HELSINKI UNIVERSITY OF TECHNOLOGY
Faculty of Information and Natural Sciences
Degree Programme in Industrial Engineering and Management

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REENGINEERING A PHYSICAL DISTRIBUTION NETWORK IN THE SPORT INSTRUMENTS INDUSTRY

Thesis submitted on partial fulfillment of the requirements for the degree of Master of Science (Technology)

Espoo, 30 September 2008

Supervisor: Professor Mr. Eero Eloranta

Instructor: Doctor Mr. Patrik Appelqvist

HELSINKI UNIVERSITY OF TECHNOLOGY ABSTRACT OF THE MASTER´S THESIS
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Today's fierce competitive environment drives companies to seek competitive advantage from their supply chains. Earlier companies focused on cost reduction, but now the ever changing environment forces companies to increase the responsiveness of their supply chains. Agility and flexibility are today's paradigms towards to more responsive supply chain.

This research studies the design of physical distribution network. This research contains two parts. First part, theoretical is based on supply chain management, physical distribution and performance management. Empirical part applies the knowledge build during the theoretical part in Finnish based sport instrument company. The main research question is "What is the optimal physical distribution network for Case Company?".

Literature part presents a general framework for companies how to analyze their supply chains and products to devise optimal physical distribution networks. To devise the optimal distribution network company has to go through four steps. First is to define the nature of product, second is to decide priorities in the supply chain, third to define a proposal for the optimal distribution network and fourth to use performance measures to define optimal distribution network.

Empirical part analyzed Case Company using the framework that literature review presented. Author conducted the four step analysis presented above in the empirical part. The research approach of thesis was constructive and also principles of the case study approach were applied.

The findings of empirical part show that companies whose products' demand patterns are unpredictable and the supply chain requires agile and flexible performance, deliveries directly to retailers can be lucrative choice when considering physical distribution structure. Depending on the As-Is state of physical distribution there is possibility to shorten total order cycle time and cut inventory levels. Distance to customer is not measured anymore in kilometers, but in time. This research shows that Case Company can be nearer to customer in time when the location of distribution centre is further. Direct delivery is possible to implement without increasing logistics cost. Direct retail deliveries will increase the costs of pollution, because companies need use more airfreight to meet the customer requirements. Direct retail deliveries are more attracting choice when delivering goods from east to west. This is due to time difference between consignor and consignee.

Keywords: Supply Chain Management, Physical Distribution, Performance Measurement	Publishing language: English

TEKNILLINEN KORKEAKOULU DIPLOMITYÖN TIIVISTELMÄ
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<table>
<tr><td colspan="3">Tekijä: Petteri Kauppinen</td></tr>
<tr><td colspan="3">Työn nimi: Fyysisen Jakeluverkoston kehittäminen urheiluinstrumenttiteollisuudessa</td></tr>
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<tr><td colspan="3">Työn valvoja: Professori Eero Eloranta</td></tr>
<tr><td colspan="3">Työn ohjaaja: Tohtori Patrik Appelqvist</td></tr>
<tr><td colspan="3">Nykypäivän ankara kilpailuympäristö ajaa yritykset etsimään kilpailullisia etuja niiden toimitusketjuista. Aikaisemmin yritykset ovat keskittyneet kulujen minimoimiseen, mutta nykypäivän alati muuttuva kilpailuympäristö pakottaa yritykset hakemaan paremmin asiakaskysyntään vastaavia toimitusketjuja. Ketteryys ja joustavuus ovatkin tämän päivän yleisesti hyväksyttyjä teoriasuuntauksia haettaessa asiakasvastaavuutta toimitusketjuista.

Tässä työssä tutkittiin fyysisen jakeluverkoston suunnittelua. Tutkimus sisältää teoreettisen ja empiirisen osan. Teoreettinen osa luo tietopohjan toimitusketjun johtamisesta, fyysisestä jakelusta ja toiminnan mittauksesta. Empiirinen osio vie teoreettisen osan tiedot käytäntöön. Teoreettisen osan tietoja tutkitaan tapaustutkimuksella eräässä suomalaisessa urheiluinstrumentteja valmistavassa yrityksessä. Päätutkimuskysymys tutkimuksessa oli ”Mikä on optimaalinen fyysinen jakeluverkosto tapaustutkimusyritykselle?”.

Kirjallisuustutkimus esittelee teoriaa toimitusketjun hallinnasta, fyysisestä jakelusta ja toiminnan mittaamisesta. Teorioiden pohjalta kirjallisuustutkimus esittelee viitekehyksen, jonka avulla yritys voi suunnitella optimaalisen fyysisen jakeluverkoston. Optimaalisen fyysisen jakeluverkoston suunnittelu sisältää neljä vaihetta. Ensimmäiseksi määritetään tuotteen kysynnän luonne, toiseksi tunnistetaan vaatimukset toimitusketjulle, kolmanneksi muodostetaan ehdotus fyysisestä jakeluverkosta ja lopuksi lasketaan mikä on optimaalinen ratkaisu jakeluverkostolle.

