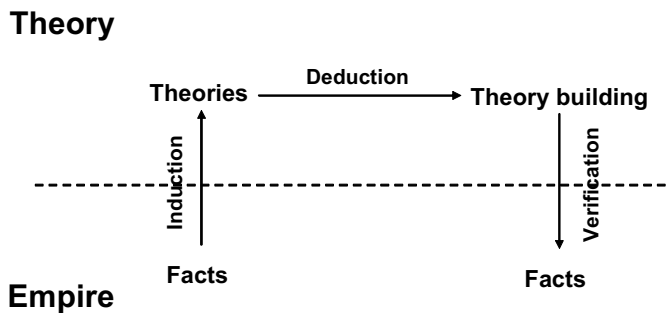


Figure 4: Arbnor and Bjerke, empire and theory circle

This research work is based on empirical case study methodology, where an inductive approach is used for gaining results from different types of real life data



analysis. Arbnor and Bjerke's systematic approach is selected as the methodological approach when the research work is based on real life data. The empirical and research circle was implemented on a practical level in this research work as the case study analysis begins with real life facts from the case company. By using induction the results from the lead time analysis are tested with existing theories and then by using deduction the empirical results in combination with existing theories will lead to new theory building, which can be tested with real life facts from the empirical world.

The supply chain management process phases of the case company had not been analyzed earlier with regard to the supply chain process phases and lead time structure, which are studied in this research work. The case company's actual statistical data (quantitative data) is available in three different IT applications. The data is explained with the aid of supporting interviews (qualitative data) in order to reach a proper understanding of the phenomenon behind the statistical data.

Inductive case research has been selected as the basis for theory building in this research work. The objective is to increase the understanding of the paper industry's supply chain and lead time management. The expected result of the research work is to develop a method for analyzing lead times for the paper industry's supply chain management. The method will be tested by using the selected supply chains. The method of analysis can then be tested against and implemented in other supply chains in the paper industry.

## 2.5 Reasons for using case studies

Theory building based on inductive case research was selected as a research approach for this empirical study. The generic objective of the research study is to gain an increased understanding of the phenomena, in other words, the case company's lead time behavior should be better understood after this research. Additionally, this research aims at the development of a testable hypothesis, which can later on be tested in various areas. The research approach used here should be an applicable method for describing and exploring new phenomena (Handfield and Melnyk, 1998) or for building new operations management theories (Meredith, 1998). This type of theory development is based on observations of the objects or participants in the theory and in its development (Glaser and Strauss, 1967; Yin 1989). The research approach is inductive and makes use of both qualitative and

quantitative data. The case study method allows the research to retain the holistic and meaningful characteristics of complex real life events (Yin, 1989).

The research constructs deal with questions by asking what should be studied in order to answer the research questions (Yin, 1989). This research work includes the analysis of three constructs: material flows, which form the selected supply chains, the relationship between the case company and the logistics service providers and the actual lead time performance of the case supply chains.

Research strategies other than the case study research strategy exist. Yin (1994, 9) presents four different research strategies, which can be used under certain conditions. They are an experimental research strategy, surveys, histories and an archival analysis. Due to the fact that the case research is based on direct observations and also on interviews it is preferred to the history research method. Archival analysis was not a feasible research method in this case as the research lacked direct access to current sources of data. Archival analysis can, however, provide data for this case study research method.

The survey method, which is frequently used in logistics, lacks the ability to provide a rich description of the analyzed phenomena. However, the case study method enables the researcher to look into the future instead of focusing on past events (Holmberg 2000, 28).

Generally speaking, the main target for logistics research is to improve existing logistics systems. Thus, because the case study method makes it possible to analyze selected phenomena in detail it was selected as the main method for collecting data in this research work.

Also closely related fields of research, such as operations management, have made general requests for more field research and case studies to be conducted. This is because the main objective of operations management theory is to guide empirical research by providing a greater understanding of the many interrelated variables influencing operations performance in real world settings.

Yin compares case studies to other research methods and concludes: "case studies are the preferred strategy when, how or why questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon with some real-life context" (Yin, 1989). Yin discusses the case study method from a point of view developed from an earlier article from 1981. He states that the case study method does not imply the use of a particular type of evidence and case studies can be conducted by using either qualitative or quantitative evidence. Furthermore, evidence may come from fieldwork, archival records, verbal reports, observations or any combination of these and a case study can involve either single or multiple cases and numerous

levels of analysis (Yin, 1981, 58; Eisenhardt, 1989, 532-550). According to Yin, the case study method is one type of research strategy. The distinguishing characteristics of the case study method are that it attempts to examine a contemporary phenomenon in its real context, especially when the boundaries between phenomena and context are not clearly evident (Yin 1981, 59).

Merriam (1998) completes Yin's case study motivation by arguing that the overall objective is to facilitate a deep understanding of a phenomenon by providing a rich description based on a holistic view. The case study method focuses on happenings and on processes rather than on "snapshots" of reality.

Lewis (1998, 455-469) supports both Yin's and Merriam's case study motivation by stating that the examination of varied research sites, methodologies and theoretical perspectives across case studies provides an increase in the understanding of the case study research method.

Yin defines, on a practical level, the implementation of the case study method. Note-taking should be distinguished from narrative writing and both quantitative and qualitative data should be assembled together. The analyzed events should be tabulated and quantitative data, in particular, should be coded and tabulated.

One major feature of the case study method is that it intends to build explanations of the analyzed phenomena. The phenomena explanation is based on an accurate rendition of the facts of the analyzed case study data. Some consideration of alternative explanations of the facts has to be made in order to observe the extreme values of the case data. The conclusions are based on the single explanation that appears most congruent with the facts (Yin 1981, 58-64).

Meredith (1998, 441-454) discusses the advantages and disadvantages of the case research method. The first strength is that the phenomenon can be studied in its natural setting and meaningful, relevant theory can be generated from the understanding that is gained through observing actual practice. The second strength is that the case method allows for the answering of the much more meaningful question of why, rather than what, and thus builds a relatively full understanding of the nature and complexity of the complete phenomenon. The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon is not at all well understood. One of the disadvantages of case research is the difficulty of identifying, how representative a single observation within a collection of observations is. Another disadvantage is a lack of understanding of the analyzed phenomenon.

Lukka et al. (1998, 23-38) discuss the role of the constructs in case study research on a general level. They state that results from natural science research are normally generalized. This leads to problems in the implementation of the

results in a business environment. There is a gap between research and practical decision making in business. The objective of constructive research is to solve real management problems so that a solution will be tested during the research process. Constructive research is based on earlier theoretical know-how regarding the problem area and the results are linked to theoretical know-how. The starting point for constructive research is a practical business problem, which is also an interesting subject for academic research. Kasanen et al. (1991, 301-328) define constructive research in a very simple way by stating that constructive research is problem solving with the assistance of a model, a figure, a plan, an organization and a machine. The authors define a construct as a design and they encourage researchers to construct new, innovative solutions for business life. Kasanen et al. (1991, 301-328) position constructive research as part of the applied sciences. The main characteristic for applied sciences is to produce new understandings, which lead to applications or the achieving of a goal (Kasanen, et al. 1991, 323).

Ellram (1996, 100) discusses the question of generalizability in case study research. The key question is how many cases are necessary in order to achieve a sufficient level of generalizability for the achieved results. One single experiment is suitable for case study research, when it represents a critical case that can be tested with a well formulated theory (Ellram, 1996, 100). However, the authors recommend that multiple case designs can be implemented in order to show contrasting results and provide several reasons for a phenomenon.

Kasanen and Lukka (1993, 348-380) define generalizability as drawing conclusions from one or several observations that are based on fact-based information. The authors also provide a definition of scientific research. According to the authors, the main objective of scientific research is to generate new and fact-based information. In addition they state that there are two types of method for scientific analysis: deduction and induction. Deduction involves drawing conclusions based on logic and has thus a demonstrative character. The truth of deductive analysis is independent of time and place. Mathematical analysis is a typical example. In contrast, induction has generalizability as its cornerstone. In induction the truth cannot be held in the same way as in deduction, as conclusions explain more than the premises. Generalizability is therefore inductive analysis as one or more individual observations lead towards a general conclusion. However, the drawing of conclusions is normally based on facts from which only an uncertain knowledge can be formulated, even if that knowledge offers the best explanation for a phenomenon (Kasanen and Lukka, 1993, 352).

### 2.5.1 Case study definitions

The paper industry's supply chains contain networks of multiple businesses and relationships. Lambert (2001, 99-125) has defined supply chains from the business processes point of view. The inter-related elements in Lambert's definition are: the structure, the business processes and the management components. Lambert divides the supply chain components into two groups: The first group includes the physical and technical components, which are tangible and measurable such as the management of product and information flows. The second group includes managerial and behavioral components such as organizational culture, the network of relationships between actors in a supply chain. Cooper et al. (1997a, 1-13) defines supply chains as a holistic approach to manage and integrate key business processes in order to achieve a smooth flow of information and products along the supply chain. In order to implement supply chain management successfully, the organizations may have to restructure and streamline their business processes and IT systems with their supply chain partners (Cooper et al., 1997 a, 1-13; Chandra and Kumar 2000, 100-113; Forza and Vinelli, 2000, 138-146; Mason-Jones and Towill 1999, 61-73).

Carlsson and Rönnqvist (2006, 590-616) and Bredström et al. (2004, 2-22) point out that a supply chain in a pulp producing company has several integrated stages. These include: harvesting, the transportation of logs, production at mills, storage (at mills, in forests and in ports), distribution to terminals by ships, storage at terminals and distribution by lorry or train to customers.

There are some common features for paper industry companies in the area of supply chain management. Four Finnish forest industry groupings; M-real, UPM-Kymmene, Myllykoski and StoraEnso, have a central organization for managing and developing their supply chains on a strategic level. Their daily operations are managed by regional and local organizations. The IT systems are also undergoing constant strong development in each company. The driving force behind the strong IT development is the demand for the better steering and control of the supply chains.

In this research work the supply chain management of the paper industry is defined so that there are three main processes: 1) the order handling process; 2) the production process and 3) the distribution process.

The order handling process is managed by the sales network, which has contact with a company's market. The order handling process provides production with information necessary for production planning. The production process, which includes production planning and production, is carried out by the mills'

production planning staff and by the market coordinators who have daily contact with the sales network. The dispatching, as a process phase, belongs to the mill's operational responsibilities.

The distribution process includes several process phases: The booking of sea transport, the booking of domestic transportation, warehouse planning in the loading port, sea transportation, warehouse planning at the discharging port and finally delivery to the customers. The cargo bookings to the shipping lines are managed by the central logistics function of a paper producing company. The booking of domestic transportation from the paper mills to ports of loading are normally managed by the mills. The annual contracts (railway and port contracts) are made by the central logistics function.

The discharging and warehousing activities in the port of discharge are controlled by the logistics organization located at the port of discharge in the receiving country. The local sales office is responsible for the local warehousing, including time management. The last process phase is delivery to customers, in which, for local distribution, a local logistics organization controls the customer delivery operation.

This research work concentrates only on the distribution process, which includes seven process phases. A detailed analysis of the order handling and production processes are excluded from the research work due to the fact that current IT applications do not have data stored in their history because the current applications were only taken into use in 2005 and 2006. The operational performance of the dispatching and distribution processes is however directly linked to the order handling and production processes.

The hierarchy of the case company's supply chain management, supply chain process phases and supply chains are summarized in Table 3. The supply chains include several physical supply chain management process phases, which are marked with a grey background color.

Table 3: Supply chain management definition, paper industry implementation

Supply chain management, main processes	Supply chain management process phases					
Order handling process	Contact to customers	Contact to the paper mills	Not included in the research work			
Production process	Dispatching	Not included in the research work				
Distribution process	Booking of sea transports	Booking of domestic transport	Warehouse planning in loading port	Sea transport	Warehouse planning in discharging port	Delivery to the customers
Supply chains; case study of four supply chains						

The paper industry supply chain can also be defined as the sum of business processes, which belong to different organizational units. The sales organization's business processes cover all contacts with the customers. The mill's business processes cover such sub-processes as production planning and dispatching. The logistics service providers' processes cover all the processes for the transportation, warehousing and logistics. The customer processes include a loop that covers placing orders and receiving orders from the customers' premises. This process based supply chain management approach has been described by several authors (Hewitt, 2002, 334-341, 1999, 785-790; Stewart, 1995, 38-44; Bechtel and Jayaram, 1997, 15-34; Cooper et al., 1997b, 1-13).

The geographical routes, in this research context, are termed supply chains. In this context collaborative planning with the logistics partners' business processes have helped to build the supply chain management of the case company. Information systems enable supply chain management. The case company's sales organization has their own order handling processes, including connections to customers, and the paper mills have production as their main process. The logistics service providers have their internal business processes. Collaborative planning combines these different business processes into one supply chain entity, while joint IT solutions give the supply chain transparency.

The case company's supply chain management processes are summarized in Table 4, which in general, also reflects supply chain management processes for other paper producing companies.

Table 4: Case company, supply chain management process phases and organizational responsibilities

<i>Supply Chain Management Process Phase</i>	<i>Main process</i>	<i>Owner of the process</i>	<i>Included in the case study</i>
	Order processing, order taking	Sales network	No
SCMPP # 1	Production planning	Paper mill	No
	Production	Paper mill	Yes
SCMPP # 2	Logistics planning (both long and short term planning)	Central logistics organization and paper mill	Yes
	Dispatching at the paper mill	Paper mill	Yes
SCMPP # 3	Land transportation to the port of loading	Paper mill	Yes
SCMPP # 4	Port operations in port of loading and port warehousing	Central logistics organization	Yes
SCMPP # 5	Sea transport	Central logistics organization	Yes
SCMPP # 6	Port operations in port of discharge and port warehousing	Sales network and local logistics department	Yes
SCMPP # 7	Delivery to the customers	Sales network and local logistics department	Yes

There are several views on the ownership of paper industry supply chains. Table 4 shows that individual processes are owned by several organizational units, but there is no “real and one owner” of the supply chain. Some paper producing companies consider ownership to belong to the producing mills, while other companies regard supply chain ownership as belonging to the sales network.

### 2.5.2 Case study design

The first step in the case study design is to decide whether to use a single case study or a multiple case study design and if each case includes single or multiple units of analysis. Yin (1994, 9) argues for the use of single case study design but only when the rationale for using a single case study design is the existence of critical, extreme or unique cases only. Yin further states that if the findings from the research meet all the requirements for explaining a theory, the theory is strengthened. One motivation for using the multiple case study design is the gaining of access to several objects; however, multiple case studies include large amounts of data and make great demands on resources.

The analyzed cases can be selected in different ways, but Yin (1994, 9) states that selection should not be based on a sampling strategy. He recommends a replication strategy meaning that a case should be selected to provide either



similar results (literal replication logic), or contrasting results but for predictable reasons (theoretical replication logic).

In this research, the case study design was originally implemented on a practical level by contacting two potential companies with a view to conducting a case research of their lead time management. After the selection of the case company, discussions with the case company's representatives started in order to understand what type of statistical data was available for the research. Several discussions were held with the case company's key personnel to solve that challenge, and to work out how to link data from different IT applications so that a lead time and supply chain process phased analysis could be performed.

The available data and its structure supported the idea that by using regression analysis, several explanatory parameters could be used for explaining the length of the lead time. This is because the lead times could be measured by using data from the case company's IT applications based on the selected supply chain management process phases.

After the selection of the method of analysis the case mills were selected. The selection of the mills was determined by the case company's logistics senior management's knowledge of both strategic and operational aspects, which helped select the most appropriate mills. Of the mills chosen one loaded its whole production directly onto railway wagons without any warehousing at the mill, while the other mill has a large warehouse facility. Lead time data, meaning time stamps, were retrieved from three different IT applications. The data was sorted in large tables, where the lead times could be calculated for each of the supply chain management process phases.

The content of the lead time and production data was discussed several times with representatives from the case company and the data was considered to be reliable after four to five rounds of data retrieval. The correctness of the data was then finally tested in discussions with a mill's representatives.

After the data correctness was approved regression analyses were made. During the analysis several new parameters and several new time entities were tested in order to find out explanatory parameters for the lead times.

As soon as the results from the regression analysis were documented in a uniform way, the results were discussed with a mill's logistics organization's representatives in order to gain a business understanding of the regression analysis results.

The conclusions were drawn based on results from the regression analysis. The conclusions were supported by information gained from the strong business understanding held by the case company representatives.

### 2.5.3 The analyzed cases

In discussions with the case company's senior logistics management different Finnish paper mills were discussed as alternatives for the case study. At an early stage of planning a paper mill located in the USA was also on the agenda, but had to be left out as the local IT applications could not provide similar, comparable lead time and production data as those applications used in Finland. Also the business model in the USA based paper mill is different as all distribution is taken care of by local trucks and the lead time has actually only three main supply chain management process phases: mill warehousing, mill dispatching and customer delivery.

Two paper mills from Finland were finally selected as case study objects. One of the mills (mill A) is located in the South Eastern part of Finland and the second mill (mill B) is located in Central Finland. The A mill's supply chains go via an Eastern Finnish port and the B mill's supply chains go via a Western Finnish port. The A mill belongs in the category of a medium size paper mill measured according to production capacity and B mill belongs in the large production capacity as it has an annual production of approximately 0.9 million tons.

Both paper mills have several paper machines (PM), but for the research work only one paper machine per mill was selected as a research object. At A mill PM 2 was selected and at B mill PM 6 was selected. The motivation for selecting these paper machines was that both paper machines produce their own type of paper qualities for the same markets.

For both mills the UK and the USA markets were selected as research objects. The UK and USA markets were selected because customers in both markets play an important logistics role for the case company and the supply chains. In addition, these markets were considered to be representative of other market areas as well.

Lead time and production data from the year 2003 was agreed to be used as this year was considered to be a normal production year. However, the winter period during 2003 was very cold in Finland and this caused vessel schedule delays due to the ice conditions on the sea routes. The delays were around five to seven days during a four week period.

Another reason for supporting the selection of year 2003 was that comparable IT applications were still in use and it was possible to retrieve the lead time and production data from the IT applications for 2003. During the following years there was a major change in the case company's logistics IT applications.

## 2.6 Methods of collecting lead time and production data

### 2.6.1 Collection of the case company's lead time and production data

During the research period the IT applications of the case company underwent strong development, which meant that there were only limited resources available for making data retrieval from the existing applications. Due to the historical IT architecture solution the data had to be retrieved from three independent IT applications. The mill's IT application controlled the production, mill warehousing and dispatching lead time stamps. The logistics organization's IT application controlled the lead time stamps from warehousing in both the loading and discharging ports. The sales organization's IT application controlled the customer delivery lead time data.

After the lead time and production data retrieval, the data elements from three independent applications were combined together by using the unique customer order number as a linking factor for all customer orders. The customer order number is a unique number, which is used in all external and internal communication within the case company, with the logistics service providers and with the customers.

The lead time and production data was first structured in data sheet tables. After the verification and the checking of the correctness of the data the lead time elements were presented in graphic format.