Empiirinen osa soveltaa käytäntöön teoreettisen osan viitekehystä. Käytäntöön soveltaminen toteutetaan tapaustutkimuksen muodossa. Kirjoittaja käy läpi kaikki neljä viitekehyksen vaihetta ja muodostaa suosituksen kohdeyritykselle optimaalisesta fyysisestä jakeluverkosta.

Empiirisessä osassa havaittujen tulosten perusteella voidaan sanoa, että yritys, joka toimii jatkuvasti muuttuvassa toimintaympäristössä ja jonka tuotteiden kysyntä on hankalasti ennustettavaa ja elinkaaret ovat lyhyitä, kannattaa harkita suoratoimituksia vähittäiskauppoihin. Suoratoimituksilla yritys voi olla lähempänä asiakasta ajallisesti vaikka fyysisesti olisikin kauempana. Yritykselle on mahdollista saavuttaa parempi asiakaspalvelun taso pienemmillä kustannuksilla ja varastoilla, jos se käyttää suoratoimituksia vähittäismyymälöihin. Suoratoimitusmalli on houkuttelevampi vaihto ehto, kun toimitukset matkaavat idästä länteen. Näin yritys voi hyödyntää aika eron kuljetuksessa.</td></tr>
<tr><td colspan="2">Avainsanat: Toimitusketjun johtaminen, Fyysinen jakelu, Toiminnan mittaus</td><td>Julkaisukieli: englanti</td></tr>
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It was fall 2002, when I started my studies in Helsinki University of Technology. At that time, I did not have a clear vision of my carrier plans. I chose department of industrial engineering and management to keep my doors open for the future. Now in the fall 2008, after six years of university studies my thoughts are much clearer for the future. Conducting master's thesis has been highly interesting and educative and this project has crystallized my studies in the Department of Industrial Engineering and Management. Now I would like to thank you all who have been guiding, commenting, and supporting me in my project.

First, I would like to acknowledge my supervisor Mr. Eero Eloranta who has been guiding me into the right direction during my project. His comments and guidance have been very valuable and educative to my thesis in this project and me. Thank you Eero, for your effort and interest you have devoted to this project.

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Last but not the least I would like to give thanks to my family and girlfriend, with whom I have not spend enough time during the spring and summer 2008. Thank you Heli, Petri, Henri, and Pia.

Espoo, August 2008
Petteri Kauppinen

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LIST OF ABBREVIATIONS

CO_2	Carbon Dioxide
CPT	Carriage Paid to
DC Europe	Refers to Parent Corporation's distribution centre in Europe
DC USA	Refers to Parent Corporation's distribution centre in the USA
DOS	Days-of-Supply
DSI	Days Sales Inventory. Inventory measure used in Parent Corporation
EMEA	Europe, Middle-East, and Africa
ERP	Enterprise Resource Planning
GrSCM	Green Supply Chain Management
HK	Hong Kong
HQ	Headquarters
IT	Information Technology
OEM	Original Equipment Manufacturer
P&L	Profit and Loss Statement
PRTM	Pittiglio Rabin Todd and McGrath
S&D	Selling & Distribution
SCC	Supply-Chain Council
SCOR	Supply-Chain Operations Reference Model
VMI	Vendor Managed Inventory
VTT	Technical Research Centre of Finland

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PART I: INTRODUCTION AND LITERATURE REVIEW

This part of the study consists of introduction, methods, and literature review. Introduction discusses background and motivation, research problem and objectives, scope of the study and research methods. Literature review discusses supply chain management, physical distribution and performance measurement.

1 INTRODUCTION

1.1 Background and Motivation

Bower and Closs (1996) have said that the operating responsibility of logistics is the geographical positioning of raw materials, work-in-process, and finished inventories where required at lowest cost possible. Logistics process converts raw materials into final products and distributes final products to customers through marketing channels. In general logistics costs for individual firms varies from 5 to 35 percent of sales depending on the type of business, geographical area of operation, and weight/ value ratio of product and materials (Bower and Closs, 1996). One of the key focuses of logistics management has always been cost reduction. Managers have sought different ways to reduce cost and improve profitability of the company. Before 1990 managers tended to look inwards and optimize the profitability of their own companies. (Lambert and Stock, 1993:18-26). In the 1990, supply chain management evolved. The supply chain management brought idea of concentrating on the whole logistics chain. Aim of the supply chain management was to squeeze costs out the total chain. Now, in the 21st century new forces are driving. Turbulent and volatile markets are becoming as a norm. Life-cycles of products become shorter and global economics and competitive forces create undesirable uncertainty. In today's turbulent environment, lengthy and slow-moving logistics pipelines have become too risky and unsustainable. Companies need fast, responsive, and agile supply chains. (McAfee et al., 2008).

This study aims to define optimal physical distribution network for Case Company in today's ever-changing market environment. This research is a partial fulfilment of the requirements for the degree of Master of Science in technology. Motivation for

the study comes from Case Company whose management has also identified the need of flexibility and agility. The increasing logistics costs and the difficulty of managing multiple distribution centres has driven Case Company to search new options to improve their supply chain. This study has two objectives: to research physical distribution networks and to provide recommendations for Case Company management how they should organize their supply chain to increase flexibility and agility with minimal costs.

1.2 Research Problem and Objectives

The main research question of the thesis is

"What is the optimal physical distribution network for Case Company?".

The main research question is divided into five sub questions in order to answer to the main research question.

- What is the right Supply Chain Strategy for Case Company? Before we can start thinking the structure of physical distribution, we need to know the supply chain strategy. The reason for this question is to ensure that the recommendations of this research are connected to Case Company's strategy.

- What is the appropriate physical distribution strategy for Case Company? Literature presents multiple options for distribution strategies. Reason for this question is to gain understanding about possible strategies, to know in which environments each strategy is suitable, and to choose appropriate physical distribution strategy for Case Company.

- What are the appropriate supply chain performance measures for Case Company? To find the optimal solution we need to compare different possibilities. The reason for this question is to gain knowledge about performance measurement in order to choose appropriate measures for selecting optimal physical distribution network.

- What are the criteria for performance measures for Case Company? This is a follow-up question for the previous one. Measuring something is not enough.

Decision-making requires criteria for measures in order to make decisions, which is good or is bad.

- What are the performances of as-is and to-be physical distribution networks? Last research question refers to operationalization of the measures.

The main research question can be solved by answering to these research questions presented above. Figure 1 summarizes the main research question, the five sub questions, and the objectives of the research.

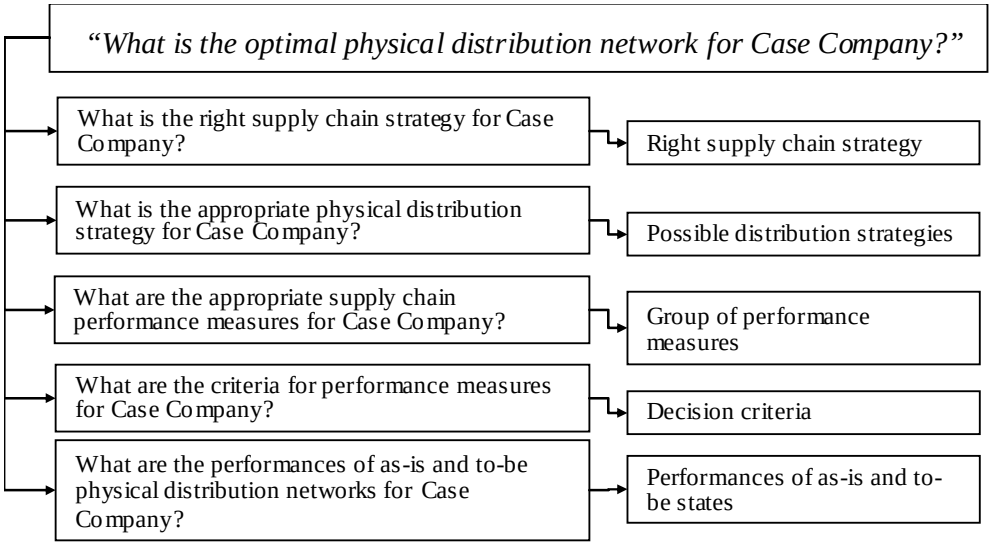

Figure 1 Summary from the Main Research Question, Sub Questions, and Objectives

1.3 Scope of the Study

This research takes holistic view of Case Company's logistics. The research focuses on finished goods movements between different levels in a supply chain and customer deliveries. This study does not consider service and, return logistics, due to their different from customer deliveries. Case Company has a subsidiary, which manufactures products that do not belong to Case Company's core business. This research does not cover distribution of this subsidiary's products.

1.4 Research Methods

According to research methods, this thesis contains two parts. First part is a literature review on devising optimal physical distribution network. The literature review

covers around 40 books and academic articles in the areas of supply chain management, physical distribution and performance management. Second part of the thesis is an empirical part. The empirical part includes qualitative and quantitative analyses, and synthesis of the analysis.

1.4.1 Constructive Approach as a Research Method

The objective of this research is to provide a solution to Case Company's practical problem. This research will adapt steps of the constructive study to reach its goal. This research will also consider principles of case study and controllability analysis.

Neilimo and Näsi (1980) presented four approaches for economic sciences conceptual approach, nomothetical approach, action-oriented, and decision-oriented approach. Kasanen et al. (1993) introduced the constructive approach from accounting research and presented this approach with Neilimo and Näsi's approaches. Figure 2 presents these approaches in a matrix. Neilimo and Näsi (1980) described decision-oriented approach in the following way. It has something to do with positivism, but on the other hand also something with rationalistic ideal of information. The focus is not the truth but a solution to some particular problem. Decision-oriented approach has a normative interest of information. Kasanen et al. (1993) presented the constructive research approach, which is closely related to decision-oriented approach. Kasanen et al. (1993) described the constructive approach in the following way. The constructive research approach means problem solving through the construction of models, diagrams, plans, organizations, etc. The difference between the constructive approach and the decision-oriented approach is practical testing. In the constructive approach, researcher tests the construction using a market-based test.