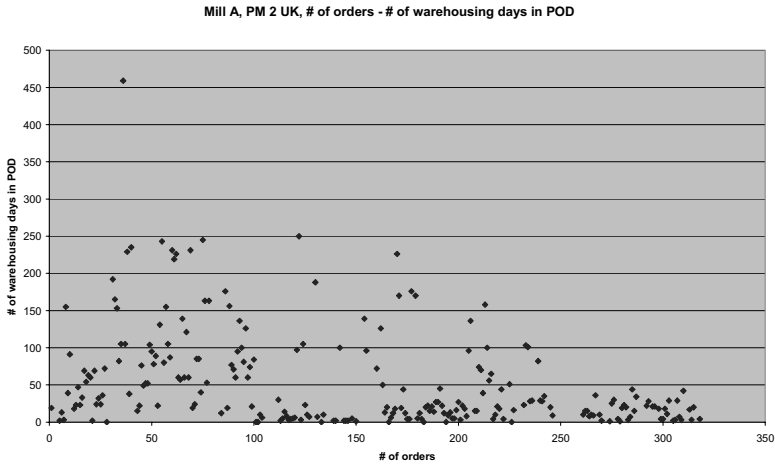


Figure 5: Lead time days in the discharging port, example

The warehousing days for A mill's PM 2 at the UK port of discharge illustrates how the lead time and production data has been structured for the purpose of analysis (Figure 5).

### 2.6.2 Comments on the data's accuracy

The data has been analyzed on a customer order level. In this analysis a customer order is understood as a customer order line. One customer order normally includes several order lines. The data included some mistakes, which have been excluded manually from the analysis. The mistakes were mainly caused by false or incorrect information being placed on the time stamps of the different processes. The number of analyzed order lines is summarized in Table 5.

Table 5: Number of analyzed order lines

Number of order lines	Mill A PM 2 UK	Mill A PM 2 USA	Mill B PM 6, UK	Mill B PM 6, USA	Total
Production days	369	53	176	386	984
Order size	383	55	179	386	1003
Production lots	383	55	179	386	1003
Dispatching days	332	53	177	383	945
Dispatching lots	350	53	177	383	963
Mill warehousing days	353	61	177	390	981
Transport to port of loading	Same as above	Same as above	Same as above	Same as above	
Transport lots					
Warehousing days in port of loading	304	52	154	323	833
Vessel loadings days	322	41	155	324	842
Shipments	332	42	155	322	851
Warehousing days in port of discharge	236	28	110	292	666
Customer delivery days	271	49	143	410	873
Customer delivery lots	273	49	143	411	876
Lead time days	267	38	134	335	774

The supply chain process analysis covers 1,003 order lines from 1<sup>st</sup> January, 2003 to 31<sup>st</sup> December 2003. The A mill's PM 2 has approximately 380 order lines to the UK market and only 55 order lines to the USA market. The B mill's PM 6 has approximately 180 order lines to the UK market and 390 order lines to the US market. The analyzed order line data is limited to one year, starting 1st January 2003 and ending 31st December 2003. The number of analyzed order lines for each of the supply chain processes differs because some of the orders were produced at the end of year 2002 but were dispatched and delivered to customers during 2003. Some of the orders were produced at the end of year 2003 and were dispatched and delivered to customers during year 2004. The individual observations for each of the supply chain processes are grouped according to selected criteria (number of days, number of lots etc).

### 2.6.3 Interviews

As soon as the basic lead time and production data was sorted in a systematic way for the purpose of analysis and presented in a graphical format the content of data was discussed with the representatives from the paper mills. The mill representatives were in charge of the production planning and customer contacts. These people also had daily contact with the logistics service providers. All major exceptions or extreme values were analyzed so that the data could be considered to be representative and correct with regard to the business. Mathematical correctness

was verified by double checking the calculation formulas and the content of the figures.

#### 2.6.4 Case study and lead time definitions

The analysis of the case supply chains is based on the actual lead times for the customer orders. The case company has been using the lead time analyses only for some selected supply chain management process phases. In this research the lead time method of analysis now includes all supply chain management process phases from production to delivery to customers.

The order taking processes were originally planned to be included in the analysis. The order handling process includes three sub processes: 1) sales orders (sales office – customer), 2) mill orders (sales office – mill) and 3) order confirmations (mill – sales office – customer). The order taking day, as part of the total lead time, had to be excluded from the analysis due to the fact, that the order handling IT systems do not record the historical data for order changes, only the last change was recorded. Another reason for excluding the order handling processes was that one order can cover delivery lots for several months ahead.

The order taking processes were excluded from this study due to data availability, but the case company made an internal, manual analysis covering the order handling processes of the sales network and all Finnish mills. The analyzed time period was from January 2003 to June 2003. During this period the sales network in selected countries had registered approximately 50,000 order lines equal to 2.1 million transported tons. The analysis revealed that approximately 40 percent of the orders are changed by the customers and by the sales network, thus causing changes that affect the logistics planning. The average time for production planning is considered to be two to three weeks. Every change in an ordered quantity resulted in new production planning at the mills. The production planning time is the time starting from the order taking day and this ends when production starts (interview with the case company, operations manager, logistics 15<sup>th</sup> September 2005).

The total lead time (physical distribution lead time) is analyzed based on the number of total lead time days, which covers the supply chain process phases from one to seven including the actual days for each individual process phase. The mill dispatching is reported for the warehousing time at the mill and the customer delivery time is reported for the warehousing time at the discharging port.

The actual lead time and production data is retrieved from three independent IT applications of the case company. The first IT application manages data from the mill (from production to mill dispatching), the second IT application manages data from the mill to the warehouse in the discharging port and the third IT application manages data from the discharging port warehouse to the customer. By using the unique customer order numbers the data for the customer orders can be linked together for the purpose of analysis.

The total lead time in this empirical case study is defined as time between first production day and last customer delivery day for one customer order, measured in days. The total lead time is then divided into individual process phase lead times. The lead time scope for the individual processes phases is the starting time of the process phase and the ending time of the same process phase. The number of days for each of the orders moving in the analyzed supply chains is reported. The total lead time also explains how long a time the mill's or the customer's capital is bound up in the lead time to the final customer.

The total lead time is described in two different ways. The first way is the absolute lead time, which is the time (in days) between the first production day and last customer delivery day.

The second way of describing the lead time is by the use of an overlapping lead time, which is the sum of the individual process phase lead times calculated according to the mathematical average values of the individual process phase lead times.

The analyzed supply chain management process phases and their respective lead times are: 1) production; 2) warehousing at the mill including dispatching from mill to port of loading; 3) transport to port of loading; 4) warehousing time in the port of loading and vessel loading; 5) sea transport to port of discharge; 6) warehousing time in the port of discharge and 7) customer delivery.

Each of the analyzed supply chain management processes phases have their own lead time, which is the time between the starting time of the process phase and the ending time of the same process phase. One example is that supply chain management process number one has its own lead time, which is termed lead time (LT number one) and the mathematical average value (A) represents the individual process phase lead time.

The analyzed supply chain process phases and their lead time definitions are described in Figure 6.

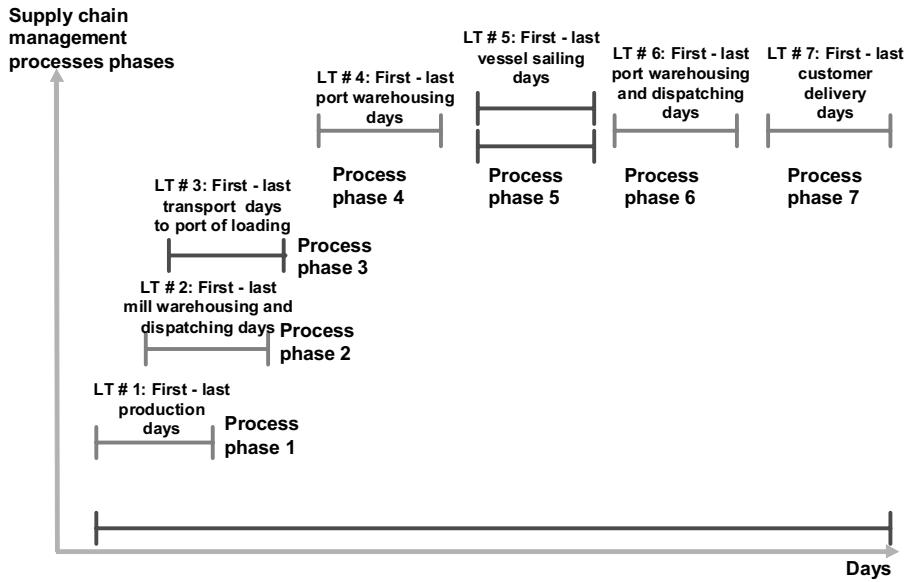


Figure 6: Case study analysis, supply chain management process phases and lead times

The presented lead time methods of analysis describe the theoretical framework of this research work. The theoretical framework was developed based on empirical know how gained from the paper producing industry. The functionality and the theoretical framework will be tested by using empirical data from the case company.



### **3 THEORETICAL FRAME OF REFERENCE**

#### **3.1 The evolution of supply chain management**

During the 1990's researchers and practitioners began to analyze supply chains as a whole. Customer focus, supplier partnership, co-operation, information sharing and business process management were promoted as core components of supply chain management (Hamel and Prahalad, 1989; Christopher, 1992, 1999; Lee and Dale, 1998).

Stabenau et al. (1996, 10-11) categorizes the development of logistics in four different phases. The first phase is seen as occurring in the 1960's when the sellers market gradually became a buyers market. Distribution was considered to be part of marketing strategies, with optimum distribution structures offering high efficiency at a low cost. Physical distribution (distribution optimization processes, supply to the market) was the key word for logistics. The second phase was when the Japanese car producers entered the European market in the 1970's with mass produced vehicles. To cope with the influx European car manufacturers changed their production strategies from mass production to make-to-order production. Production planning and control became part of the logistics chain (Stabenau et al. 1996, 10-11). The development of in-house production signals phase number three. The level of in-house production has changed dramatically over the last 30 years. According to Stabenau et al. (1996, 10-11) the level of in-house production of German companies in the early 1980's was 67 percent yet in 1990 it was less than 50 percent. By 1995 the level had fallen in Germany to 45 percent. These figures clearly indicate the development of the outsourcing of production capacity. The purchasing of components for production increased and logistics transactions increased. The fourth phase is a result of the development of outsourcing. The optimization of logistics processes for improving a company's ability to compete.

World trade and supply chains are currently globalizing. Several reasons for this development can be identified. Customers are becoming more global, there are new customers in the emerging markets. Competitors are also globalizing their

activities. The production processes, including sub contractor philosophies, are also becoming increasingly global. Political trade barriers have been reduced and advances in technology have led to the fact that production takes place where the technological advantage can be best made use of. The globalization of the markets does not mean that world trade will automatically grow. Rather it means that the same products are sold in several countries. Globalization also leads to the establishing of new logistics networks whenever a production plant is relocated and the importance of the domestic sales markets remains unchanged. Innovations in logistics have also improved trading facilities for all companies both locally and globally. The easy-to-use Internet-based trading solutions are also making business more global as for only the price of a telephone communication a business platform can be opened on the Internet.

Drewry (I.T. and Shipping, 2000, 69) defines the key reasons for the globalization of the supply chains.

- Globalization of customers
- New customers in emerging markets
- Globalization of competitors
- Globalization of production – including sub-component operations in low cost environments
- Reduced trade barriers
- Advances in technology
- Greater customer responsiveness

American and Japanese companies are decreasing their procurement processes in their local markets and at the same time they are becoming more active in regional and global procurement markets. European companies are leaving the local market and turning both to regional and global procurement markets. European manufacturers judge their own countries to be threatened manufacturing locations (because of labor costs etc). Asian companies count on having more procurement from the local market and thus hope that regional and global markets will decrease. However, in *The Next Wave of Logistics – Global Supply Chain Efficiency* (Baumgarten and Wolff, 1999, 31) it is mentioned that procurement processes will be more global than local. The trend is also in favor of regional and global procurement. The trend is that there will be more cargo volumes in more frequent shipments and in smaller shipment lots.

Bowersox and Closs (1997, 167) have analyzed the differences between global and local logistics and the authors have identified four specific features, which separate them.

The first feature is that global performance cycles are generally much longer, because of greater distances, more intermediaries and, significantly, the use of slow ocean transport. On the contrary local logistics have much shorter delivery times to customers.

The second feature is that global logistics operations are more complex as a result of the increased number of stock keeping units, more extensive documentation, a greater number of inventory stock locations and less developed service suppliers, such as carriers and warehouse operators. In a global logistics chain there are normally several logistics service providers. Local logistics are usually operated by a fewer number of actors.

The third feature is the demand placed on information systems, which is increasing because of the requirements for extended communication, alternative languages and process flexibility. Global logistics employ several logistics service providers and the information flows of these service providers have to be linked with each other. In local logistics, the number of logistics service providers is normally quite small and thus the need for information exchange between the partners is lower. Global logistics can only be successful if the management of information is successful.

The fourth feature is the challenge to develop and maintain global manufacturing, logistics and marketing alliances (Bowersox and Closs, 1997, 167). As business operations are global, company alliances also have to be on a global level. In a local market companies can survive with a smaller number of alliance companies.

Each of the service providers in the logistics chain imposes not only time and costs on the transport chain, but also introduces uncertainty and risk. Uncertainty and risks are among the most expensive and least controllable elements in a trans-ocean supply chain, and therefore effective supply chain management must now devote much of its effort to controlling and reducing such risks. Operational uncertainties, such as the weather and breakdowns are risks, but more important are management mistakes and human failure. Operational uncertainties increase as the links in a logistics chain increase as there are more opportunities for problems arising from a lack of information or false or poor information, misunderstood communication or ineffective logistics management (Frankel et al., 2002, 57-69).

## 3.2 Characteristics of the supply chains

### 3.2.1 Definition of logistics

Numerous companies have recognized the strategic importance of logistics in the new global environment. More than 50 percent of the surveyed companies consider logistics to be their first or second priority in their internal development. Companies in all trading regions will increasingly involve suppliers and customers in their supply chain processes in order to improve their supply chain effectiveness as the scope moves from local and national to regional and global levels (Baumgarten and Wolff, 1999, 10).

The Council of Logistics Management has defined logistics management as (CLM, 2003): “*Logistics management is that part of the Supply Chain Management process 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 involves the integration of information, transportation, inventory, warehousing, material handling and packaging. The overall goal of logistics is to achieve a targeted level of customer service at the lowest possible total cost. The customers of logistics companies increasingly demand products with added value, but at a lower cost. The competitive challenge for the logistics industry is to find new ways of producing value added services at a lower cost. Fawcett and Fawcett (1995, 24-42) discuss logistics services as an integration tool within a company's business processes. Logistics services aim to integrate with purchasing, marketing, management and other operations in creating success within the supply chain that benefits the customer.

Bowersox and Closs (1997, 12) define logistics from a company's operational point of view. A typical enterprise seeks to develop and implement an overall logistical competency that satisfies key customer expectations at a realistic total-cost expenditure. Very seldom will either the lowest possible total cost or the highest attainable customer service constitute the most desirable logistics strategy. A well-designed logistical effort must have high customer response capability, while controlling operational variance and minimizing inventory commitment (Bowers and Closs, 1997, 12). The same authors split logistics into three operational areas: physical distribution, manufacturing support, and procurement.

To achieve internal integration between the three operational areas, the inventory and information flows must be co-coordinated. The three operating areas must be synchronized toward the simultaneous attainment of 1) rapid response, 2) minimum variance, 3) minimum inventory, 4) movement consolidation, 5) quality and 6) life-cycle support (Bowersox and Closs, 1997, 55).

Cooper (as editor, 1994, 14) defines logistics as the strategic management of movement, storage and information relating to materials, parts and finished goods in supply chains, through the stages of procurement, work-in-progress and final distribution. Its overall goal is to contribute to maximum current and future profitability through the cost-effective fulfillment of customer orders. Cooper's definition of logistics and supply chain management also covers the importance of information handling.

Many authors consider supply chain management as being the same as integrated logistics management and focus their research on inventory reduction both within the individual companies and within partners in supply chains (Jones and Riley, 1985, 16-26; Davis, 1993, 35-46; van Hoek, 1998, 95-109; Boyson et al., 1999; Naylor et al., 1999, 107-118).

Logistics management is an integrative process that seeks to optimize the flow of materials and supplies through an organization to their customers. If all firms involved in a particular supply chain optimize their logistics systems independently of other firms in that chain the management of product flow across the whole chain, or "pipeline", is likely to be suboptimal. Attempts to overcome this problem have resulted in the creation of "supply chain management" (TRILOG-European summary report, 1).

Oliver and Webber made a logistics study on companies in the US, Japan and Western Europe in 1982. The conclusion was that logistics channels did not work in a satisfactory way. The authors introduced a new perspective in logistics management, which was called supply chain management. Some major differences were identified when comparing logistics management (steering of production and materials) with supply chain management. The major differences were that supply chains build one entity, supply chain management is dependent on strategic decision making and supply chain thinking provides new possibilities for developing warehousing functions and interaction between partners (Oliver and Webber, 1982, 63-75).

Finnish forest industry logistics has been very much process oriented and based on process integration with logistics service providers. Generally speaking logistics organizations have built up their logistics network including inland transportation, sea transportation, and operations at loading and discharging ports.

However, their logistics organizations have not performed supply chain management as this role has been the business divisions. Hence, Cooper's (as editor, 1994, 14) definition of logistics is also applicable for the Finnish forest industries.

### 3.2.2 Supply chain definition

There are several definitions regarding the scope of supply chains. Supply chain is mentioned in literature for the first time in the 1970's. Banbury (1975) mentions supply chains in his article "Distribution – The final link in electricity supply chain" (1975, 773-775). Banbury's definition had one strategic view, which is still valid after 30 years. The supply chain starts from production and ends at the final customer.

It is difficult to point out the real founder of supply chain management. Several authors have described supply chain management based on different types of business case descriptions.

Hicks (1997, 45) defines supply chains as "... a collection of all components and activities associated with the creation and delivery of a product or service." Bowman (1997, 28-32) and Hanfield and Nichols (1999, 2-3) highlight the importance of information flows by including logistics related business processes such as order processing. The authors also include inbound and outbound transportation to supply chains.

Several authors (Lambert et al., 2000, 65-83; Cooper and Ellram, 1993, 13-24) have discussed the interdependence between supply chain management and logistics. The general understanding is that, in supply chain management, logistics systems cover the total material and information flow from supplier to end customer including supporting activities, physical facilities, information systems and organizations in the participating companies. Lambert and Cooper (2000, 65-83) discuss the supply chain framework, which consists of three main components: supply chain network structure, supply chain processes and supply chain integration. The supply chain network structure contains the participating companies and their physical cargo handling facilities. The supply chain processes contain the necessary business processes (order handling, demand management etc.) for managing the supply chain. Supply chain integration contains IT systems and jointly agreed reporting systems. The integration also contains the integration of management philosophies between the participating companies.

Lee (2001, 1-12) defines the functionality of demand chain management as obtaining more reliable and detailed information about their consumers. It provides information on changing customer tastes, evolving product life cycles and the impact of promotions. The integration between demand chain and supply chain management will lead to supply chains which deliver the right products and services with greater frequency. Heikkilä (2002, 747-767) defines demand chain architecture as understanding the nature of demand and developing a modular demand chain structure including order penetration points, inventory buffer locations and sizes, and assembly capacity. Uncertainty in the demand chain planning is widely discussed. Davis (1993, 35-46) states that uncertainty has a major influence on supply chain planning. Sources of uncertainty here include a lack of information about supplier performance, manufacturing processes and customer demand. Schwarz and Weng (2000, 231-253) have analyzed uncertainty from the perspective of the lead time's influence on safety stocks. Their conclusion is that a reduction in the uncertainty of lead times improves the whole supply chain's performance. Stalk (1998, 41-51) has come to a similar conclusion. He suggests that demand chain efficiency can be improved by reducing time delays in the flow of information and materials through the whole demand chain.