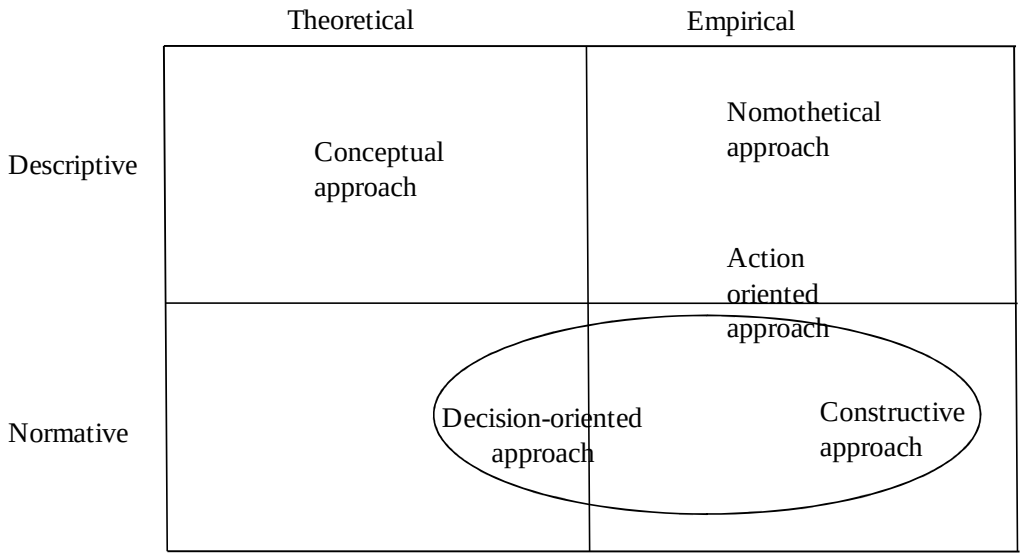

Figure 2 The Location of the Constructive Approach in the Established Accounting Research Approaches. Applied from Kasanen et al. (1993)

An essential part of the constructive approach is to tie the problem and its solution with accumulated theoretical knowledge. As well, researcher has to demonstrate the novelty and the actual working of the solution. (Kasanen et al., 1993). Figure 3 presents the elements of the constructive research. Kasanen et al. (1993) divided the constructive approach into six phases. Table 1 lists the phases of constructive study.

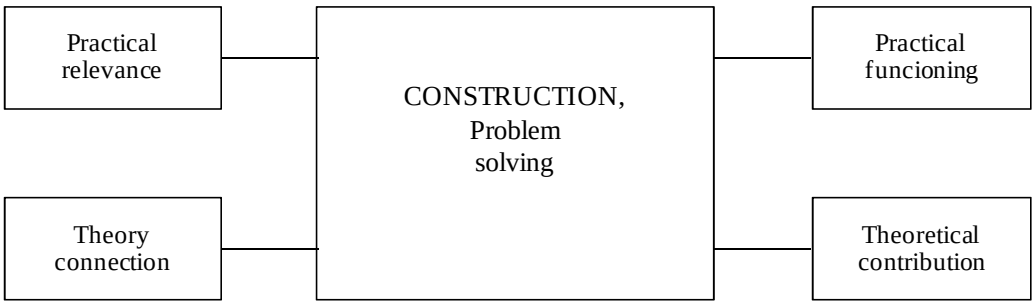

Figure 3 Elements of the Constructive Study. Applied from Kasanen et al. (1993)

Researcher can test managerial construction in reality using a market-based test. The market-based test bases on the concept of innovation diffusion. Managerial constructions are products that compete in the market of solutions. There are three levels of market test weak test, semi-strong test, and strong test. The weak market test measures if there is any manager responsible for the financial results of his or her business unit and been willingly to apply the construction in question in his or her

actual decision-making. The semi-strong market measures if the construction has become widely adopted by companies. The strong market test measures if the business units applying the construction are performing better than the ones that do not apply. It may appear that weak market test is easy to reach, but in reality, the weak market test is relatively strict. It is probably not often that a tentative construction is able to pass it. For example, there is no lack of formal optimization models, but still no one is using them in practice. (Kasanen et al., 1993).