The Council of Logistics Management defines supply chain management as (CLM, 2003): *“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.”*

Baumgarten and Wolff (1999, 15) describe the evolution from logistics to supply chain management in a very practical way. Classic logistics contains the traditional functions of logistics (warehousing, shipping, external transport and materials management). Total logistics management, however, has developed from classic logistics management by adding new functions, such as internal transportation, order processing, procurement and production planning. Supply chain management includes product development, the management of information systems, production control, quality control, customer service and recycling and waste management. The Baumgarten and Wolff definition of the development of logistics management towards supply chain management is illustrated in Figure 7 (Baumgarten and Wolff, 1999, 15).

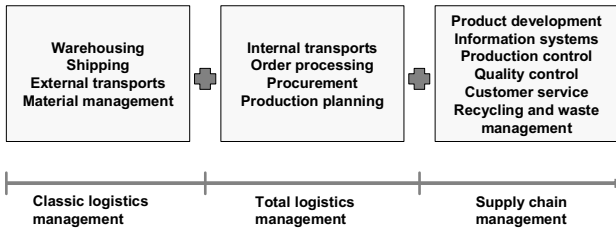


Figure 7: The development of logistics management towards supply chain management, Source: Baumgarten and Wolff, 1999

Coyle et al. (1996, 1) have identified seven different factors, which are typical of logistics. Traditional logistics is normally very much firm focused, including cost minimization for one’s own firm. In the supply chain approach most of the factors are described as being on a collaborative level. Inventory management is defined as pipeline coordination between partners. Inventory flows are said to be visible between partners and information and risk factors are factors that are shared between them. Supply chain planning is defined as constituting a team work approach between partners. The landed cost principle means that all supply chain partners have an understanding of the costs they are creating in the supply chain and how these cost elements affect the final product. In the supply chain approach the partners have a realistic understanding of the partner’s costs.

Coyle et al. (1996, 9-11) have compared the differences between traditional logistics and supply chains and their main findings are summarized in Figure 8.

Factor	Traditional	Supply Chain
Inventory management	Firm focused	Pipeline coordination
Inventory flows	Interrupted	Seamless/visible
Cost	Firm minimized	Landed cost
Information	Firm controlled	Shared
Risk	Firm focused	Shared
Planning	Firm oriented	Supply chain team approach
Interorganisational relationships	Firm focused on low cost	Partnerships focused on landed cost

Figure 8: Comparison of the Key Characteristics of Traditional Systems with a Supply Chain; Source: Coyle et al., 1996

Berglund (1997, 19-22) has analyzed supply chains in connection with third party logistics providers. Berglund defines (1997, 21-22) supply chain management as a concept that stands for the management of chains as opposed to the management of the individual entities of a chain. The ultimate goal of supply chain management is to achieve supply chains that operate as one coordinated



entity, even though each entity is individually governed. “Supply chain management is complete when all individually governed entities of a generic supply chain are, in all critical processes of business making, managed as one coordinated entity.”

Christopher (1994, 15) analyzes supply chain management as an organizational issue. Supply chain management is based on partnerships in the marketing channel and one or more linkages between the entities in a marketing channel. The traditional view in logistics aims at maximizing company specific profits and at the same time minimizing costs without taking into consideration how these aims affect business partners. Under the supply chain management model the goal is to maximize profit through enhanced competitiveness in the final market. This competitive advantage can be achieved by serving the final customer in the shortest possible time frame. All partners in the supply chain can reach this goal only if the supply chain, as a whole, is closely co-coordinated. This means individual companies do not compete with each other as company against company. Hence, modern competition is between supply chains.

The philosophical objectives of supply chain management can be summarized with reference to three objectives: The first objective is to improve overall transparency for all partners in a supply chain. The second objective is an improvement in overall process co-ordination. The third objective is to find faster ways of responding to planning and performance reporting.

In this research work the paper industry supply chain management definition for ready made products is based on the individual process phases. Some of the supply chain management process phases are controlled by the paper industry itself and some of the process phases are managed by the logistics service providers. In the paper industry supply chains there are several logistics service providers with their own business processes, which are integrated into the paper industry’s supply chains.

### 3.2.3 Supply chain research

Supply chain management and other similar terms such as “logistics management”, “network sourcing”, “value chain management”, “supply pipeline management” and “value stream management” have received increasing attention from academics, consultants and from the operational and strategic management of companies (Scott and Westbrook, 1991, 23–33; Saunders, 1995, 476-485; Cooper et al., 1997 a, b; Tan et al., 1998, 2-9;). These terms describe the integration of

those business processes that start with the supplier's suppliers and end with the customer's customers. These business processes cover order handling, production, the delivery of goods and services to the final consumers. According to this business process based approach, companies do not seek cost reductions or profit improvements at the expense of their supply chain partners, but instead seek to make the supply chains more competitive as a whole.

Logistics and supply chain management have been researched with respect to the scope of their business processes and contribution to business success and improved customer service (Cooper et al. 1997b, 1-13). Bechtel and Jayaram (1997, 15-34) describe the research evolution of logistics and supply chain management. Logistics and supply chain management were considered to be part of the interorganizational relationships and physical distribution management part of marketing channels. However, the current thinking within logistics and supply chain management research is that they are part of the integrated materials management activities, both at intra-organizational and inter-organizational level, which leads to the satisfaction of end customers. Logistics and supply chain management are also closely linked to marketing strategies. Flexibility is required from supply chain management in order to support marketing strategies both long and short term. Generally speaking this means that supply chain management needs to be flexible in the short term to offer operational opportunities and also be flexible in the long term in order to offer new marketing channel solutions. Flexibility is in this context understood as "the ability to change or react with little penalty in time, effort, cost or performance" (Upton 1994, 72-89). Marketing and distribution channel theory have also transferred analytical know-how to logistics and supply chain management by clarifying the role of supply chain management in marketing and in distribution (Coughlan et al. 2001).

Heikkilä divides supply chain management research into two main categories. The first category deals with research concerning the chain structure (e.g. Forrester, 1958, 37-66; 1961; Burbidge 1961, 769-784; Sharman, 1984, 65-77; Sterman, 1989, 321-339; Towill et al., 1992, 3-13; Lee and Billington, 1992, 265-73; Lee et al., 1997a, 93-102, 1997b, 546-558; Holmström, 1994, 91-98, 1995, 185-191; Fisher, 1997, 105-116) and the second category deals with industrial networks and the relationship between organizations in the supply chain (e.g. Williamson, 1985; Heide and John, 1990, 24-36; Mohr and Spekman, 1994, 135-152; Hakansson and Snehota, 1995; Kumar et al., 1995, 348-356; Dyer, 1996a, 271-291, 1996b, 649-666, 1996c, 42-56, 1997, 535-556; Monczka et al., 1998, 553-573).

The supply chain management of the paper industries covers both aspects defined by Heikkilä. The logistics organization of the paper industry manages supply chain structure by contracting logistics service providers, who then carry out the daily supply chain operations. This is called, in this research context, integration with logistics service providers. Logistics service providers co-operate with each other in order to create a well functioning supply chain to the customer. The co-operation between the different logistics service providers is very important for the successful operation of the customer's supply chain. An example of co-operation between the logistics service providers is performance reporting. Performance reporting from one logistics service provider is used as planning information for the next service provider. In the case study analysis for example the railway company informs the port operator of the arriving wagons and this information acts as planning information for the resource planning of the port operator.

### 3.2.4 Strategic aspects of supply chains

Supply chains can be understood as a mutual dependence between firms in marketing channels (Alderson, 1957; 1965; McCammon and Little 1965; Stern, 1969). Existing interdependencies create a basis for collaboration between companies in order to achieve individual and mutual goals. Supply chains can be regarded as single entity (Alderson 1965), a super-organization (Stern et al., 1996) or a social system (Balderston, 1964, 176-189) that consists of independent companies which distribute products to consumers.

A growing range of goods, a higher number of customers, more orders per customer and decreasing order sizes are the basic driving forces of the increased importance of supply chain management. The competition structure between companies has changed. Competition is no longer one company competing with other companies, but is one supply chain is competing with other supply chains (De Souza et al., 2000, 348).

There are several ways of defining the role of supply chains in a business environment:

- 1 The supply chains are based on the philosophy of integrating activities in order to manage the total flow of a distribution channel from supplier to ultimate customer (Cooper and Ellram, 1993, 1-10).

- 2 A strategic concept that involves understanding and managing the sequence of activities – from supplier to customer – that add value to the product supply pipeline (Battaglia and Tyndall, unpublished, 1996).
- 3 The integrative management of the sequential flow of logistical, conversion, and service activities from vendors to ultimate consumers that are necessary to produce a product or service efficiently and effectively (Stenger and Coyle, 1996).

Cusumano, (1985, 1994); Håkansson, (1987); Contractor and Lorange, (1998); De Bresson and Amesse, (1991, 363-379); Thoburn and Takashima, (1992) have described supply chains as an inter-firm production relationship. In these organizations coordination between the companies of the procurement-production-delivery cycle is a prerequisite for building effective supply chains (Lamming, 1994). In order to make coordination successful companies have to agree on joint organizational and logistics integration rules.

Supply chains are normally the sum of collaborative business processes between several partners. Mentzer et al. (2000, 52-58) define supply chain collaboration as a long term relationship between partners, in which they actively work together as one towards common objectives. Several authors have analyzed the collaborative functions of such supply chains. Andraski (1999) concludes that supply chain collaboration is a business tool that builds sales. Citera et al. (1995, 551-559) define supply chain collaboration as an interaction among peers sharing a common set of goals and measures. Haeckel (1998, 63-71) defines supply chain collaboration as a process in which partners jointly search for solutions. Sriam et al. (1992, 303-320) define collaboration as a relationship in which trading partners develop a long term cooperative effort. Alvarado and Kotzab (2001, 183-198) define supply chains also as “an integration of business processes among channel members with the goal of better performance for entire channel system.” Carbonara et al. (2002, 159-176) define supply chain management as “the integrated and process oriented management of material and information flows, which connect the source of supply to the end customers, with the aim of producing value for the customers, by improving customer service and lowering costs.”

Although supply chains can be defined in several different ways, the essence of a supply chain is the integrated management of the sequential flow of materials and associated activities from vendors to the ultimate customer. The effective management of a supply chain requires certain key characteristics, pipeline coordination and seamless flows of inventory, a focus upon the landed cost to the

customer, sharing information and risk, planning based on the supply chain team and a strong partnership or alliances (Coyle et al., 1996, 22). According to Coyle et al. supply chain management is the managerial tool for planning, operational supervising and the financial control of the supply chain (Coyle et al., 1996, 22).

Supply chain management requires, in principle, two types of information: planning information and performance reporting. Planning information is used for the operative planning of the supply chains and performance reporting is used for controlling supply chain performance. The role of information in supply chain management is very important. The boundaries among partners in a supply chain gradually disappear as the level of integration, collaboration and information sharing is improved between the partners (Preiss et al. 1996; Marshall et al., 1999 a).

Vrijhoef and Koskela (2000, 169-178) illustrate a set of three supply chain typologies. The first type of supply chain strategies covers business processes, such as order information transparency, a reduction in variability, the synchronizing of material flows, the management of critical resources and the configuration of the supply chain (Lin and Swah, 1998, 197-299). The second type of supply chain strategies covers additional processes, such as the establishment of stable partnerships, the modular outsourcing of components, flexible manufacturing technologies and information sharing. The third type of supply chain strategies includes all partnership elements, logistics management, controlling the flow by involving all the actors in a chain and continuous improvement (Giunipero and Brand, 1996, 29-37).

Anon (1997) defines three business management levels of supply chain management. The reactive level of supply chain management is defined as purely satisfying a request from a trading partner. The tactical level of supply chain management includes the implementation of specific business processes in order to improve the efficiency of the operations. The strategic level includes integrated supply chain management, where the partners set joint development processes and joint targets.

### 3.2.5 The role of logistics service providers in supply chains

Logistics service providers participate in their customers' supply chains in their specific operational areas. Logistics service providers have to be very flexible in order to match the supply chain requirements of several customers. Each customer can have different requirements for transportation and warehousing. The challenge

for logistics service providers is that they have to serve several customers using their joint networks and joint transport capacity according to the individual needs of the customers.

The logistics service providers have to differentiate themselves from their competitors and, in order to attract new customers, they must offer better service quality than their competitors (Rowley, 1998, 321-333). Parasuraman et al. (1985, 41-45) define service quality as the difference between a customer's expectations of the service and the perceptions of the services they actually receive. The authors define ten characteristics which constitute quality in services: reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding the customer and tangibles.

The companies normally have several types of supply chains depending on the products and even on the organization of the company. This is the case with the forest industries. Paper products have a different operational supply chain compared to timber product supply chains or pulp supply chains. Even the logistics service providers may be different.

Choi and Hartley (1996, 333-343) argue that logistics service providers in a supply chain face different competitive environments, which are generated by the different requirements of buyers or product markets. Logistics service providers have to provide individual services for their customers. Fung and Wong (1998, 324-329) also discuss the role of the logistics service providers. According to the authors, the role of the logistics service providers is to align suppliers' and customers' marketing objectives through technological resources and organizational structure. Stank et al. (1996, 43-57) discuss the role of logistics service providers from the information exchange point of view. They argue that responsiveness and a customer's perception of a logistics service provider's performance is said to be the main concern of the logistics service providers.

Gloshal and Gratton (2002) have defined supply chain integration with regard to logistics service providers as being the sum of four different types of integration, which have a strong internal influence. The first type of integration is operational integration, which includes standardized technologies and infrastructure. The second type of integration is intellectual integration, which includes shared know how. The third type of integration is social integration, which includes such elements as collectively agreed performance criteria. The fourth type of integration is emotional integration, which includes such items as common purpose and identity. Several other authors (Christopher 1992, Herzt 2002, 21-22) include the following items in integration: information sharing, common standards, a common culture, the coordination of independent flows,

joint planning, joint mission, joint product development and increased social contacts.

In this research context the logistics service providers are the port operators, shipping, trucking and railway companies. The operational processes of these companies create the supply chains of the paper industry. The sum of the individual operational processes of the logistics service providers creates the whole supply chain for a paper industry. A paper industry supply chain includes both in-house operational processes and operational processes provided by logistics service providers.

### 3.2.6 Supply chains and information technologies

An increasing number of companies are implementing modern information technologies in order to facilitate communication between supply chain partners and at the same time these companies want to bring the customer closer to them. Sharing information with customers and suppliers enables companies to know the current situation of a supply chain. Having the right information, in the right place, at the right time makes logistical decision making more streamlined and ultimately helps to create competitive advantage. In particular, multinational supply chains depend as much on the reliable flow of materials as on the reliable flow of information.

The words information and data are often used with the same meaning. The difference between information and data lies in the fact that knowledge is obtained in relation to information not to data (Jansen 2001, 18).

Customer demand is the starting point of the supply chains. The distributors, suppliers and the manufacturers have to co-operate in order to meet customer needs. Operational reporting is based on IT solutions and this provides the necessary tools for supply chain partners to overview their performance in order to meet customer needs.

Supply chain management aims at optimizing all information, material and value flows including the customer's customers and the supplier's suppliers. The companies have to go from sub-optimizing to the full optimization of the supply chain. An integrated supply chain structure seeks to minimize inefficient logistics activities and to avoid the waste of resources.

Leading logistics companies and logistics service provider companies typically have information systems that are capable of monitoring logistical performance in real-time, which gives them the capability to identify potential operational

breakdowns and take corrective action prior to customer service failure. EDI and Internet-based applications provide the necessary means to create transparency and information integrity and ensure a sufficient flow of information with consolidated supplier-buyer relations.

Information exchange is a crucial component in a successful supply chain partnership. Monczka et al. (1998, 553-573) define information exchange as containing two components, which are information sharing including information quality and the level of participation. Mohr and Spekman (1994, 135-152) define information sharing as the extent to which critical and proprietary information is communicated to supply chain partners. Information sharing can be measured by the quality and quantity of information. Information quality includes such components as the accuracy, timeliness, adequacy and credibility of the information exchanged (Huber and Daft, 1987). Information participation typically describes the scope of collaborative supply chain planning.

Gavirneri (2002, 644-651) states in his research, that organizations have identified the role of information sharing. According to Gavirneri information sharing is a low cost approach to improving the efficiency of supply chains. Gavirneri also states that in order to reach the benefits of information flows, the operative processes have to be streamlined first. Cachon and Fisher (2000, 1032-1048) and Aviv and Fedegruen (1998) studied the benefits of information flows in one warehouse multi-retailer system. Both studies came to the same conclusion that order handling and warehousing costs could be reduced by approximately 2 percent with the better use of IT solutions.

Kalchschmidt et al. (2003, 397-413) have grouped supply chain information into two categories: local and global information. Local information implies that each location sees demand only on that order information, which is handled in the specific location. The location also has only local visibility in an inventory status and on a local cost structure. Global information means that the decision maker has total visibility of the demand, cost and inventory status of all the locations in a supply chain.

Electronic links between the supply chain partners enables companies to transmit and receive purchase orders, invoices and shipping information. The lead times of information sharing should therefore be much shorter than previously and cut the total time required for order handling and dispatching (Murphy, 1998, 115-118). Electronic commerce also opens up new possibilities for links between supply chain partners via the improvement of flexibility in market channel development (Aldin and Stahre, 2003, 270-279).



Coyle et al. (1996) define the role of information systems architecture in supply chain management by stating that overall information system architecture must be capable of linking the information systems of an individual chain's partners into a cohesive information system. To do that the information systems should support both proprietary and shared data. Proprietary data is in-house data used by the company. Shared data is used for managing a supply chain. Shared data should be available via information interfaces to customers, logistics service providers and other parties involved in a supply chain's operations. Martin (1995) has proved in his research that by using modern information technology, and by sharing information between partners, companies can increase resource utilization and reduce costs.

Stefansson (2002, 135-146) has defined logistics information systems based on Kotler's (1986) value chain by saying; "A Logistics Information System is an interacting structure of people, equipment, and procedures which together make relevant information available to the logistics manager for purposes of planning, implementation, and control."

Hofman & Reiner (2006, 214-230) point out, that there are two specific supply chain enablers, business processes and information technologies. Intensive in-house collaboration between the business processes and information technologies assists companies in improving their supply chain performance.

### 3.2.7 Supply chain and logistics management as an organizational issue

Results from logistics and supply chain management research and from practical business implementations have helped to develop logistics organizations in companies. The growth and development of logistics organizations occurs in three stages: an operational orientation, a managerial orientation and a strategic orientation (Coyle et al., 1996, 558). Stevens (1989, 3-8) also points out that logistics development should be analyzed on three different levels, strategic, tactical and operational.

Business process management and development is considered to be a general approach to organizational development. Zairi (1997, 64-80) defines business process management as "a structured approach to analyze and continually improve fundamental activities such as manufacturing, marketing, communications and other major elements of a company's operation." This definition of the business process development fits well with the process oriented supply chain management of the paper industries. McAdam and McCormack (2001, 117) and Lee and Dale

(1998) and Peppard and Rowland (1995) suggest in their articles that a supply chain can be used inter-changeably with business processes.

There are several ways of describing logistics and supply chain functions and organizations in a manufacturing company. Coyle et al. (1996, 521-522) describe the evolution of logistics organizations as development in three stages. *In stage one* the focus is on operational activities, such as the effective management of finished good transportation and warehousing. The co-ordination of the warehousing and transportation are the only common features for logistics integration. These are typical functions for a logistics organization. The objective of *stage two* is to integrate the distribution of finished goods and to control inbound transportation. The individual activities are considered to be part of an overall physical distribution process. The finished goods distribution and the control of inbound transportation are normally coordinated with the marketing and manufacturing activities of a company.