Table 1 Phases of the Constructive Study. Applied from Kasanen et al. (1993)

Phase	Description
Problem definition	Find a practically relevant problem which also has research potential
Building understanding	Obtain a general and comprehensive understanding of the topic
Constructing a solution	Innovate, i.e., construct a solution idea
Demonstrating the solution	Demonstrate that the solution works
Connecting solution to theory	Show the theoretical connections and the research contribution of the solution
Examine the applicability	Examine the scope of applicability of the solution

A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not evident. Case studies are preferred tools when researcher asks "how" and "why" questions. Case studies can be exploratory, descriptive, or explanatory. A case study is suitable when the research topic is either broad one, it covers contextual or complex multivariate conditions or it relies on multiple non-singular sources of evidence. (Yin, 1990:1-17).

1.4.2 Data Collection

Case studies typically combine data collection methods such as archives, interviews, questionnaires, and observations. The evidence in the case study research may be qualitative, quantitative, or both. (Eisenhardt 1989). In this research, quantitative and

qualitative data is combined. Interviews of Case Company's employees provide qualitative data. These interviews were mainly semi-structured discussions in person. When it was suitable, two interviewers conducted the interview. After interview, interviewees compared their notes. Author and instructor conducted the interviews during spring 2008. In this research, interviews of Case Company's employees provided process descriptions, description of current supply network, and information about contact persons abroad. Interviews mainly provided qualitative data. Chapter 8 presents the list of Case Company and Parent Corporation interviews. List contains nine interviews of Case Company's employees and three interviews of Parent Corporation's employees.

Case Company's archives and ERP system were main sources of quantitative data. Archives provided mainly invoices and financial data from year 2007. ERP system provided transactional data from year 2007. Transactional data included deliveries, and order line information from the period 1.1.2007-31.12.2007. ERP system also provided master data from customers. Case Company's employees explained and validated all the data fields of transactional and master data. Explanations and validations of Case Company's employees minimize the possibility of false interpretations of the collected data. For analysing quantitative data, Microsoft Access and Excel were used.

Jick (1979) broadly defines triangulation as "the combination of methodologies in study of the same phenomenon." The idea in triangulation is to measure the same phenomenon from multiple perspectives. Concretely this means to have multiple ways of collecting data while remaining the focus. (Jick, 1979). This research uses triangulation to validate both qualitative and quantitative data. In some cases, qualitative data gained from interviews validated the quantitative data received from ERP system and archives. In some cases, quantitative data received from ERP system and archives validated the qualitative data.

1.5 Disposition of the Research

This research report contains three parts. Figure 4 presents the disposition of the research. Fist part is the introduction and literature review. The first part presents the research motivation, problem, and methods. Literature review establishes the

concepts and theory of the research issue. Second part discusses empirical work of the research. Empirical part has two chapters. Chapter 4 presents Case Company analyses, its products and supply chain and gives proposal for physical distribution network. Chapter 5 presents analyses of as-is and tentative physical distribution networks and then gives a proposal for to-be physical distribution network. Third part of the study is discussion and conclusion. This part discusses of the findings during the research, concludes main results, ponders the contribution of the research, and gives suggestion for future research.