The *third stage* suggests the priority of integrating a total logistics process and includes coordinating decision making between the physical distribution and materials management. The overall orientation therefore shifts to strategic issues, such as a company's overall logistics and marketing operations strategy. The changes in the external business environment are responded to as part of the strategic development of a company's activities. The third stage includes such strategic views as reductions in current assets (inventory and accounts receivable), while at the same time the asset productivity and utilization increases. The third stage of logistics organization is close to a typical supply chain management organization.

Coyle et al. (1996, 527-532) have identified three major types of logistics organizations. The main features in the *functional logistics organization* are that several directors of functional activities report to the vice president of logistics and the vice president of logistics reports to the president/CEO. The *logistics service division* in some organizations is the pure supply chain service/management division. The supply chain service/management has complete responsibility for all supply chain services, including distributor management and strategy, contract administration and rebate processing, order fulfillment, inventory management, physical distribution, international distribution services, transportation, invoicing, credit and collection. In this type of organization the president of corporate marketing reports to the president of the supply chain services/management.

The third alternative for structuring the logistics organization is the *process-oriented organization*. There are three major main logistics processes: the order

management process, the replenishment process and the process of developing an integrated production and distribution strategy.

In the Finnish paper industry the role of the logistics organization is frequently discussed as the paper producing companies still work with a separate logistics organization, which mainly takes care of physical transportation, while supply chain management is carried out by mills. The organizational evolution progress of the Finnish paper industry is still under development.

### 3.2.8 Supply chain integration

In the 1960's companies considered their logistics from a total system perspective. At the end of the 1990's companies started changing their strategies and began moving in the direction of channel integration. Channel integration is defined as channel partnership and as strategic alliances (Stern et al., 1996, 150). According to Stern et al. (1996, 150) the main purpose is to streamline physical and information channel flows by reengineering the distribution processes (Stern et al., 1996, 150). Channel integration has changed management thinking from logistics cost minimizing to profit improvement and an improved level of customer service. The channel strategy formulation begins with the determination of customer needs and requirements.

Cooper et al. (1997a, 67-89) see supply chain management as a philosophy for integrating all the business processes in the life of a product or a service. Their definition covers processes from the earliest source of raw materials to the ultimate customer. The authors point out that customer focus is an integral part of the supply chain. Every partner in the supply chain must have the same mission and objectives, which is; to satisfy the final customer and to maximize the value added by the overall chain. Bask and Juga (2001, 136-152) have structured supply chain integration into several independent types of integration, which reference structural integration (e.g. Bucklin, 1996), system integration (e.g. Integrated Advanced Logistics for Freight Transport, 1996), process integration (e.g. Bowersox et al. 1999; Lamey, 1996), relational integration (e.g. Gummesson, 1999, Lambert et al., 1998) and other types of integration through socialization (Stern et al. 1996). The level of integration can vary between supply chain coordination and full integration.

Cavinato (1991, 10-15) and Kotzab and Schnedlitz (1991, 140-153) define supply chains as strategic partnerships with positive effects on the overall performance of their channel. According to these authors the key element in

supply chain management is the integration of the activities. Heide (1994, 71-85) defines integration as the theoretical typology of inter-firm governance. His definition includes three main relationship dimensions for supply chain integration: relationship initiation, relationship maintenance and relationship termination. These three dimensions describe integration in chronological order. Sohal et al. (2002, 97-109) have listed the main components of integration as being co-operation, collaboration, information sharing, trust, partnership and shared technology. Towill (1997, 37-56) defines integration from the organizational point of view as a seamless supply chain where territorial boundaries between trading partners are eliminated and they in practice operate as being a part of one organization. Wickramatillake et al. (2007, 52-59) point out in their article, that inter-organizational collaboration and learning between partners has to improve in order to achieve good operational performance results.

The concept of integrating business processes within a company can be represented by Porter's "value chain." The value chain contains two types of business processes; primary business processes (inbound logistics, operations, outbound logistics, marketing, sales and services); supporting business processes including infrastructure, human resource management, technology development and procurement. The main objective of Porter's value chain philosophy is to maximize the efficiency of the firm. Maximized efficiency leads to improved profits, to improved competitive advantage and added value for the shareholders (Porter 1987). Integration occurs between the primary activities in each value chain and is enabled by the supporting activities. Integration also takes place between the processes in different companies. Integrated supply chains are supposed to offer several benefits such as shorter delivery times, more reliable customer delivery promises, better scheduling of distribution, lower stock levels, a lower number of quality problems and more stable prices. The conclusion is that competition is more intensive between the integrated supply chains than between individual companies (Christopher, 1994).

Bask and Juga (2001, 137-152) discuss the essence of supply chain integration by stating that supply chain integration is "seen as an avenue to cost reductions or service improvements, and ideally both." This statement reflects the collaborative role of supply chain integration between business partners.

Stern et al. (1996, 151-153) defines six supply chain integration components. These components are: 1) the development of customer service standards; 2) the selection of transportation modes; 3) the determination of the optimal number and location of warehousing facilities; 4) the setting of inventory management and control procedures; 5) the determination of production scheduling involving the

quantity and kind of finished products to be produced and 6) the design of order processing and information systems. The features of these supply chain integration components are discussed later on in this research work in the case study section.

Customer service as the driving force for successful supply chain integration includes aspects which improve the integration level. All jobs in integrated companies should be seen as customer service jobs and quantitative standards of performance for each service element should be defined and the actual performance for each service level should be measured. The variances between the actual service provided and the standards set should be analyzed.

Stern et al. (1996, 154) also mention the role of networked information systems. Joint information systems help the companies to stay better informed. Better information also assists the companies in moving products faster. The authors also state that the collection, creation, management and communication of information is critical for the efficiency and effectiveness of any market channel (1996, 401-402).

Neuman & Samuels (1996, 7-10) have identified a considerable amount of frustration with slow supply chain integration processes in their research. They note that partners lacked trust and missed the implementation of jointly agreed processes such as forecasting, information sharing and performance measurements.

Olsson (2000, 135) has analyzed supply chains in the Swedish construction industry. He has identified six concrete obstacles to the implementation of supply chains.

The first obstacle is organization. According to Olsson, know how is missing in supply chain management. Internal resistance to new thinking was mentioned as one of most difficult problems. The second obstacle concerned dealing with low logistics and supply chain competence within organizations. Limited competition was mentioned as obstacle number three. This is due to the fact that there is not enough competition in the construction industry in order to reduce costs. Attitudes were mentioned as obstacle number four. This obstacle is described as the desire to see differences instead of similarities as treating projects as unique obstructs supply chain approaches. The fifth obstacle is dealing with traditions. Pricing systems with price reductions and a lack of cost transparency creates difficulties for the approach of a supply chain based supply. The last obstacle is a technical obstacle. There is a very large amount of products, and handling equipment for those products, in the construction industry. A lack of technical standards has created this obstacle.

The supply chains are normally based on planning and reporting activities, which are managed in IT solutions. However, there are some arguments that say that a company's management cannot rely on the data produced by the company's IT solutions. These arguments build obstacles to the implementation of information-based supply chain management (Braithwaite & Christopher, 1991, 60-11).

Jones and Riley (1985, 1987, 94-104) have also identified the problems of information systems in supply chain management. Hertz (2002, 24) analyses the dominant problems of integrated supply chains. The biggest problems of the integrated supply chains are low flexibility to changes in a market, the complexity of their supply chains, problems in controlling a supply chain, power conflicts between supply chain partners and cultural issues.

Several researchers have described the disturbances in supply chains (Bruk and El'Yanov, 1975, 50-53; Drucker, 1990, 94-102; Hammer 1992, 38-41; Hay, 1987, 62-66). Drucker and Hammer state that disturbances in a manufacturing capacity can vary between 20 per cent and 50 per cent of the time available in manufacturing capacity.

Svensson (2000, 732-747) has analyzed the vulnerability of supply chains. He defines vulnerability as "the existence of random disturbances that lead to deviations in the supply chain of components and materials from normal, expected or planned schedules of activities, all of which cause negative effects or consequences for the involved manufacturer and its sub-contractors." Svensson (2000, 739) categorizes disturbances as quantitative and qualitative disturbances. Quantitative disturbances are created by a lack of components and materials for downstream activities in the supply chain. Delays in transportation and bad weather conditions are examples of reasons for quantitative disturbances. Quality deficiencies in components and materials, such as poor paint surfaces, measurement errors and non-functioning articles belong to quality disturbances.

Bates and Slack (1998, 63-72) describe the shift of power as one of the supply chain obstacles. The authors mention three simple examples where power has shifted from the customer to the suppliers. A shift of power may occur if the customer is significantly smaller than the supplier and if the supplier is in possession of key technologies and, therefore, may have effective monopoly power. The supplier can lock-in the customer through investments in special production tools and thus make supplier changing very expensive for the customer.

Narayanan and Raman (2004, 94-102) highlight the value of incentives to human behavior, to business processes and finally to supply chain management.

The authors state that executives normally tackle intra-organizational problems, and overlook cross-company problems, because they are easier to observe. The authors further write that there may be different types of hidden actions both in the intra-organizational and cross-company supply chain management. As an example of hidden actions, the authors mention personal incentives in supply chain management. It is quite obvious that personal incentives may cause irrational behavior in supply chains. The hidden actions in a supply chain management are normally generated by the fact that the partners in a supply chain do not understand the processes of their supply chain partners. The authors' recommendation is that there should be better transparency within supply chain management and that executives should coordinate the interests of all companies in a supply chain at the same time. The second recommendation is that the personal incentives of decision makers in a supply chain should be aligned.

Another issue, which is described by Narayanan and Raman, is the discount policy in supply chains. They observed that changing the discount calculation point from purchased volumes to sold volumes improved supply chain performance.

### 3.3 Lead time research

Operations management literature has described the 1980's and 1990's as a period of time based management and of the relationship between the speed of operations and efficiency (e.g. Stalk, 1988; Stalk and Holt, 1990; Womack et al., 1991; The Toyota Production System, 1995). Writing in the 1980's Stalk (1988) described how time has become one of the most competitive advantages in manufacturing industries.

Several researchers have identified the fact that the production paradigm has now changed from cost effectiveness and conformance quality to lead time and flexibility issues (Dugay et al., 1997; Jaikumar, 1986; Kenney and Florida, 1989; Roobek, 1987; Spina et al., 1996).

Helo (2004, 567-577) has identified two reasons for the importance of lead times. The first reason comes from the customer perspective. Customers expect the fast delivery of even tailor made products. The second reason comes from the perspective of other supply chain partner companies, as they are not willing to carry excess inventory for better sales availability. Price erosion and market prices force production planning to move goods fast in a chain and only keep stock for inexpensive components and raw materials.

Following a traditional cost accounting principle capacity utilization level is connected to the unit cost of produced goods. Capacity utilization normally defines the lead time for order fulfillment. Kumar and Motwani (1995, 36-53) concluded that time related performance leads, through better product availability and more efficient production, to better profitability.

Lot sizing decisions are probably the most important issue in lead time production. There are several lot sizes that should be taken into account in production planning. Typical lot sizes are: manufacturing lot size, ordering lot size, set-up lot size and transportation lot size. In a typical forest industry supply chain there are even more lots, such as the dispatching lot and its size, the number of shipping lots and customer delivery lots. Helo (2004, 567-577) has analyzed the relationship between lot sizes and capacity utilization by using queuing theory in order to describe the relationship. His conclusion is that lead time is very sensitive to lot sizes especially with capacity utilization. A combination of big lot sizes and high capacity utilization results in long lead times, which may affect customer satisfaction and force the producing company into a price competition.

Hilmola (2004, 125-135) has identified three different important streams in production management literature. Firstly, Materials Requirements Planning (MRP) uses a very simple method for calculating the requirements for materials and resources (Ptak, 1997; Plossol, 1994). In the MRP approach orders are pushed through the production process by using standardized production batches and by using backward scheduling to build up the production schedules. Secondly, Just-in-time (JIT) production planning works in a total different way as compared to MRP based planning. The basic idea with JIT is that the production lot sizes should be as small as possible with reduced setup times. By achieving smaller production lot sizes, a production system can respond to demand requirements with so called Kanban cards, which aim to respond to customer orders directly. Hilmola concludes also that lead time improvement is a strategic target for producing companies, but the financial consequences have mostly been left unanalyzed.

Lastly, during the 1980's a Theory of Constraints (TOC) was introduced as a combination of MRP and JIT production planning theories (Goldratt, 1988, 443-445, 1990; Mahoney 1997, 157-207). The TOC production planning theory assumes that production operations are most likely unbalanced in terms of production capacity. The TOC approach emphasizes that production capacity should be as high as possible and not too much attention should be paid to non-constraint operations.



De Souza et al., (2000, 348-364) define the dynamics of orders, including the lead time aspect, as the difference between the company's response and the customer demand. The difference between the company's expected stock level and the real stock level is defined as the dynamics of inventory. Generally speaking any difference between the actual outcome and the expected outcome of a system could be defined as dynamics. The authors also define forecasting as the ratio of forecast information used in determining order quantity. De Souza et al. (2000, 348-364) have analyzed seven different reasons for supply chain dynamics. The reported reasons are: 1) shortage game; 2) capacity constraints; 3) information delay; 4) poor coordination; 5) material delay; 6) demand signaling and 7) order batching. The authors define the objective of supply chain coordination as optimizing the resource allocation, attaining supply chain economy equilibrium and at the same time reducing dynamics. Shortage gaming can be reduced by long term partnerships between customer and suppliers. When a capacity shortage occurs, the material arrived sometimes can not be processed immediately and the parts inventory builds up. The information delay time includes the time for information processing and the time for information transfer. Information delay time can be minimized by using EDI or other data communication solutions. Forrester (1958 and 1961) states that a delay in information correlates directly with a delay in materials. The elimination of the information delay rather than a shortening of the material delay can obtain a more dynamic performance improvement and also increase service levels. The role of poor coordination between material and information management plays an important role, when capacity is utilized to its maximum level. The reduction of a material delay leads to an improvement in the performance of a system. In addition, a reduction in manufacturing and transport lead times usually increases facility investments. Demand signaling assists in the determining of the desired inventory level and the determining of the desired production and transport capacity. Order batching is considered to be one of the reasons for the Bullwhip effect (Lee et al. 1997 b). According to De Souza et al. (2000, 348-364) order batching does not have such a big influence on supply chain dynamics.

Schwarz and Weng (2000, 231-253) have analyzed uncertainty from the perspective of a lead time's influence on safety stocks and the authors have identified three main elements of uncertainty: a lack of information about supplier performance, manufacturing processes and customer demand. Their conclusion is that the reduction of uncertainty regarding lead times improves the whole supply chain's performance. Stalk (1988, 41-51) has come to a similar conclusion. He

suggests that demand chain efficiency can be improved by reducing time delays in the flow of information and materials throughout the whole demand chain.

Charnsirisakskul et al., (2006, 153-169; 2004, 697-707) have defined flexibility in supply chain management by using three different types of flexibility. The first type of flexibility is lead time flexibility, which is defined as manufacturer producing complete orders following specific due dates to the customers. The second type of flexibility is inventory holding flexibility, which is defined as the manufacturer producing orders early before the orders arrive at production planning. The third type of flexibility is partial fulfillment flexibility, which is defined as the manufacturer fulfils only part of the ordered quantity. The authors also state that lead time flexibility enables manufacturers to increase profits by better production optimization by selecting more profitable orders that could not be produced otherwise.

Several researchers have stated that short and reliable lead times provide value by helping customers reduce uncertainty in their business and also by reducing the inventory level. Short and reliable lead times also lead to more accurate production and distribution plans. Longer lead times (using a higher lead time flexibility) may result in additional costs to the case manufacturing company, such as a decrease in the probability of customers placing an order (Charnsirisakskul et al., 2004, 697-707; Sheridan, 1999; Teresko, 2000; Rodin, 2001).

Towill et al. (2002, 3-13) discuss in their article the role of industrial system dynamic simulation models in designing the supply chains. They analyzed two different supply chains with the assistance of dynamic simulation models and they found out which factors have an influence on the lead time performance. Supply chain integration with the partners, and in particular free exchange of information, is a prerequisite for shortening the lead time. The second case shows that reduction in lead times by using JIT thinking brings benefit to the supply chain management. The authors, however, state that supply chain integration and JIT thinking are only individual development tools for better supply chain management. The companies should have an overall strategic view on supply chain management development. Disney et al. (1997, 174-196) describe how simulation models can be implemented in supply chain design. The authors identified three parameters (sales forecast, inventory and work in progress), which are used in the supply chain simulation model. The simulation results show, that a lean supply chain model can be achieved by using three specific explanatory parameters in the simulation. Bartezzaghi et al. (1994, 5-20) identified in their research thirteen time drivers, which have a direct influence on the lead time. In their research the lead time was linked to business processes and the conclusion was that lead time can be

reduced when the business processes are streamlined. De Souza et al. (2000, 348-364) analyzed seven causal factors, which have an influence for the lead time. They used a simulation model in order to solve the dynamic performance of a generic supply chain. Their conclusion was that reduction of coordination dynamics is an alternative solution to structural re-engineering, e.g. shortening of manufacturing and transport lead times.

### 3.4 Paper industry's supply chain management research

Paper industry supply chains have not been extensively researched. This can partly be explained by the fact that the paper industry exists only in such areas where there is a natural access to the raw material necessary for production. Only in those countries where there is a paper industry do local universities and other research institutions conduct research work on paper industry supply chains.

Kaj-Mikael Björk wrote his doctoral thesis on "Supply Chain Efficiency with Some Forest Industry Improvements" in 2006. He analyzed the supply chains of forest industry products, fine paper and plywood. Björk explains the Bullwhip effect and flexible lead times through mathematical simulations models. His main conclusions were that flexible lead times will result in increased order quantities and that flexible order quantities reduce the Bullwhip effect (Björk, 2006, 61-90).

Charnsirisakskul et al. (2004, 697-707) have researched lead time flexibility in several business environments including the paper industry. Their conclusion is that lead time flexibility is useful in all environments with no inventory flexibility and both with and without price flexibility. According to the researchers price flexibility plays a bigger role than lead time flexibility in several business environments.

Hämäläinen and Tapaninen (2008, 83-93) report in their paper industry supply chain cost research, that the customer order sizes vary very much and this leads to cost increase in the supply chain management. Their conclusion is that smaller customer orders, such as few tons or some hundred kilos, pay even twice higher transport costs than the large customer orders.

Carlsson and Rönnqvist (2005, 589-616) have analyzed the supply chain of a Swedish pulp producing company. Their research work concentrates on raw material supply to pulp mills and to vessel capacity and terminal optimization for ready made products. Their conclusion is that, for the raw material wood supply, concrete operational savings can be achieved by developing lead time management for the raw material (logs) supply to production. Neither the lead

times nor the working capital of the exported products are included in their research.

Bredstöm et al. (2004, 2-22) have also conducted mathematical research work at a pulp producing company. There they analyzed the cost of changes in pulp production. The issues dealing with lead time and working capital were excluded from their study.

Research on forest industry supply chain management has mainly used mathematical modeling and tools of analysis. As the forest industry's supply chain definition includes the supply of raw material it is natural that two of the research works deal mainly with the supply of logs and raw materials to production. Another research work deals with the cost of production changes and two others discuss lead time issues. The joint conclusion from the two lead time research works is that price flexibility is more important than lead time flexibility. None of the research works studied has analyzed distribution, including actual lead times and the working capital of the supply chains for the ready made products.

There is plenty of production oriented research work for the paper industries. The main target for this kind of research work is to improve production efficiency and develop new products. Supply chain management research has not been supported by the industry itself. This can be explained by the fact, that the strategic role of supply chain management is not clear within the paper industry.

### 3.5 Summary of theoretical frame of reference

Section 3 highlights the basic facts and definitions of logistics and supply chain management. A more detailed description has been made for supply chain management, covering such areas as supply chain research, the strategic aspects of supply chains, supply chain integration and organizational aspects. Also the role of logistics service providers and IT is discussed with reference to supply chain management. Lead time and paper industry supply chain management research are described as separate issues.

The generic descriptions and definitions of logistics and supply chain management are tested and implemented in the case company's business environment. Supply chain integration with its logistics service providers is one crucial element in the measurement of lead time, as several components in the lead time are managed and controlled by the logistics service providers. The organizational aspects of supply chain management are also discussed with reference to the case company's business environment, especially from the

strategic point of view. Supply chain IT issues are not discussed separately, but the role of the IT applications is highlighted when describing the order to delivery processes. The theoretical aspects of lead time and supply chain research are described and the later on implemented when developing the lead time measurement system.

The theoretical frame of reference and its implementation in the case study is summarized in Table 6.

Table 6: Theoretical frame of reference, conclusions

Theoretical frame of reference, main components	Objective of this research	Case study implementation	Contribution to theory building and to the frame of reference
Supply chain management research and selected characteristics	Description and understanding of supply chain management, including those selected characteristics, which have a direct link to the case study implementation.	Background understanding of supply chain management in the empirical case study.	Do the results of the thesis confirm earlier theories for supply chain management and lead time behavior?
Lead time research	Background understanding of lead time research, especially for the parameters influencing the length of the lead time.	Generic development of the lead time measurement system and its implementation in the case study.	Do the results confirm the dependence between production lots and lead time, which has been described in earlier studies?
Paper industry supply chain management research	Background understanding of paper industry supply chain management and new aspects of this research area.	Contribution to the paper industry supply chain management research. This is based on results from the case supply chain analysis.	Does this research open new understanding for supply chain organizational issues and for lead time behavior especially for those parameters, which have not been discussed earlier in the paper industry?

As this research is, to a large extent, case study oriented, the research work is mostly based on empirical case study material and therefore the theoretical frame of reference describes the analyzed phenomena first and this is based on earlier research in this area. The theoretical frame of reference is then later implemented in the case study analysis, which provides the final results and conclusions of this research work.

The contribution to theory building and to the frame of reference can be addressed in three specific questions: 1) Do the results of the thesis confirm earlier theories for supply chain management and lead time behavior? 2) Do the results confirm the dependence between production lots and lead time, which has been described in earlier theories? 3) Does this research open new understanding for

supply chain organizational issues and for lead time behavior especially for those parameters, which have not been discussed earlier in the paper industry? As a background statement, we can say, that paper industry supply chains have not been, in wide scale, object for academic research so far.

## 4 CASE STUDY DESCRIPTION

### 4.1 Case company description

Selecting a case company for a research study is not easy. Two Finnish paper producing companies were contacted during the planning phase of this research work. Both companies had, by that time, their logistics network and supply chain operations working in a similar way, meaning that they were using the same logistics service providers. One of the companies had a large internal logistics network development project ongoing and no resources were available for an external research project. The other company confirmed that they would like to share data and human resources for an external research study, as the results could benefit the development of the logistics and supply chain management operations. Time from both the logistics top management and from the operational top management was allocated for the research project.

The total turnover of the case company in 2005 was approximately 10 billion EUR. The number of employees globally was around 30,000. The case company has 16 production plants in Europe and another 6 production plants outside Europe including 51 paper machines globally with an annual production capacity close to 13 million tons. The production plants are located in Finland, Germany, Great Britain, France, Austria, USA, Canada and China.

The products are sold in all markets throughout the world. There are two major market areas, the EU countries and North America and 85 percent of the turnover comes from sales to these two market areas. The case company has more than 72.000 shareholders globally (CC AR, 2003, 7; CC AR 2005, 10).

The case company's business focus is on printing, specialty papers for the converting industry, converted paper products and wood products. The key factors for success are good customer relations, skilled employees, cost effectiveness and a global market position for the company's main products. The company has close and lasting relations with both local and multinational customers and its logistics network is one the key factors of its success. According to the annual reports the

company operates a global and highly efficient logistics network. The high proportion of shipments made by sea ensures competitive deliveries, which are backed up by modern IT management systems (CC AR, 2003, 10-11, 2005, 10).

#### 4.2 Order handling and the logistics planning of the case supply chains

The global sales offices and sales agent networks of the case company have direct, daily contacts with their customers. Customers place an order enquiry to the sales offices and the enquiry data is entered into a global order handling application. This means that all customer orders are made based on the “make to order principle.”

Only on a very marginal level is the make-to-forecast used as a basis for production planning. In paper industry production planning customer requirements are directly linked to production so that decisions are based on real customer demand, rather than demand forecasting. The make-to-order principle forces companies to look at their total optimization. The customer centric view means companies have to react quickly to demands for changes and it also forces them to reduce inventory costs and decrease discounting (Holweg and Pil, 2001, 74-83).

Make-to-order and make-to-forecast production planning systems have been discussed in supply chain management literature both from the theoretical and practical point of view. The make-to-forecast system benefits from economies of scale in production by optimizing the production and distribution of products to wholesalers and retailers. The make-to-order system is known for its adaptive production efficiency. In the make-to-order system a value adding process takes place only after someone demands it by following the just-in-time principle and by minimizing the inventory risk (Papadakis, 2006, 25-33).

The order handling IT application is in real time contact with production planning at the selected mill. Mill selection is made by the sales office based on the required quality of paper. The paper mill’s production planning application confirms to the logistics module, regarding the order handling application, that the required quality and amount of products can be produced in the required time window. The logistics module of the order handling application proposes the supply chains and standard logistics costs for each of the orders. The sales offices have access to this logistics planning information on a real time basis. Possible changes in the production planning are reported to the sales network and the supply chains and the scheduling are updated as necessary.



The logistics operations are planned based on annual transport budgets measured in tons. The annual logistics planning routines with the railway companies (in Finland and at the destinations countries) are also based on the annual transport budget volumes. The central logistics organization contracts annual transport capacity from the railway companies. Wagon and truck ordering is made by the mills in all geographical areas of the case company. Daily variations in production volumes are reflected in the number of ordered wagons per day. The logistics organization of the case company makes annual capacity reservations to the shipping lines. Annual budgeted transport volumes are divided into the daily/weekly sailings and the shipping lines guarantee a volume allotment on each of the sailings.

As soon as the order is confirmed before production, automatic booking information is released from the order handling system to the shipping line. The booking information is received by the shipping line and placed in the daily/weekly allotment. If the mills are not able to fill the planned vessel capacity allotment, the shipping line has the possibility to offer the free capacity to other customers. In case of over booking, the situation will be discussed together with the logistics organization and the shipping line. Normally over bookings are solved so that some customer orders are rebooked onto another ship with the customer's permission. The shipping line confirms the bookings by sending a booking confirmation message to the case company's logistics module for order handling applications.

When the orders are dispatched from the mill, the mill IT application sends the waybill information (reel and pallets identification and logistics planning information) to the port operator in the loading port. Based on this information the port operator conducts operational planning (resource and warehouse planning). The port operators discharge the arriving wagons and trucks and place the orders in port warehouse for interim warehousing before the planned vessel sailing. After the orders are loaded onboard the vessel, the port operator sends port confirmation information to the case company's order handling system. The port confirmation message confirms which orders have been loaded onboard the vessel. The port confirmation information is also used for commercial invoicing and for informing the discharging port about the arriving orders.

The order handling system sends the logistics information (what was loaded onboard the vessel) to the logistics company or to the in-house logistics organization in the discharging port. The local logistics organization, which is part of the case company's regional organization, distributes the order and vessel information to the port operator for planning purposes. The port operators also

receive stowage plans from the shipping company and then discharge the vessel and place the orders in the port warehouse. The port operators also have two additional special functions. They report damages to the case company's logistics organization in the discharging port and then the port operators also receive information about those orders, which are loaded directly on railway wagons and trucks for immediate delivery to customers or to distribution centers. Some orders stay in the discharging port for local distribution and warehousing. Customer call offs are made to the port warehouse or to the distribution centers.

#### 4.3 Selection criteria of the case company's paper machines and market areas

The A mill has two paper machines with an annual production capacity of 580,000 tons. The split between the production capacities per machines is so that PM 1 has an annual production capacity of 335,000 tons (58 percent) and PM 2 (case machine) has an annual production capacity of 250,000 tons (42 percent).

The B mill has four paper machines with an annual production capacity of 860,000 tons. The case machine's (PM 6) annual production capacity is 345,000 tons, which is 40 percent of the mill's total production capacity. The market and production characteristics are summarized in Table 7.

Table 7: Case mills' markets and production information

<b>Key characteristics, production and markets</b>	<b>A mill PM 2</b>	<b>B mill PM 6</b>
Annual production capacity (tons)	580.000	860.000
Number of paper machines	2	4
Product grade of the case paper machine	Magazine paper, LWC paper, catalogue, rotogravyr	Mechanical coated and uncoated printing paper
Annual production capacity of the all/case paper machine (% share from mill's annual production)	<b>PM 1 = 335.000 tons (58%)</b> -> <b>PM 2 = 250.000 tons (42%)</b>	<b>PM 3 = 140.000 tons (16%)</b> <b>PM 4 = 120.000 tons (14%)</b> <b>PM 5 = 255.000 tons (30%)</b> -> <b>PM 6 = 345.000 tons (40%)</b>
Annual tonnage to USA/case machine (2003) (% -share from case machine)	<b>PM 1 = 34.000 tons</b> -> <b>PM 2 = 10.500 tons (4%)</b>	<b>PM 3 = 23.000 tons</b> <b>PM 4 = 3.600 tons</b> <b>PM 5 = 54.000 tons</b> -> <b>PM 6 = 109.000 tons (32%)</b>
Annual tonnage to UK/case machine (2003) (% -share from case machine)	<b>PM 1 = 116.000 tons</b> -> <b>PM 2 = 32.000 tons (13%)</b>	<b>PM 3 = 16.000 tons</b> <b>PM 4 = 4.900 tons</b> <b>PM 5 = 9.700 tons</b> -> <b>PM 6 = 19.000 tons (6%)</b>

The warehousing capacities at the case mills, transport capacities per train and per day, the share between truck and rail transports, the transport time, train schedules and number of trains are summarized in Table 8.

Table 8: Case mills' supply chain information

Key characteristics, logistics	A mill PM 2	B mill PM 6
Warehousing capacity at the mill	Max 9.000 tons Extreme 10.000 tons	No specific warehousing space at the mill, but warehousing exists at the mill
Transport capacity per train	No capacity limitations	No capacity limitations
Transport capacity per day	No capacity limitations Combination with other mills	No capacity limitations Combination with other mills
Share between rail and trucks	70 % rail, 10 % truck (containers) 20% truck including domestic deliveries (E-Fin port) 90% rail and 10% truck (W-Fin port) from A mill	90% rail and 10% trucks
Number of trains/day to port of loading	To E - Fin port (UK) = 2 trains/day To W-Fin port(USA) = 3 trains /week	To W- Fin port (UK and USA) = 3 trains/day
Train arrival times	From A mill to W-Fin port, arrival time 11.00 From A mill, arrival times to E-Fin port 02.00, 13.30, 18.30	Arrival times to W-Fin port 02.00 14.00 19.00
Transport time from mill to port of loading (by rail)	To E-Fin port (UK) = 15 hours To W-Fin port (USA) = 20 hours	To W-Fin port (UK) = 12 hours To W-Fin port (USA) = 12 hours

The warehousing capacity, vessel sailing frequency, sea time of the vessels and the warehousing capacity in the discharging ports are summarized in Table 9.

Table 9: Case mills' logistics information

Key characteristics, logistics	A mill PM 2	B mill PM 6
Warehousing capacity at port of loading	To E-Fin port (UK) To W-Fin port (USA) Unlimited capacity	To W-Fin port (UK) = 20.000 tons To W-Fin port (USA) = 20.000 tons Unlimited capacity
Sailings/week to port of discharge	W-Fin – USA = 1,5 sailings/week E-Fin – UK = 3 sailings/week	W-Fin port– USA = 1,5 sailings/week W-Fin port– UK = 3 sailings/week
Sea time from port of loading to port of discharge (days)	W-Fin port – USA = 12 days E-Fin port – UK = 4 days	W-Fin port– USA = 12 days W-Fin port – UK = 4 days
Warehousing capacity at port of discharge	Baltimore and Tilbury Unlimited warehousing capacity	Baltimore and Tilbury Unlimited warehousing capacity

The business motivation for selecting PM 2 as a case study object is explained by the fact that the logistics management had estimated that PM 2 had more deviation from the target lead times than PM 1 and in both on the USA and UK markets there were annual reports stating that the lead times were extra long for PM 2.

The business motivation for selecting PM 6 and the USA and UK markets as case study objects were discussed by the case company's logistics management in the following statements. The B mill loads all customer orders directly from

production onto railway wagons and onto trucks for transport to the West Finnish port. Thus, the case study enables the analysis of two different supply chains via two different loading ports in Finland to same markets. The dispatching processes of the case mills are based on different philosophies. A mill has a large mill warehouse. In contrast, B mill has direct loading to vehicles from production. For both mills and especially for the UK and USA markets, there have been some major disturbances in the supply chain management. This motivated the selection of the UK and USA markets for the case study analysis.



## **5 SUMMARY OF THE PUBLISHED ARTICLES**

### **5.1 Introduction**

This summary of the four published articles follows the sequence of the articles. The first article describes three specific problem areas for the paper industry's supply chains including the lead time of the case company's selected supply chains. This article is the starting point for the whole research work and the other three articles jointly lead to the conclusions and final discussion. The first article highlights the actual problems by including three specific areas that experience disturbance in the case company's supply chains, and includes proposals on how to develop the supply chains to make them more effective tools within customer service operations.

The second article describes the supply chain management's role as a strategic issue within the case company. The interaction between the case company's corporate strategy and logistics, and the supply chain management strategy is described by including the current set of key performance indicators.

The third article analyzes the lead time by explaining two parameters such as the number of production lots and the number of produced reels. It firstly explains the actual lead time to the selected market areas and secondly tries to explain lead time behavior with reference to strategic management issues and thirdly explains the length of the lead time, measured in days, according to two selected parameters with the starting point being production.

The fourth article discusses the USA supply chain as a non-containerized intermodal supply chain from Finland to the USA. The tracking of containers is globally used by shipping lines as one key element in their customer service. In the analyzed USA supply chain, however, the shipments are done mainly as break bulk cargo, meaning also that there is no real time tracking of the individual paper reels and pallets. The differences between containerized and non-containerized supply chains are described in the fourth article.

## 5.2 Supply Chain Challenges of North-European Paper Industry

This research work is based on two different case studies completed for one major North-European paper manufacturer, with important customers in Europe and the USA. The first case study (preliminary one) started when supply chain challenges were recognized at the end of 1990's, and the manufacturing unit was seeking managerial remedies, this investigation only concerned one manufacturing unit, while not separating any particular supply chain in the analysis. Recently, a more detailed case-study of this paper manufacturer was conducted, which concerned the lead time performance of four different strategically important supply chains. These supply chains are organized by two different large manufacturing units (the preliminary analysis concerned one of these two paper mills). The objective of this research work is to identify whether general lead time and response studies, mostly completed in the automotive industry, are applicable to paper production.

The first article, which is the starting point of the four articles, describes three operational disturbance areas and how these disturbance areas affect the supply chain behavior of the case company. These disturbance areas begin at the very beginning of the supply chains and start with the booking of vessel capacity for transportation from the loading port to the discharging port.

The results show that the shipping lines face serious problems with vessel capacity management as the mills' production plans are often changed at very short notice. This phenomenon is described by real life data, which shows that it is very seldom that vessel capacity bookings do not undergo any major volume changes.

The second disturbance area describes the booking of railway wagons. The results show that there is an obvious gap between the mills and the railway company in the wagon ordering processes as the ordered amount of wagons very rarely matches the delivered number of wagons. Old and traditional wagon ordering procedures explain this phenomenon; however the processes have been improved in a very positive way recently.

The third disturbance area describes the arrival of trucks at the loading port. It has been agreed between the mills and the port operator that all trucks should be pre advised to the port operator, in order to make an efficient resource planning for the truck discharging.

According to our analysis North-European paper manufacturers hold approximately 45 days of distribution inventory. Interestingly, in our case study it was found that this does not result in high efficiency with regard to distribution. On the contrary, different parties involved (railway, port operations and vessels)



need to have considerable amounts of free and unused capacity in their operations to ensure the smooth flow of materials.

The case studies were completed in the factories of one large North-European multinational paper producing company. Therefore, our observations are limited to this company. However, in order to generalize our results further, we have analyzed North-European paper producers through macro data and financial reports. To cover mismatches, between company level quantitative analysis and macro data, the research results were discussed with several key persons in the case company. By doing that the triangulation of the empirical data was achieved.

The actual lead time performances for the analyzed paper mills show that there are major differences between the mills. The average lead time for the UK market for the A mill is 90 days and for the B mill 81 days. In the US market the average lead time is 72 days for the A mill and 117 days for the B mill.

Four different types of reasons were identified. This study argues that those four reasons are, namely: 1) scale emphasis in production; 2) IT systems to support supply chains; 3) sea shipment and 4) outsourced distribution. All those factors play a vital role in the forthcoming performance improvement initiatives. At the moment this results in long supply chain lead times whatever the distance to the actual market is. Decision makers in practice need to find solutions for these in order to improve performance further.

Supply chains are rarely analyzed in research works through more than one supply chain, however, an analysis of four different supply chains with reference to lead time is presented here. The analysis is based on the Enterprise Resource Planning (ERP) database, and the findings are verified by interviews with the managers and directors of the case company.

Those three specific disturbance areas, which were analyzed in the first article, have then later on been improved by cooperation between the railway, shipping company and the mills. Thus, the supply chains currently work in a more efficient way. This study has therefore led to lead time savings for the supply chains.

### 5.3 Supply Chain Strategy in a Global Paper Manufacturing Company – A Case Study

The first article analyzed daily operations and their influence on the supply chain management of the case company. The second article mainly discusses the strategic aspects of the case company's business and supply chain strategies. The main objective of the second research article is to analyze the relationship between

corporate and supply chain strategy, as well as its implementation in a multinational paper producing company. Traditionally, paper producing companies have had a strong interest in developing a physical infrastructure for their customer deliveries. However, supply chain thinking is still an unstructured issue in the case company.

The core findings concern the individual business division strategies, which jointly comprise the corporate strategy. Some of the business divisions do have a certain amount of supply chain management aims in their strategies. Furthermore, there is no real corporate supply chain strategy. When communicating these findings to the case company's management, it was jointly understood, that the supply chain strategy issues are also, on a practical level, an area where business responsibilities are unclear. This can be explained by the current organizational structure, where the supply chain management responsibilities are specifically unclear between the business divisions and the logistics organization.

The research was conducted at a company with a strong presence in Northern Europe, which limits its applicability. Thus, the research results mainly reflect a Northern European business environment and thus cannot be generalized on a global level.

The conclusions of the research work include a recommendation for a new management model for the corporate supply chain strategy, which is based on cooperation between the business divisions and logistics organization.