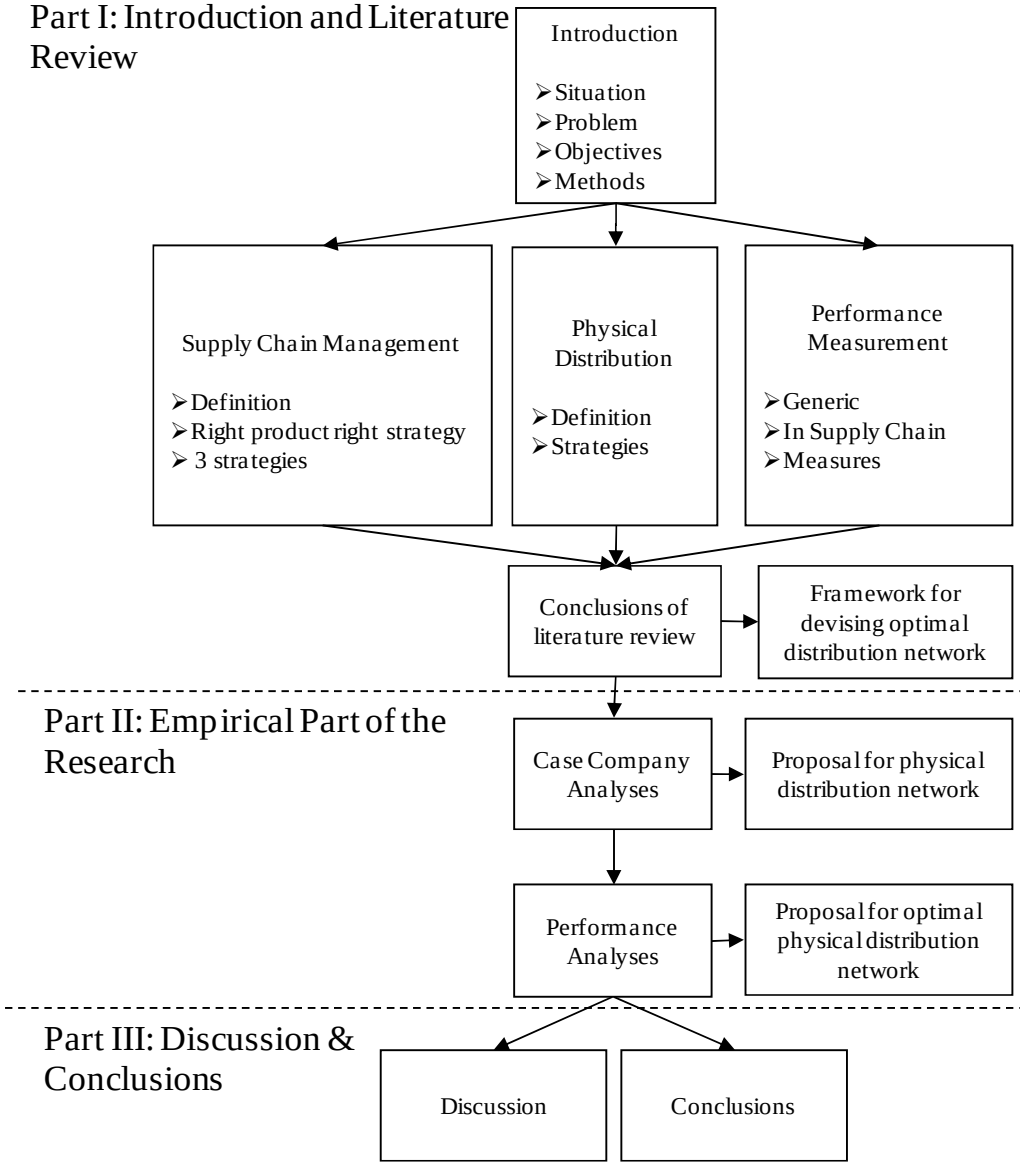

Figure 4 Disposition of the Research

2 LITERATURE REVIEW

Literature review concentrates on three broader topics supply chain management, physical distribution, and performance measurement. Chapter 2.1 presents definition for supply chain management, introduces method for choosing right supply chain, describes three different supply chain strategies, and introduces ideas of green supply chain management.

2.1 Supply Chain Management

A supply chain is a network of organizations that are involved, through upstream and downstream linkages. In this network, different processes and activities produce value in the form of products and services for the end customer. (Christopher, 1998). Figure 5 presents a design picture of supply chain network. The term supply chain structure refers to the sequential links among sourcing, production, and distribution (Persson and Olhager, 2002). The supply chain encompasses all activities associated with the flow and transformation of goods from the raw material stage (extraction), through to the end user, as well as the associated information flows. Material and information flow both up and down in the supply chain. (Handfield and Nichols, 1999). Not so long ago many logistics practitioners, academics, and consults viewed supply chain management as an extension of logistics outside the firm to include customers and suppliers (Lambert and Pohlen, 2001).

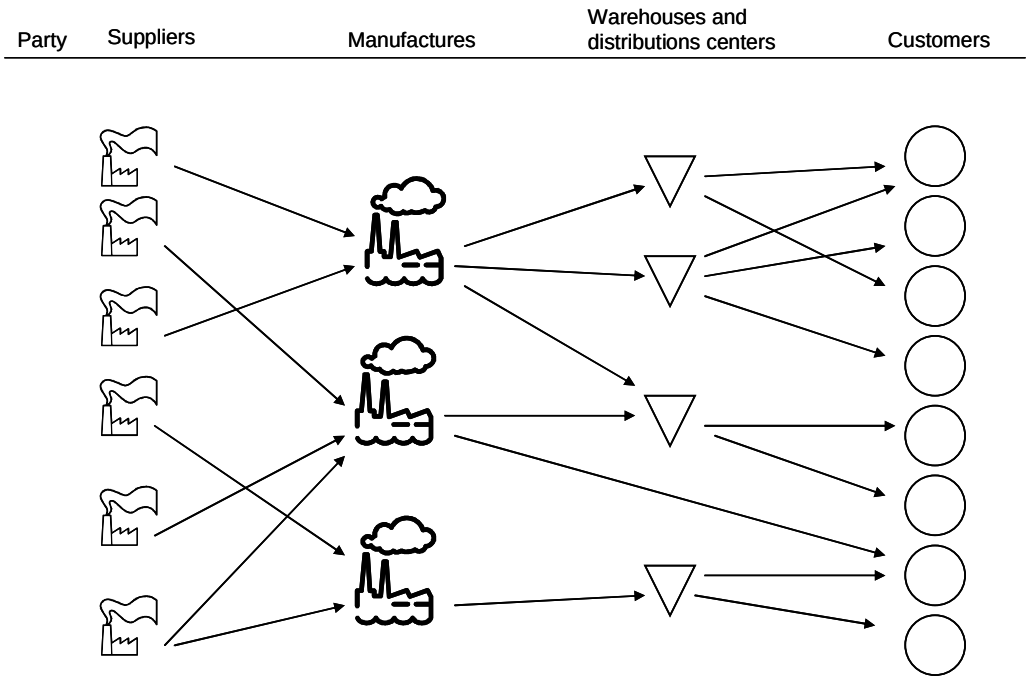

Figure 5 Supply Network. Applied from Simchi-Levi et al. (2000:2)

From the above it is possible to see that there are varying ways to define supply chain and logistics. Variations in defining supply chain and logistics can be confusing to reader. These varying definitions make it difficult for the reader to distinguish between the supply chain management and the logistics management. Due to that justification, this research makes difference between the supply chain management and the logistics management in the following way. This research defines supply chain as Persson and Olhager (2002) do. The supply chain refers as a sequential links among sourcing, production, and distribution and logistics management refers as

"The process of strategically managing the procurement, movement and storage of materials, parts and finished inventory and all the related information flows through the organization and its marketing channels in such a way that current and future profitability are maximized though cost efficient fulfilment of orders" (Christopher, 1998).

2.1.1 The right Supply Chain for the Product

Fisher starts his article by telling that never before has so much technology and brainpower been applied to improve supply chain performance. In the next paragraph, he continues by saying that albeit of all the effort those companies have made, the performance of many supply chains has never been worse. Fisher gives two examples of worst performance: adversarial relations between supply chain partners and dysfunctional industry practices such as an over reliance on price promotions. Fisher says that companies have to devise right supply chain strategies for their products. (Fisher, 1997).

First step in devising the right supply chain strategy for a product is to identify whether the product is functional or innovative. The main distinction between functional and innovative product is the demand pattern of the product. Predictable demand with low variation is a sign of functional product. Unpredictable and highly fluctuating demand is a sign of innovative product. Examples of functional products are goods that retail outlets, such as grocery stores, gas stations, and hypermarkets sell. Fisher claims that companies can identify whether their products are functional or innovative by studying the demand that products face. Table 2 presents a tool for managers to identify the nature of the product. (Fisher, 1997)

Table 2 Functional Versus Innovative Products: Differences in Demand. Applied from Fisher (1997)

Aspects of Demand	**Functional** (Predictable Demand)	**Innovative** (Unpredictable Demand)
Product life-cycle	More than 2 years	3 months to 1 year
Contribution margin	5 % to 20 %	20 % to 60%
Product variety	Low (10 to 20 variants per category)	High (often millions of variants per category)
Average margin of error in the forecast at the time production is committed	10 %	40 % to 100 %
Average stock out rate	1 % to 2%	10% to 40%
Average forced end-of season markdowns as percentage of full price	0%	10 % to 25 %
Lead-time required for made-to-order products	6 months to 1 year	1 day to 2 weeks

The next step for managers is to decide whether their companies' supply chains are physically efficient or responsive to the market. Typical characteristics of the responsive supply chain is ability to react quickly for market changes, high products margins, information flow through the chain and form market place to the chain, and companies select their suppliers based on their speed and flexibility, not for their low cost. (Fisher, 1997). Table 3 presents more detailed criteria how to distinct between physically efficient process and market-responsive process.

Table 3 Physically Efficient Versus Responsive to the Market. Applied from Fisher (1997)

Nature of Supply Chain	Physically Efficient Process	Market-Responsive Process
Primary purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand in order to minimize
Manufacturing focus	Maintaining high average utilization rate	Deploy excess buffer capacity
Inventory strategy	Generate high turns and minimize inventory through chain	Deploy significant buffer stocks of parts or finished goods
Lead-time focus	Shorten lead-times as long as it does not increase cost	Invest aggressively in ways to reduce lead-time
Approach to choosing suppliers	Select primarily for cost and quality	Select primarily for speed, flexibility, and quality
Product design strategy	Maximize performance and minimize cost	Use modular design in order to postpone product differentiation for as long as possible

Functional products require an efficient process and innovative products require a responsive process. Figure 6 presents the matrix that managers can use to determine right hit for supply chain and product. Third step after determining nature of products and supply chain priorities, managers can match the product with supply chain. (Fisher, 1997)

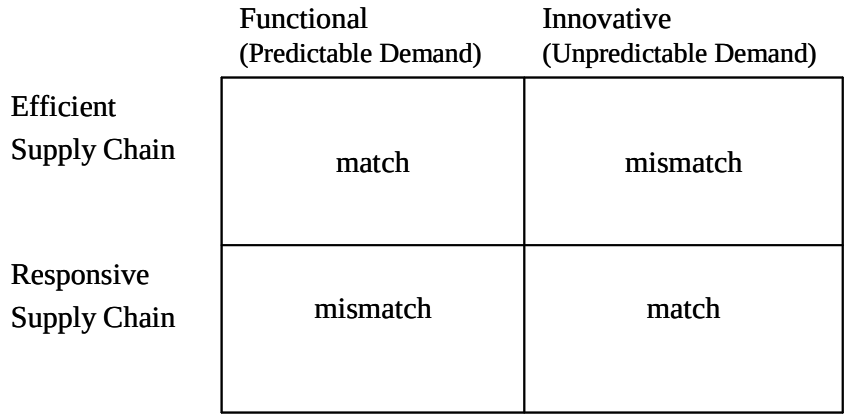

Figure 6 Matching Supply Chain with Products. Applied from Fisher (1997)