#### 5.4 Production Lots as Determinant of Paper Production Lead Time Performance

The first article highlights selected disturbance areas including the lead time behavior and the second article highlights the interaction between the case company's corporate and supply chain strategies. The third article supports the first two articles by describing the supply chains and lead times, specifically by analyzing parameters which can explain the lead time behavior.

The third article tries to provide answers for the two following research questions: 1) 'To what extent do the number of produced reels explain the length of the production lead time?' and 2) 'What is the role of used production lots (as an entire production batch is split into smaller lots to enable the transfer of lots) regarding the lead time?'

In this article, we are interested in the connection between lead time performance, and production order sizes, and in how many production lots an

order actually produced. Based on the system dynamics simulation model, the a priori assumption of how production lots behave in a multi-product environment gained a better explanatory power. The empirical findings provided support for this as the number of production lots explains the production environment manufacturing lead time much better than the production order size. Further support is gained from supply chain phases, which are similarly analyzed. However, the explanatory power of production lots decreases, in this respect, and seems to be significantly lower in more distant markets.

The content of this research article had also been previously identified by the case company but the research questions had never been analyzed in a systematic way based on real life data. Hence, the findings of this article provided a totally new understanding of the case company's supply chain management. The supply chain and logistics specialists in the case company were extremely surprised with the findings of this article. The traditional thinking in the case company explained the length of the lead times only through order sizes.

The findings of the third article should be communicated to the mills, where production optimization is carried out. The number of production lots is actually the starting point for the case company's supply chain management. All other phases in the supply chain management and logistics organization handle the supply chain's and customer's orders after the production planning.

## 5.5 Intermodal and Non-Containerized Supply Chains Connecting Northern Europe to North America

The three previous articles have described the case company's supply chains management behavior both on an operational and strategic level. These articles describe the current supply chain model, which is based on the non-containerized supply chain model. In practice this means, that all customer orders (the paper reels and pallets) are shipped as break bulk, not in an unitized way. The fourth article discusses the conceptual alternatives for moving the non-containerized supply chains into containerized supply chains.

The fourth article compares the case company's non-containerized supply chain to the US market by analyzing the basic features of containerized supply chains from the point of view of intermodal transportation.

Intermodality is often discussed in the research literature from the point of view of containerized transportation. The fourth article illustrates an intermodal and non-containerized supply chain solution throughout the case company. The supply

chain connecting Northern Europe to North America is analyzed with reference to the different transportation modes and product flow throughout the chain.

The research results show that pre-transport from production to the loading port runs in a very efficient way. The longest warehousing time is at those points, where a switch in the mode of transportation occurs, i.e. in the port of loading and in the port of discharge. In order to lower the amount of working capital bounded up in the products during the extensive warehousing time the company's management needs to reconsider its supply chain management policy in general and as part of customer relations in particular.

The findings of the fourth article are very challenging for the case company. Deliveries to the USA are generally considered to be deliveries to overseas markets. In current supply chain management model the customer orders are shipped in a non-containerized way. However, for other destinations, such as Far East destinations, containers are used for customer order shipments. Shipments to the US market have traditionally been shipped in a non-containerized way as the volumes have been big and enabled an almost weekly shipment with an average shipment size of 10,000 tons. As world trade has been developing more rapidly in the Far East markets it has provided greater possibilities for the use of containers. The availability on containers has been limited for USA-Europe trade recently. Global trade does not, in its current situation, enable the case company to move products by means of containers to the USA, however, there would be obvious savings for the case company via a more efficient supply chain management.

## 5.6 Summary of the purposes and findings of the four published articles

In order to get a transparent picture of the purposes and findings of the published articles a summary table (Table 10) is presented below. For each article the purpose and findings are described separately.

Table 10: Summary of the purposes and findings of the published articles

Article	Purpose	Findings
Supply Chain Challenges of North-European Paper Industry	Aim in this research work is to identify improvement areas in the new supply chain context of paper production, and possibly give further support for the general development of the discipline.	The results show, that North-European paper manufacturers hold approximately 45 days of distribution inventory, while the average lead time for the UK market is 85 days and for the USA market 90 days. Interestingly, in our case study we found out that in distribution this does not result in high efficiency, on the contrary different parties involved (railway, port operations and sea vessels) need to have a considerable amount of free and unused capacity in their operations to ensure the smooth flow of materials.
Supply Chain Strategy in a Global Paper Manufacturing Company – A Case Study	The main objective of this article is to analyze the relationship between corporate and supply chain strategy, as well as its implementation in a multinational paper producing company. Traditionally paper producing companies have a strong interest in developing a physical infrastructure for their customer deliveries.	The core findings concern the individual business division strategies, which jointly comprise the corporate strategy. Some of the business divisions do have a certain amount of supply chain management aims in their strategies. Furthermore, there is no real corporate supply chain strategy.
Production Lots as Determinant of Paper Production Lead Time Performance	This article tries to give answers to the two following research questions: (1) ‘To what extent do the number of produced reels explain the length of the production lead time?’, and (2) ‘What is the role of used production lots (as an entire production batch is split into smaller lots to enable the transfer of lots) with regard to lead time?’	In this research work, the connection between lead time performance and production order size, and how many production lots the order eventually produced is analyzed. Based on the system dynamics simulation model, production lots were assumed to have a better explanatory power in a multi-product environment than order size. The empirical findings provide support for this as the number of production lots explains the manufacturing lead time much better than production order size with regard to the production environment.
Intermodal and Non-Containerized Supply Chain Connecting Northern Europe to North America	This research article tries to give answers to three specific questions: 1) What are the special features of the supply chain involving intermodal and non-containerized transports?, 2) Which main factors determine the success of a non-containerized intermodal transport solution? and 3) How can the performance of an analyzed supply chain can be improved in the future?	This article illustrates intermodal and non-containerized supply chain solutions through the case of a Finnish paper producing company. The supply chain connecting Northern Europe to North America is analyzed with reference to different transportation modes. The research results show that pre-transport from production to the loading port runs in a very efficient way. The longest warehousing time occurs at those points where the switch of transportation mode occurs, i.e. in the port of loading and in the port of discharge. In order to lower the amount of working capital bounded to the products, during the extensive warehousing time, company management needs to reconsider its supply chain management policy in general and part of its customer relations in particular.

These four articles describe the case company’s supply chain management from operational and strategic perspectives. The main conclusions for each of the articles will be summarized here.

The main conclusion for article one is that the current model of information sharing between partners in supply chains is an obstacle to the development of more efficient supply chain management models. Real time and exact information would make the operational planning more efficient for all partners in the supply chains. The current model leads too much to the sub-optimizing of the individual supply chain partners, as there is no real time steering data available.

The findings from the second article are summarized as; integration between the corporate strategy and supply chain strategy does not work in an efficient way. There are too many supply chain responsibility areas, which are not clearly defined in the case company.

The third article confirms that the number of production lots, is the starting point for supply chain management in the case company. In earlier thinking, the size of the customer order had been seen as the main explanatory parameter for determining the length of the lead time. The number of production lots is decided by the producing mill and other partners in the supply chains have to live with the current model. A better optimization (i.e. a fewer number of production lots) would obviously improve operational supply chain management and then directly decrease the working capital, which is currently bound up in the supply chains.

The fourth article recommends that the case company should move from non-containerized supply chains to containerized supply chains for deliveries to the US. Conceptually, this approach is correct, but in the current economic climate the container balances do not allow for this kind of change because the shipped volumes to US are so large.

## 6 DISCUSSION

The empirical case study started with lead time and production data collection from the supply chain management process phases, which were defined as a research target at the beginning of the case study. The implemented method of analysis is a new way of analyzing the paper industry's supply chain. This way of analyzing the processes proved to be correct as soon as data from the process phases was available. The new analytical structure brought new insight and understanding to the case company's activities because the lead time had not previously been analyzed in that way. The case company's previous method of discussing the lead time had been to deal with the total lead time without specifying the lead time for the different process phases.

Retrieving data from the three different IT applications was difficult. The lead time data and production data divided into the process phases included some low quality information that required a manual cleaning of the data. The data was combined based on the order line reference numbers from one data sheet, which was the basis for all analyses. As the data was fragmented and retrieved from three different applications, this means that the case company did not have any possibility to automatically do the same type of process analysis and thus this type of supply chain method of analysis cannot be implemented, based on current IT applications, as a daily management tool. Future IT applications are said to have features, which will enable the use of this kind of process phase based method of analysis on a monthly basis.

Four different research questions were defined at the beginning of this research work: *The first research question* was: What is the actual lead time performance for the case company's selected four supply chains? *The second research question is*: What is the relationship between the corporate and the supply chain strategy, and how does that relationship function in a multinational paper producing company? *The third research question* tries to provide answers to two detailed research questions: 1) 'To what extent does the number of produced reels explain the length of the production lead time?' and 2) 'What is the role of used production lots (as an entire production batch is split into smaller lots in order to enable the transfer of lots) with regard to lead time?' *The fourth research question*

tries to give answers to the following detailed research questions: 1) What are the unique features of a supply chain involving intermodal and non-containerized transportation? 2) Which main factors determine the success of a non-containerized intermodal transport solution? 3) How can the performance of the analyzed supply chains be improved in the future?

The theoretical frame of reference of this research work was mainly based on describing several individual issues close to supply chain management research. The specific features of lead time and paper industry research were also highlighted. The case company analysis including the development of the lead time performance measuring system was based on the interaction between theory and experience from the case company. The actual lead time performance of the case company was analyzed having the lead time research as background to the first research question. Also the role of the logistics service providers was highlighted in this discussion. The relationship between the corporate and supply chain strategies was tested against the supply chain management organizational issues. The idea of having the number of the production lots as explanatory parameter for the length of the lead time was tested with experience from other industrial cases, which have been building the theory for lead time behavior. The discussion for the non-containerized and containerized supply chains did not have a clear link to the theoretical frame of reference. The theoretical frame of reference for this research question was based on the intermodal transports' theoretical aspect, which was separately discussed in article four.

## 6.1 Discussion, first research question

The first research question was: What is the actual lead time performance for the selected four supply chains?

### 6.1.1 Case company's lead time performance

The theoretical framework of this research work included the development and testing of a lead time measurement tool for the paper industry. The method of analysis studied the supply chain management process phases of the case company. The analyzed lead time data included the timestamps for customer orders and for individual supply chain management process phases. The



production data included the number of produced reels and the numbers of the production and dispatching lots.

The lead time method of analysis was based on actual data and produced new development ideas for the case company's supply chain management. The method of analysis also contributed to the research by combining empirical, practical results with supply chain management theories and thus added to the understanding of the behavior of supply chains. The lead time method of analysis can be also be implemented for other production industries.

Total lead time was defined as the time between the first production day and the last customer delivery day. The total lead time was then divided into seven individual lead times based on the seven supply chain management process phases. Previous to this study, the case company did not have IT based tools for measuring the individual, process phase based lead times and thus the results from the case study brought a new understanding of the importance lead time issues to the case company.

The case company's logistics organization had defined the optimal target lead times for the case supply chains. The optimal target lead time for the UK market is 30 days and in the USA 40 days. The results show, that for the UK market only 32 percent of the orders from A mill reached customers within the optimal target lead time and for B mill only 35 percent reached the customers within the optimal target lead time. The USA market experienced similar results, where for the A mill only 45 percent of the orders reached customers within the optimal target lead time and for the B mill only 28 percent reach the customers within the target lead time.

The average lead times calculated in days show that for the A mill's UK market, the lead time average was 90 days and for the B mill it was 81 days as the target lead time is 30 days. In the USA market, the average lead times were 72 days for the A mill and 117 days for the B mill and the target lead time was 40 days. These results show very clearly that the optimal target lead times for both markets were not achieved.

The results from the case study analysis can also be discussed as one major element of the case company's logistics strategy. One conclusion is that the logistics department's integration into the internal business divisions is not satisfactory as customer orders remain for a long time in warehouses in discharging ports in both market areas. This statement is motivated by the fact that the local sales organization including the local logistics organization has not communicated the supply chain management consequences (lead time) to the customers in a way that the lead time would be shortened and the cost of capital would be lower.

The longest lead time component is the warehousing time in the discharging port warehouses. In both markets the target time for discharging port warehousing and customer deliveries is 12 (seven days in warehouse, plus five days for customer delivery) days, but in practice the orders stay on average between 53 and 67 days in the UK port warehouses depending on the mill and in the USA market the average figures for the warehousing time vary between 41 and 80 days. Customer delivery is planned to be completed within five days in both markets, but in practice the UK market requires between 33 and 40 days and the USA market between 38 and 65 days.

The case company has internally planned two days for production in the theoretical lead time and three days in the target lead. The lead time and production data analysis results show that for A mill the average production time is between nine and ten days and the median production time is between one and three days. For B mill the average production time is between four and six days and the median production time is between one and two days. A general conclusion is that the planned lead time for production is relatively close to the actual production time, when using the median values, but when using the average production days there is an obvious difference between the planned and actual production days.

The mill warehousing including the dispatching time is planned to be a maximum of two days for both mills and for both markets. The results show that the actual performance for the mill warehousing is very different to that planned. The average warehousing time at A mill is between 15 and 17 days and the median warehousing time is between seven and eight days. In the early discussion of the research work it was mentioned that B mill does not have any warehousing capacity at the mill, but the results show that the average warehousing time for B mill is between six and seven days and the median time is two days for both markets. Even here the extremely long warehousing times explain the high average values. In contrast, B mill's median value is two days, which is equal to the planned warehousing days. The A mill has orders approximately five days longer than planned at the mill's warehouse. The only explanation for this is said to be the internal rules of the case company (customer service manager, mill A, 29<sup>th</sup> September 2005).

The actual transport times from the mills to the loading ports follow the planned transport times. The same conclusion is valid for sea transportation, where the actual sea time is equal to the planned sea time. Both the train and sea transports follow their time schedules and this leads to minimal time deviations under normal conditions.

The optimal target warehousing time in the loading ports for both mills is seven days. For A mill the average warehousing time is between nine and 25 days. The median warehousing time is between seven and eight days, which are well in line with the target warehousing time. B mill's average warehousing times in the loading ports are between six and 11 days and the median times are between five and seven days. Even in this case the median values are quite close to the optimal target warehousing days. We have to keep in mind that the logistics organization controls the warehousing time in the loading ports.

The sales organization at the destination country controls the warehousing operations in the discharging ports. The warehousing time in the discharging ports also includes the customer delivery time. The optimal target warehousing time in the discharging port is planned to be 12 days. However, the average warehousing time for A mill's orders is between 40 and 53 days and the median days are between 15 and 24 days. For B mill, the average warehousing time is between 67 and 81 days. The median value is between 21 and 43 days. It is very clear that the biggest deviations between the optimal target and actual lead times are for the warehousing time in the discharging ports. The representatives from the case company explain these deviations by saying, that the sales organization does not communicate the logistics and capital cost issues to the customers. The results from the regression analysis support this statement as the number of production lots explains quite well the warehousing time.

In summary, it can be stated that the lead times are much longer than planned. The production planning of the case company is based on the make-to-order principle and still the lead times are longer than planned. This can partly be explained by the order intaking procedure. When the customer places one annual order at the beginning of the year covering deliveries for the coming 12 months some of the product quantities may be produced well in advance, when it is economically feasible for the paper mill, and thus lead to a long lead time. In this type of lead time case the make-to-order principle is not really valid. The lead time has in this type of case features from the make-to-forecast principle leading to longer lead times.

### 6.1.2 Lead time and the cost of capital

The cost of capital depends directly on the number of the lead time days. The cost of capital can naturally be divided based on the individual supply chain process phases following the individual lead times. In order to simplify the comparison of

the cost of capital for the lead times, a cost of capital coefficient is used. The cost of capital coefficient shows how many times the cost of capital for the current average lead time is higher than the cost of capital for the target and median lead times.

For A mill's UK deliveries the cost of capital for the current average lead time is three times bigger than the cost of capital for the target lead time. For A mill's US deliveries the cost of capital coefficients for the current average lead time are a maximum of three times higher than for the other analyzed alternatives.

For B mill, the cost of capital coefficients are a little bit lower compared to the coefficients of A mill. For the UK market the coefficient shows that the capital cost for the current average lead time is five times higher for PM 6 than the target lead time. For the USA market the cost of the capital coefficient shows that the cost for the current average lead time is three times higher than the capital cost for the target lead time.

The cost of capital for the current average lead time for all A mill's deliveries to all markets is 10.1 million EUR based on the assumption that all deliveries behave in the same way as in the UK market. Based on the USA lead time behavior, the cost of capital for the current average lead time is 8.1 million EUR. The potential savings for the cost of capital for all A mill's deliveries is between four and seven million EUR per annum.

The cost of capital figures for B mill are naturally bigger than for A mill as the annual production of B mill is bigger than A mill's annual production. The cost of capital for the current average lead time for B mill is 13.6 million EUR based on the UK lead time profile and 19.6 million EUR based on the US lead time profile. These assumptions for both profiles are based on the total annual production of the mills. The cost of capital is, for the target lead time, for B mill 5.0 million EUR based on the UK lead time profile and 19.6 million EUR based on the US lead time profile. The potential savings for B mill in relation to the cost of capital is between nine and 13 million EUR depending on whether the UK lead time or the USA lead time profile is implemented for all the mills' deliveries.

### 6.1.3 Warehousing costs

The warehousing costs in the port of loading and in the port of discharge belong to those process phases which can be managed by the logistics organization. The warehousing costs in the loading port can be directly managed by the logistics organization itself, but in the discharging port warehousing time management is

completed indirectly by the logistics organization, as customer behavior dictates the warehousing time. The results show that, if all the case mills' supply chains would have the same profile as the case study supply chains the case mills would pay, on an annual basis, approximately five million EUR for warehousing in the loading and discharging ports. The warehousing costs in the discharging ports are significantly higher than in the loading ports. The figures also reveal that B mill has lower warehousing costs both in the loading and discharging ports.

## 6.2 Discussion, second research question

The second research question is: What is the relationship between the corporate and supply chain strategy, and how does that relationship function in a multinational paper producing company?

The results reveal that the roles for supply chain management and for logistics management are not entirely clear concept in the case company. These statements are based on the fact that the case company does not have clear internal rules concerning the lead time control of the individual supply chain process phases. Also the lead time management roles between the logistics organization and business divisions are not clearly defined.

Daily operations and management responsibilities are clear, but there are still some missing links in the whole supply chain ownership. An often discussed question was whether the supply chain ownership should belong to the sales network or to the mills' or to the logistics organization. In the current supply chain management concept of the case company, the first two supply chain process phases (production and dispatching from the mill) do belong to the mills' organizational responsibilities. The mills' IT applications provide the necessary data for the logistics organization for planning, managing and monitoring the process phases.

The business divisions own the problems of capital costs, warehousing costs and customer interface. The logistics department is a facilitator for contracting the logistics service providers. It is recommended that supply chain thinking should be more clearly defined as a strategic target in the case company's logistics strategy. This can be achieved by closer cooperation between the logistics organization and the business divisions.

The following action can be proposed to the case company in order to shorten the current lead times and to improve the overall supply chain performance, including improvements for customer service.

The supply chain management organizational issues should be clarified. The business divisions (mills and sales organization) should have a clearer supply chain management responsibility, including the individual supply chain management process phases. The logistics department should be seen as a fourth party logistics service company, which sells services to the business divisions. The case company should move the supply chain management from a fragmented management model to an internally integrated management model, where the operational roles are located in only two organizational units. The Finnish logistics organization could be responsible for all the processes from mill dispatching until the orders have arrived at the discharging port. The local sales and logistics organization at the discharging port could then have operational responsibility from the discharging port to the final customer.

Sea transportation is also in the scope of the business responsibilities of the logistics organization. The warehousing process and customer delivery process at the discharging ports should be clearly the responsibility of the business divisions and the logistics organization should also have the fourth party logistics service provider's role at the destination ports.

The sales network, which is part of the business divisions, should be trained in order to improve the understanding of the supply chain management, including the cost elements and lead times. This would lead to the better planning of customer deliveries and thus to shorter warehousing times at the loading and discharging ports.

The future supply chain management responsibilities of the case company are summarized in Figure 9. The basic idea is that the logistics organization would have responsibility for maintaining and developing the logistics network (transport routes, ports etc.) and also making contracts with all logistics service providers covering freight and handling costs.

The business divisions would have three main roles, where the supply chain management would be the core role. The supply chain management would then include lead time and working capital issues. The supply chain management would also have a leading role in strategically managing the logistics network structure including the freight and handling costs, which organizationally belong to the logistics organization.

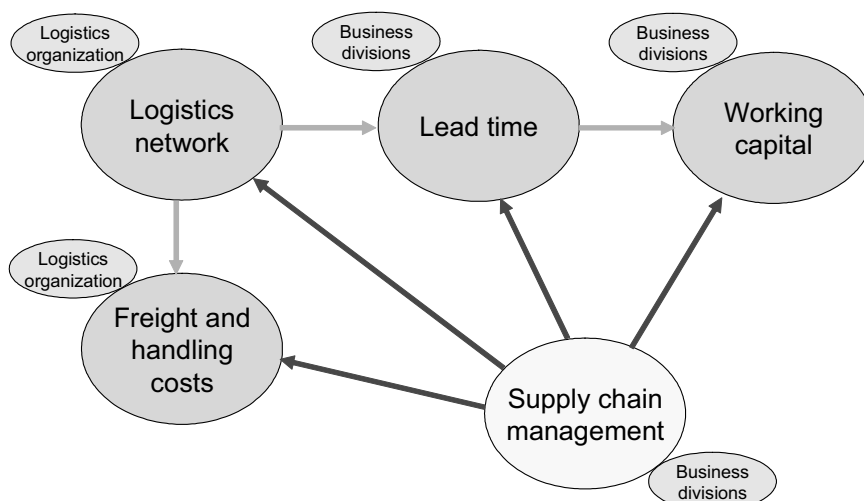


Figure 9: Proposal for the division of the case company's future supply chain management responsibilities

The future evolution of the roles for the logistics organization and business division of the case company is highlighted in Figure 10. The supply chain management on the customer order level should fall within the responsibilities of the business divisions. The freight and cargo handling costs, which are normally measured in €/ton, are the responsibilities of the logistics organization. The lead time reflects the total time, which the customer orders stay in the supply chains, and the lead time is measured in days. Lead time management should belong to the business divisions as well as the working capital management. Working capital is normally calculated by multiplying the tons of the customer order by the value of the customer order or by the cost of capital and finally multiplying by the number of lead time days. The logistics organization manages the logistics network and the logistics service providers include the warehouses in the loading and discharging sea ports. The mills control the mill warehouses and the business divisions control the distribution centers.

It is further recommended that the logistics organization should be considered an internal logistics service provider that has the role of a “fourth party” logistics service provider role. In the proposed new supply chain management governance model, the logistics organization has financial responsibility for daily logistics operation costs and the sales network has financial responsibility for the working capital.

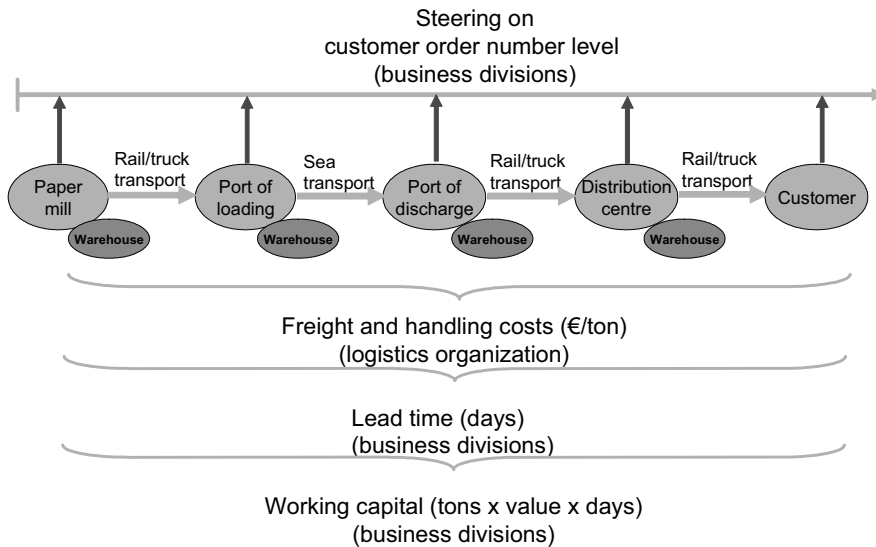


Figure 10: Case Company's evolution of roles for the logistics organization and business divisions

Figure 10 above also illustrates the different operational roles of the logistics organization and the business divisions. It is quite obvious that it will take some time before the roles are clearly defined due to the fact the collaboration between the logistics organization and the business divisions is still undergoing strong development.

The case company's new logistics IT application was taken into use during 2006 and some new supply chain management features should be developed for the IT application. It is recommended that the method of analysis of the lead time and production data, developed in this research work, should be part of the new logistics IT application and also support the business divisions. Supply chain process phase performance reporting should also be developed following the guidelines of the research work and new key performance indicators for the seven supply chain process phases should be communicated to the mills on a regular basis.

It is further recommended that the logistics organization should be the producer of the supply chain process phase performance data. The current logistics strategy does not include concrete key performance indicators, which could be used by the mills. The current key performance indicator discussion better supports the logistics organization than the business division.



Production planning at the mills decides how many production lots one customer order produces and how long it will take to produce the customer order. In the interviews with the logistics staff members and mill production planning staff members all respondents said that logistics cannot and should not influence production planning (Customer service manager, mill B, 16<sup>th</sup> September 2005, Senior vice president logistics, 25<sup>th</sup> September 2005, Customer service manager, mill A, 29<sup>th</sup> September 2005). Thus, logistics has to adapt to supply chain management and follow the production processes.

These statements lead the discussion to the size of the paper mills. It can be argued that the current paper mills have too large a production capacity and are too inflexible in production planning. If the mills would be smaller and more flexible in production planning, the number of production lots would decrease and thus logistics planning could be based on more streamlined information. This would lead to shorter lead times for customer orders and to a lower cost of capital for the orders.

When the results from lead time and production data analysis were communicated, the case company decided to change the current management processes, with the result that the logistics organization took over daily dispatch planning at the mills. The warehousing and vessel loading processes at the loading port are currently controlled by the logistics organization. In the new supply chain management model the logistics organization manages all supply chain process phases starting from mill dispatching up to the loading of reels and pallets on board the vessel that transports them to the discharging port. The local logistics organization at the destination country, including the local sales organization, is then responsible for the supply chain management process phases at the discharging port (warehousing and customer delivery).

### 6.3 Discussion, third research question

The third research question was: 1) To what extent do the number of produced reels explain the length of the production lead time?', and 2) 'What is the role of used production lots (as an entire production batch is split into smaller lots to enable the transfer of lots) with regard to lead time?'

The third research question tries to find explanations for the length of the lead time based on the production facts. The internal discussion in the case company has not touched upon, in a systematic way, explanations for the length of the lead time.

This is understandable as there are no uniform IT based measurement tools for measuring lead time on a process phase level.

From a research point of view the combination of a real life lead time and production data with statistical explanation methods is not so unique. However, in the research literature this kind of method of analysis is infrequently used. In fact, lead time research articles develop relatively complicated simulation methods, which cannot directly be implemented in real life cases.

When analyzing the total lead time three explanatory parameters were used: the number of produced reels, production time, production lead time and the amount of lots belonging to each customer order. The results from the regression analysis also show that the number of produced reels does not explain the number of lead time days. The highest level of explanatory value for the produced reels is approximately seven percent. The same conclusion can be drawn, if the amount of production lots is used as a regression parameter. The highest level of explanatory value for the production lots is six percent.

The regression of the amount of production lots was also analyzed for Finland (time from production until loaded onboard the vessel). For B mill's UK deliveries production in three lots explained 34 percent of the days in Finland and for A mill's USA deliveries production in three lots explained 15 percent of the Finland days (days stored in Finland). For other markets the explanatory level was between six and seven percent.

The results of the Finland days regression analysis confirms that the amount of different lots have a higher explanatory value than the amount of produced reels. The amount of lots starting from dispatch by a mill is controlled by the logistics organization, meaning that the logistics organization can have an influence on the different amounts of lots in the supply chains.

The mill time was also analyzed as an independent time constraint inside the total lead time. The regression analysis results are again consistent. For B mill's UK deliveries two parameters the number of produced reels and number of reels in the mill warehouse only explain 18 percent of the mill days. For A mill and for B mill's USA market the explanatory level is between three and nine percent. The explanatory level for the amount of production lots and mill dispatching lots were relatively high. For mills and for markets the explanatory level was between 18 and 25 percent.

For the destination days (time from vessel arrival until customer delivery) the regression analysis gave similar results to those for Finland days. The number of produced reels and the number of reels in the port of discharge warehouse explained between 0.5 and 15 percent of the destination days. The  $R^2$  values for A

mill are much higher (eleven to fifteen percent) than for B mill for destination days. The amount of production lots and the amount of customer delivery lots explains between 16 and 27 percent of the destination days. This conclusion confirms once again that the amount of lots better explains the lead time than the amount of produced reels.

Two individual process phases were identified where the  $R^2$  values have a high level of explanation. The first process phase is the production and the second process phase is the mill dispatching. For A mill's UK deliveries the production lots explain 41 percent of the production days and for A mill's USA deliveries the production lots explain 26 percent of the production days. For B mill's deliveries to the UK market the same explanation level is 52 percent and for the USA market the explanation level is 28 percent. For mill dispatching the production lots explain the amount of dispatching days. For A mill's UK deliveries the production lots explain 17 percent of the dispatching days and for the USA market the explanatory level is 26 percent. For B mill's UK deliveries the production lots explain 39 percent of the dispatching days and for the USA deliveries the explanatory level is 30 percent.

The conclusion for the lead time days is that the number of reels in the different supply chain management process phases does not explain the total lead time neither for Finland days nor for the destination days. The number of production, dispatching, shipping and customer delivery lots does have an explanatory value for the total lead time and for Finland days and destination days. The number of production lots is the starting point for the logistics planning and supply chain management of the case company. Another conclusion is that B mill works in a more disciplined way as the  $R^2$  values in several cases explain more of the correlations than the similar  $R^2$  values of A mill.

The case study regression analysis results can also be described as time required for the different process phases. The regression line coefficients explain how much more time, or less time, is required if the number of produced reels increases with one reel or if the production lots are increased by one lot.

The lead time sensitivity for the supply chain management process phases is summarized in two tables below. The first table (Table 11) shows the time sensitivity for the seven individual process phases and the second table (Table 12) shows the time sensitivity for the different lead time entities (mill days, Finland days, destination days and the total lead time). Two of the supply chain processes are not analyzed, transport to port of loading and sea transport. These two processes are excluded from the analysis due to the fact the transport time is under

normal conditions constant. The lead time sensitivity for the individual supply chain processes are summarized in Table 13.

Table 11: Lead time sensitivity for the case company's supply chain process phases

Supply chain process phase (SCMPP)	Time sensitivity for both mills One additional reel increases the lead time by days/hours One additional lot increases the lead time by days/hours		
	<b>Lead time sensitivity Number of reels</b>	<b>Lead time sensitivity Number of lots</b>	<b>Type of lot</b>
SCMPP # 1 Production	Min 2 hours Max 6 hours	Min 2 days Max 4 days	Number of production lots
SCMPP # 2 Mill warehousing	Min 0 hours Max 1 hour	Min 2 days Max 4 days	Number of production lots
SCMPP # 2 Mill dispatching	Min 0,5 hours Max 1 hour	Min 2 days Max 3 days	Number of production lots
SCMPP # 3 Transport to port of loading	Not analyzed	Not analyzed	
SCMPP # 4 Warehousing time in port of loading	Min minus 2 hours Max 1 hour	Min minus 4 hours Max 2 days	Number of production lots
SCMPP # 5 Sea transport	Not analyzed	Not analyzed	
SCMPP # 6 Warehousing time in port of discharge	Min 1 hour Max 8 hours	Min 4 days Max 9 days	Number of production lots
SCMPP # 7 Customer delivery	Min 1 hour Max 9 hours	Min 3 days Max 10 days	Number of production lots
		Min 9 days Max 20 days	Number of customer delivery lots

The lead time sensitivity analyzing results show that lead time sensitivity, based on the number of produced reels, varies between hours in the individual process phases. One additionally produced reel in production increases the lead time, mathematically, by a minimum two hours or by a maximum six hours. In the port of discharge warehousing, one additional produced reel increases the lead time by a maximum of eight hours and in the customer delivery process the lead time increase is a maximum of nine hours or a minimum of one hour.

Lead time sensitivity based on the number of production lots shows a much stronger impact than lead time sensitivity based on the number of produced reels. The lead time sensitivity based on the number of reels is between one to nine hours and, based on the number of production lots, the sensitivity variations are between two and twenty days. One additional production lot increases the lead time by between two and four days in production. Mill warehousing time also increases by between two and four days as one additional production lot is

produced. The mill dispatching sensitivity is between two and three days. The mill dispatching time is included in the mill warehousing time.

Time sensitivity in the discharging port warehousing is between four and nine days for one additional lot produced. The most significant lead time sensitivity is in the customer delivery process phase. Based on the number of production lots lead time sensitivity is between three and ten days. The conclusion is that the number of production lots and the number of customer delivery lots play a much more significant role in lead time sensitivity than the number of produced reels.

When analyzing the total lead time sensitivity for the three main components mill days, Finland days, destination days the conclusion is the same as it is for the individual supply chain process phases. Time sensitivity varies between one hour and a maximum of one day based on the number of produced reels. The mill day sensitivity analysis based on production lots shows that the time sensitivity is between two and six days and if the analysis is based on the dispatching lots the time sensitivity is between six hours and a maximum of four days. The biggest time sensitivity is for the shipping lots. One additional shipping lot increases the lead time by a maximum of 29 days. This means in practice that e.g. short shipments in the loading port increase the lead time very much. The results from the destination time sensitivity analysis show that one additional customer delivery lot increases the lead time by a minimum of nine and by a maximum of 21 days. For total lead time sensitivity the lead time increases by a maximum of 12 days, if the production lots increase by one lot.

The total lead time sensitivity results including the specific lead time components are summarized in Table 12.

Table 12: Total lead time sensitivity summary including the specific lead time components

Supply chain process combinations	Time sensitivity for both mills One additional reel increases the lead time by days/hours One additional lot increases the lead time by days/hours		
	Lead time sensitivity Number of reels	Lead time sensitivity Number of lots	Type of sensitivity parameter
Mill days First production day – last dispatching day	Min minus 1 hours Max minus 6 hours	Min minus 2 days Max 4 days	Number of produced reels, production lots
	Min 1 hour Max 7 hours	Min minus 6 hours Max 4 days	Number of reels in mill warehouse, dispatching lots
Finland days First production day – last warehousing day in loading port	Min minus 4 hours Max 1 hour	Min minus 12 hours Max 4 days	Number of produced reels, production lots
	Min minus 5 hours Max 1 hour	Min minus 7 days Max 4 days	Number of reels in mill warehouse dispatching lots
	Min 1 hour Max 7 hours	Min minus 16 days Max 29 days	Number of reels loaded on board the vessel, shipping lots
Destination days Vessel arrival day – last customer delivery day	Min minus 1 day Max 8 hours	Min minus 1 day Max minus 3 days	Number of produced reels, production lots
	Min minus 1 hour Max 1 day	Min 9 days Max 21 days	Number of reels in discharging port warehouse, customer delivery lots
Total lead time days	Min minus 1 hour Max 8 hours	Min minus 1 day Max 12 days	Number of production lots

The lead time sensitivity results for the specific lead time components confirm the results from the individual process phase regression analysis results. The number of different types of lots plays a much more important role in the lead time management than the number of procured reels. The results confirm that the lot management issues should be included in the supply chain management rules of the case company. The business divisions, including the sales organization, should also have a better understanding of the role of the different types of lots and especially the role of customer delivery lots with regard to the total lead time.

Time wise the longest component in the lead time is warehousing in a discharging port. The warehousing time at a discharging port depends on two main issues. Firstly the warehousing time depends on the production time and secondly it depends on customer behavior, meaning their ordering behavior. The basic assumption is that all customer orders are made on the make-to-order principle. A

further assumption is that mills can influence warehousing time with more accurate planning but that mills cannot influence the number of customer calls.

When summarizing the number of customer deliveries with reference to the number of warehousing days at the discharging port we can draw the following conclusions for the case supply chains. For A mill's UK deliveries only 37 percent of the customer deliveries are delivered in 2 lots (reflecting the median value) and in less than 30 days; 63 percent stay more than 31 days in the discharging port warehouse and are delivered in more than 2 delivery lots. For A mill's USA deliveries the same figures are 52 percent and 48 percent. B mill's UK deliveries have the lowest value of 25 percent, delivered in less than two lots and with less than 30 days in the discharging port warehouse and 75 percent delivered in more than 3 lots and with more than 31 warehousing days. The same figures for B mill's USA deliveries are 51 percent and 49 percent.

Table 13: Summary of discharging port warehousing days and customer delivery lots

	Warehousing days in discharging port	0 - 30 days (% share)	31 – 510 days (% share)	Total # of orders
<b>A mill UK</b>	<b>Less than 2 customer delivery lots (median value)</b>	<b>37</b>	<b>63</b>	<b>236</b>
<b>A mill USA</b>	<b>Less than 2 customer delivery lots (median value)</b>	<b>52</b>	<b>48</b>	<b>28</b>
<b>B mill UK</b>	<b>Less than 2 customer delivery lots (median value)</b>	<b>25</b>	<b>75</b>	<b>110</b>
<b>B mill USA</b>	<b>Less than 3 customer delivery lots (median value)</b>	<b>51</b>	<b>49</b>	<b>292</b>

The findings from Table 13 confirm that less than half of the customer orders are produced on the make-to-order principle, meaning that the orders stay less than 30 days in the discharging port warehouse. As said earlier, the discharging port warehousing time depends on the production time, which has been agreed with the customers already at the order taking phase. More than half of the customer orders seem to behave according to the make-to-forecast production principle as they stay for more than 31 days in the discharging port warehouse. The basic assumption was that the mills cannot influence the number of customer call offs.

#### 6.4 Discussion, fourth research question

The fourth research question was: 1) What are the special features of the supply chain involving intermodal and non-containerized transportation? 2) Which main factors determine the success of a non-containerized intermodal transport solution? and 3) How can the performance of the supply chains analyzed be improved in the future?

Intermodal transportation is normally linked to containerized supply chains, which are generally much more disciplined due to vessel scheduling and operational time slots in the loading and discharging ports. The analyzed case study is a non-containerized supply chain, where the time discipline is more flexible as the vessel loading and discharging are more time consuming, due to the implemented cargo handling techniques. The loading and discharging of individual paper reels and pallets takes much longer than the loading and discharging of one container.

The handling of individual paper reels and pallets also provides a major challenge for tracking and tracing in the supply chain. The tracking of containers is implemented globally, but the tracking of individual paper reels and pallets is implemented only by few companies. The tracking is mainly based on the number of reels and pallets.

The study revealed some specific features for the non-containerized intermodal supply chains. This type of supply chain includes several physical handling stages, which make the tracking and tracing quite difficult. Another feature is that the shipment lots have to be large in order to make the sea voyage economical. The non-containerized supply chains are industry based supply chains, whereas the container transports are based on a common carrier principle serving several customers.

The results show that in a non-containerized supply chain the waiting/warehousing time, lead time elements are long at those points where the products are shifted from one transport mode to another. The longest waiting times are in the loading and discharging ports.

The warehousing and dispatching time at the case mills were analyzed in order to attain an understanding from the starting point of the inter-modal transportation.

In total, 14.7 percent of A mill's order lines to the USA market are dispatched the same day as the production takes place while 19.7 percent of A mill's USA orders are dispatched within one day. In contrast, 11.3 percent of B mill's order lines to the USA market are dispatched during the production day to the loading



port. In total, 41.3 percent of A mill's USA order lines are dispatched within one day. The detailed warehousing time distribution is summarized in Table 14.

Table 14: Distribution of the mill warehousing and dispatching time

Mill warehousing days	0 days in mill wh = dispatched same day	One day in mill wh	2 – 5 days in mill wh	6 - 10 days in mill wh	11 – 15 days in mill wh	>16 days in in mill wh	Total # of orders	Average # mill warehousing days	Median
<b>A mill USA</b>	9 14.7%	3 5.0%	14 23.0%	12 19.7%	8 13.1%	15 24.6%	61	17	8
<b>B mill USA</b>	44 11.3%	116 30.0%	103 26.4%	48 12.3%	32 8.2%	47 12.1%	390	7	2

The case company's logistics strategy does not have any specific statements on the warehousing issues and warehousing time at a mill. The mill warehousing issue belongs, according to the mill's operational responsibility, to the supply chain management. The unwritten rule is that all order lines should be dispatched as soon as transport capacity is available and if there are no commercial issues, which will stop the dispatching. This statement is valid also for domestic order lines, which are going to another local mill e.g. for coating.

The A mill has three trains per week to the Western Finnish port for US order lines. This train frequency leads automatically to the need for warehousing at A mill as the produced reels have to wait more than one day for the next train departure. In both routes the train capacity is not a bottleneck as the railway company can normally add some more wagons to the trains. The main capacity limitations for the trains are the length of the train and the cargo weight of the train.

Basically it is said that B mill does not have any warehousing capacity at the mill before the dispatching process phase. The analyzed figures however reveal that there is warehousing capacity at B mill and the whole production is dispatched to the case markets on three daily trains to a Western Finnish port. The daily train frequency should not, in normal cases, lead to a warehousing capacity requirement at the mill. The reels are loaded directly from the packaging machine to the railway wagons. The first train departure time is in the evening, the second train departure is early in the morning and the third train departure is late afternoon. The train schedules mean in practice that a production of 24 hours can be loaded three times onto the trains and the theoretical waiting time at the mill is a maximum of eight hours.

The warehousing time analysis shows very clearly the process differences between A mill and B mill. B mill has direct loading onto railway wagons just after production. For the USA market 41.3 percent of the order lines are loaded directly onto wagons and trucks. In contrast at A mill the same figure is 19.7 percent. A mill has a large warehouse. Streamlining the warehousing processes at A mill would decrease the value of products in the mill's stock.

The port operator in both West Finnish ports gives 14 days free warehousing time for customer orders. After the fourteenth day the mills pay an agreed warehouse rent, which is based on the square meters, tons in warehouse and warehousing time. The so called "free warehousing time" has long been a tradition in the port warehousing business in the main loading and discharging ports. If the warehouse rent cost would start immediately as soon as the order lines arrived at the loading port, the warehousing time would obviously be shorter as it would generate a real cost for the mills.

78.8 percent of A mill's USA order lines stay less than fourteen days in the loading port warehouse and avoid having an extra warehousing cost at the loading port.

81.5 percent of B mill's USA order lines stayed less than fourteen days in the port warehouse. The loading port warehousing time is summarized in Table 15.

Table 15: Distribution of the warehousing time at W-port (Finland)

Warehousing days in POL	0 – 7 days	8 – 14 days	15 – 30 days	31 – 40 days	> 41 days	Total # of orders	Average	Median value
<b>A mill</b>	<b>26</b>	<b>15</b>	<b>9</b>	<b>1</b>	<b>1</b>	<b>52</b>	<b>9</b>	<b>8</b>
<b>USA</b>	<b>50.0%</b>	<b>28.8%</b>	<b>17.3%</b>	<b>1.9%</b>	<b>1.9%</b>			
<b>B mill</b>	<b>163</b>	<b>100</b>	<b>46</b>	<b>3</b>	<b>11</b>	<b>323</b>	<b>11</b>	<b>7</b>
<b>USA</b>	<b>50.5%</b>	<b>31.0%</b>	<b>14.2%</b>	<b>0.9%</b>	<b>3.4%</b>			

The main conclusion from the loading port warehousing time is that the different dispatching lots are kept together in the loading port before the whole shipment is loaded on board a vessel, thus causing warehousing time. This could be avoided by changing the steering rules of the supply chain management. New rules would include a principle that allows the production's dispatching lots to be shipped individually to the discharging port without collecting all dispatching lots together at the loading port.

The interviews with the mill representatives provided some other explanations of the warehousing time at the loading port. Some customers have large orders and

the large orders are generally produced during a longer time period and this leads to a longer warehousing time in the loading port. Some foreign customers use the Finnish loading port as their warehouse. Another explanation for the long warehousing time comes from the fact that damaged reels are included in the statistical data thus adding warehousing time. Also short shipped orders are included in the statistics and thus add warehousing time at the loading port (Customer service manager, B mill 16<sup>th</sup> September 2005 and Customer service manager, A mill, 29<sup>th</sup> September 2005).

The vessel sailing frequency does not play such an important role in the port warehousing as there are three sailings for every 12 days from the West Finnish port to the USA. The vessel sailing frequency does not explain the long warehousing time in the loading port. The explanation of the warehousing times lies more with the case company's internal supply chain management rules. This conclusion was also discussed with representatives from the case company. The current supply chain management rules of the case company have been developed over the last ten years. The case company is also initiating a development project aimed at improving the supply chain performance of the non-containerized supply chains in order to lower the amount of working capital, which is bound up in products during their warehousing time in loading and discharging ports.

It is very obvious that a non-containerized supply chain should learn more about the containerized supply chains. Lead time discipline is the most important element in a containerized supply chain. This provides new challenges for the case company's logistics organization and for the producing mills and sales organization. In practical terms this would mean that the case company's current supply chain management rules, which are developed for non-containerized transportation should be developed according to the supply chain management rules of the containerized transportation.

It is recommended that for future research the lead time of a containerized supply chain should be analyzed in order to reach an understanding of the lead time behavior of the containerized supply chains, which normally cover overseas, global deliveries.

## 6.5 Discussion; the generalizability of the research results

As this research is, to a large extent, case study oriented, the research work is based mostly on empirical and first hand case studies, and therefore on methodology that supports that, which is an inductive approach mixing

quantitative and qualitative analyses to gain results from different types of real life supply chains. The systems approach, developed by Arbnor and Bjerke, was selected as the methodological approach. The results from the lead time analysis, which were generated by induction, were tested with existing theories. The empirical results combined with existing theories lead to new theory building through the use of deduction. The results of this research work are derived mainly from the case study observations and then tested with current theories.

Generalizability is defined as drawing conclusions from one or several observations that are based on fact-based information (Kasanen and Lukka 1993, 348-380). The results of this research work are paper industry specific results, which could easily be adapted and implemented in such forestry industry areas as pulp and timber production. The Finnish steel industry, especially the stainless steel industry, could also implement the results as their production and customer delivery unit is steel coils and the supply chain solution essentially follows the geographical solution of the paper industry. The lead time performance measurement system could also be used by totally different business areas that have a long delivery distance to customers. A spare parts business in a global environment could be one example.

The strategic conclusions of this research work are based on case study methodology combined with theoretical understanding. The results can be implemented, generally speaking, by production industries that own their supply chains. The results cannot be implemented by the logistics service providers, as they are not owners of the supply chains.

## 7 CONCLUSIONS

### 7.1 General conclusions

One trend in the Finnish paper industry supply chain management is that competing companies are not willing any more to co-operate in the area of supply chain management and transport solutions. Some years ago the companies used the same shipping lines to the main destinations, but the large paper companies have now developed their own supply chain solutions, including the use of different shipping lines and different loading ports. However, the discharging ports are still the same and operations take place in separate port areas.

There are some development trends in supply chain management, which can be identified in the Nordic paper industry. UPM-Kymmene is making a strategy change by moving from a common carrier chain to a dedicated chain. This development has been achieved by taking the automatic loading and discharging of railway wagons into use between its Kajaani mill and Rauma Stevedoring.

StoraEnso's Swedish mills have been using a dedicated supply chain model since 1999. The transportation from the mills to the loading ports and sea transportation are controlled by StoraEnso Logistics, which acts in the role of supply chain manager. The same dedicated logistics and supply chain management strategy is also currently implemented for the biggest StoraEnso mills in Finland.

These two examples clearly show that the two big paper producing companies are putting more effort into logistics and supply chain management development in their own business environment. Both companies have joint targets, such as improving the efficiency of the current supply chain management and also cutting the current cost structure. What is interesting to note is that the two companies base their future supply chain management concepts on totally different technical solutions. This observation is typical of the paper producing industry, where future logistics solutions are quite often developed based on technical solutions. Supply chain management and lead time management development often lag behind the supply chain management's technical development. Making the supply chain

management understand this in the paper producing companies would require a change in thinking in this production oriented business environment.

## 7.2 Research objectives and research questions, conclusions

The research work had two main objectives. The first objective was to contribute to academia and:

*Develop a conceptual measurement system for the lead time measurement of supply chains, which are managed by several actors.*

The second objective of this research was to contribute practical information to the case company and:

*Provide a measurement system for the total lead time and for the individual supply chain management process phases of the supply chains. The target of the new measurement system is to assist the case company in lowering the supply chain cost structure.*

The research objectives have been discussed in four individual research questions and four individual articles. The four individual research questions can be summarized in following way:

*The first research question* describes the phenomena to be analyzed and asks: What is the actual lead time performance? The contribution to the first research objective includes the verification that the lead time measurement system is feasible in the paper industry business environment. The contribution to the case company is the fact, that through the implementation of the proposed lead time measurement system, significant savings in operational costs and in working capital can be achieved.

*The second research question* analyzes the relationship between corporate and supply chain strategies, which govern the analyzed phenomena. There is a joint conclusion both for academia and for the case company: The organizational roles and responsibilities are not clear in the relationship between the corporate and supply chain strategies.

*The third research question* analyzes production lots as a new explanatory parameter for the length of the lead time. The contribution to academia includes the confirmation that the number of production lots increases lead time, as

measured in days. Similar observations have been found in other production industries. The contribution to the case company includes a new understanding of the role of production lots. Previously, the case company explained the length of lead times with reference to the amount of the product produced.

*The fourth research question* compares a non-containerized supply chain (case company) with a containerized supply chain. Here, there are joint conclusions both for academia and for the case company. In a non-containerized supply chain there are long warehousing times at both the loading and discharging ports. In contrast, in a containerized supply chain, there are only a very few days waiting time in both the loading and discharging ports. That is because container movements are tightly scheduled and follow vessel schedules.

The research objectives have been met by the conclusions gained from the four individual articles. Thus, the contributions have brought new understanding and new knowledge to both academia and to the case company.

### 7.3 Case company conclusions and recommendations

The main conclusions and recommendations from the published articles can be summarized in following eight observations:

1) The first recommendation is that the *monitoring of actual lead times* for the individual supply chain management process phases should be a strategic measurement tool for the case company. The essence of lead time measurement should be developed via an improved understanding of the working capital.

2) The second recommendation covers the *integration of the logistics organization with the business divisions*. This recommendation also covers the organizational roles and responsibilities. It is recommended that the supply chain management responsibilities should be in the business divisions and that the logistics organization would have the role of a fourth party logistics service provider that is strongly integrated into the business divisions. The case company's logistics organization currently works more on the physical infrastructure of the supply chains, which is a typical solution in the paper producing industry. The contracting of logistic service providers, developing warehouse facilities (both in the loading and discharging ports), and developing IT applications are typical examples of current supply chain management or, more accurately, logistics management.

3) The current *logistics or supply chain management IT applications* of the case company do not automatically provide, in a uniform way, lead time and

production data, which could be systematically analyzed on regular basis for lead time management purposes. Plenty of manual work has been used in the case study in order to sort out the data for the purpose of analysis. It is recommended that new IT applications with additional functionalities for lead time and production data management should be developed.

4) The case study results provided some additional, individual observations about the current supply chain management, which have not been widely discussed in the case company. It was a surprise to the case company, that the number of production lots, dispatching lots and customer delivery lots provide the highest explanatory values for the length of lead time. The internal discussion in the case company normally explained lead time length by referring to the number of produced reels.

This conclusion sets supply chain management a challenge. Obviously a better understanding of the role of the lot management in the different process phases would decrease the cost of capital of the lead time. This also means, for the paper industry, that supply chain management should be a more disciplined function. It is further recommended that *lot management issues* should be understood as one measurement tool in the case company's supply chain management.

The biggest lead time savings can be achieved by changing the current rules of supply chain management. The case company's current supply chain management rules state that individual production lots should be physically handled as one entity. This means, in practice, that the first production lots have to wait for the last production lot, before the whole customer order line is transported to next location. The recommendation to the case company is that; in the future, *lot based supply chain steering should be changed to reel based steering* meaning that the planning and monitoring level should be carried out on an individual reel level. Supply chain steering rules should be also changed so that the first produced reels do not need to wait for the last reel that belongs to the same customer order. As soon as reels are ready for transportation, they should be released to supply chains and the monitoring should be carried out on a reel level.

The number of logistics service providers will decrease as the preferred partners gain a deeper understanding of the daily operational level of the steering parameters of the supply chain. The integration of logistics service providers is currently good. The same philosophy would also mean that the case company will use fewer ports, but this will mean they will be able to find and develop partners who have a deeper understanding of their supply chain management. A smaller number of loading and discharging ports should also lead to a smaller number of shipping routes.



5) It is also recommended that customer call offs could be made before all reels in the same customer order have arrived at the destination port. This *new type of call off procedure* would cut warehousing time in the destination and discharging ports.

6) Reel supply chain planning and reporting would also create new requirements for the supply chain management IT applications. In brief; *Supply chain transparency should be carried out with reference to reels*. This would mean that the supply chain IT applications would handle reel based status reports for each of the seven supply chain management process phases. The amount of supply chain management data would increase, but with current IT applications managing such a massive amount of reel based data is feasible.

Only 20 to 30 percent of the lead time can be explained by the selected parameters analyzed in the study. The rest can be explained by human behavior, which in this case operates according to the supply chain management rules of the case company, or according to parameters, which were not included here, such as order handling procedures and production planning.

7) The case company should transfer supply chain management rules from non-containerized transport to containerized transport. The global containerized shipping business follows strict management rules, which could, with minor adjustments, be implemented for the case company's supply chain management principles.

8) Based on the lead time results it is recommended that the case company's supply chain development should begin from the customer's end. This is because the case company needs a more holistic view of supply chain management, which should cover both internal and external factors.

The recommendations to the case company can be summarized in a very simple statement: "If you cannot measure it, you cannot manage it."

#### 7.4 Strategic conclusions

The developed lead time performance measurement system proved to be practical and feasible in the paper industry supply chain business environment. There are four strategic conclusions, which support the lead time measurement system: 1) Sharing of supply chain performance information plays a very important role in managing supply chain operations. Jointly agreed real time supply chain information improves the overall efficiency of the supply chains, and thus does not leave space for logistics service companies' individual sub-optimizing; 2) defining

more precisely the organizational responsibilities of the business divisions and the logistics organization, in the area of supply chain management, would improve the relationship and operational efficiency between the corporate and supply chain strategies of the case company. A successful supply chain strategy implementation requires supply chain management specific indicators to be developed on operational level; 3) the number of production lots has a higher explanatory value for the length of the lead time than the number of produced reels. Developing new supply chain rules, based on this observation, would improve the efficiency of the case company's supply chains, especially when seen from the working capital point of view and 4) the four analyzed supply chains are based on a break bulk, non-containerized supply chain model. Based on inter-modal thinking between different modes of transport, it was noticed, that the longest waiting times occurred at those points, where customer orders are moved from one transport mode to another. When using containerized supply chains such waiting times could be minimized, as there is normally a better supply chain discipline in containerized supply chains due to tight scheduling of the container vessels.

This research brings new understanding for paper industry supply chain behavior, which has similar features as the supply chains for timber and steel industries. Four specific areas of new understanding in the frame of reference can be identified: 1) This research work concentrates on the readymade products and their supply chain behavior. The supply chain management processes have been identified so that the lead time can be explained by individual supply chain management processes creating the lead time measurement tool; 2) The interaction between the case company's corporate strategy and supply chain strategy confirms, that supply chain management is currently not seen as a strategic issue in the case company. This is a conflicting observation compared to the supply chain management literature, where it is generally stated that supply chain management and its organizational issues are strategic development tools for the companies; 3) The lead time behavior of the case company is explained especially by two selected parameters. The results from these analyzes confirm earlier research results. The number of production lots has a direct influence on the length of the lead time and, on the contrary, the produced amount does not explain the lead time so much. Similar observations have been argued in earlier theories and articles. The findings of this research bring also new understanding to the paper industry logistics research, especially for the ready made products. Earlier paper industry logistics research has been mainly focusing on raw material and production optimization cases; 4) The analyzed paper industry supply chains are non-containerized supply chains using so called break bulk shipments. A

comparison to the containerized supply chains reveal, that the containerized supply chains do have higher discipline in lead times as the vessel scheduling is done on fixed time schedules. This finding brings new understanding on the operational level of the supply chain management theories.

## 7.5 Future research areas

The lead time and production data analysis conducted for this research study covers only two paper machines per production location and two market areas. In future research it would improve the overall understanding of one production location, including all local paper machines, if the lead times and supply chain process phases of all market areas were to be analyzed. Such future research would then improve the understanding of the supply chain management of one production location covering all market areas and all paper machines.

The lead time method of analysis could also be taken into use in strategic customer discussions meaning that the case company could show the actual lead time performance to some selected customers. Based on the actual lead time performance both the customer and the case company could jointly develop new ways of managing supply chains in a more efficient way.

Customer's call off decision making would also be an interesting area for future research. It would be of great importance to understand a customer's internal production planning process, which sends call offs to the case company's warehouses.

Making a benchmarking study with another paper producing company would follow the same lead time and production data method of analysis as used for this research work and would improve the overall understanding of the paper industry's supply chain management on a global basis.

Another interesting research topic for the future would be an analysis of the relationship between the production costs and the logistics costs. Production people often argue that the production process is so expensive that supply chain management has to adopt its daily routines and follow production. It would be most interesting to quantify the production and the logistics costs in order to understand whether the production costs create additional costs for logistics or could the logistics costs be decreased with better production planning.

Another area, where the lead time method of analysis could be tested is the overseas container shipments. Overseas containers are filled at the mills and are then delivered directly to the customers. In this type of overseas transportation

there are several logistics operations. A comparison of the overseas containers' lead times and the lead times for European deliveries would obviously highlight differences in supply chain management practices between European and overseas markets.

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