2.1.2 Lean Supply Chain

Womac, Jones, and Roos link the roots of lean thinking to the automotive industry and especially Japanese car producers in their seminal book "The Machine that Changed the World". Among Japanese automakers, they focus especially on Toyota. Lean thinking embraces the elimination of waste in its various forms. The lean paradigm considers all activities that consume resources but do not generate redeeming value in the eyes of customer as waste. Lean management emphasizes the pursuit of process efficiency. According to lean paradigm, eliminating waste from the supply chain will generate the efficiency. There are eight types of waste in the supply chain according to lean paradigm. (Goldsby, et al., 2006).

- Defects in production
- Over production
- Inventories
- Unnecessary processing
- Unnecessary movement of people
- Unnecessary transportation of goods
- Waiting by employees
- Goods and services that fail to meet the needs of customers

To be a lean enterprise, a company has to identify the value inherent in specific products, identify the value stream of each product, support the flow of value, let the customer pull value from producer, and pursue perfection. Companies have to take holistic view of organization beyond functional strategies toward broader supply chain strategy. (Goldsby, et al., 2006).

The "pull" replenishment is a principle of lean enterprise, but from where to pull. Womac and Jones speak of the "customer" but ordinarily lean system does not pull from the end customer. The manufacturing responds to the demand signal emitted by the next-stage customer. Most of the time next-step customer is not the end customer. (Goldsby, et al., 2006).

2.1.3 Agile Supply Chain

Agile supply chain strategy focuses on effective, flexible accommodation of unique customer demand (Christopher, 2000). An Agile company is one that uses market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace (Naylor, Naim, and Berry, 1997). Key to provide agile response is flexibility in supply chain (Goldsby et al., 2006). The agile or response-based supply chains are often characterized as "short", with few or no intermediaries. Supply should be located nearby, and information sharing among the parties must be open and frequent. (Christopher, 2000; Christopher and Towill, 2001).

2.1.4 Leagile Supply Chain

Lean and agile paradigms have common objective: meeting customer demand at the least total cost. Researchers have suggested that lean and agile approaches need not to represent as opposing point of views. They could merge in various ways to create so-called leagile approaches. (Goldsby et al., 2006).

Christopher and Towill (2002) identified three distinct leagile hybrid approaches. The first approach embraces on Pareto (80/20) rule. The Pareto (80/20) rule recognizes that 20 % of products generate 80 % of the company's revenue. Christopher and Towill's (2001) suggestion is that this 20 % of products use lean supply chain and the remaining 80 % of products use agile supply chain. The second type hybrid focus on handling basic demand with lean paradigm. This means coping with everyday business by companies own resources. However, when demand spikes over the course of peak seasons or heavy promotion periods, companies procure outside capacity to meet the demand spikes. When companies use outside work force it is the agile part of the second type hybrid. Third hybrid calls for form postponement. The form postponement refers in delaying final assembly of products. (Christopher and Towill, 2001). The final assembly of products is done near customer, from customer order (Feitzinger and Lee, 1997; Zinn and Bowersox, 1988). Form postponement works best when companies can develop goods from common materials into a near-finished state with final touches to the product providing for diverse assortments that accommodate distinct customer needs (Mason-Jones, Naylor and Towill, 2000).

2.1.5 Green Supply Chain

According to Srivastava (SK., 2007) Green supply chain management (GrSCM) is gaining increasing interest among researchers and practitioners of operations and supply chain management. The escalating deterioration of the environment mainly drives the growing importance of GrSCM. Good examples of deterioration of the environment are diminishing raw material resources, overflowing waste sites and increasing level of pollution. However, it is not just about being environment friendly; it is about good business sense and higher profits. (Srivastava SK., 2007) In fact, it is a business value driver and not a cost centre (Wilkerson, 2005).

Earlier GrSCM has focused mainly on return and minimizing waste in the supply chain, which also is a good thing. Recently there has emerged an awakening in the area of global warming. Now, the hot topic is green house gases. There are a couple of green house gases, but carbon dioxide (CO_2) has become the centre in discussions of global warming. Present time consults, managers, researchers have to take into account environmental issues when reengineering supply chains. Development actions should not only consider to improve logistics cost, but also at the preservation of environmental sustainability. (Vorts et al., 2007).

Vorst et al. (2007) modelled environmental effect of supply chain by calculating CO_2 emissions for different supply chain strategies. Their approach was to calculate the energy used in different scenarios and convert the used energy into CO_2 emissions. For transportation, calculating CO_2 emissions is straightforward task to do. Technical Research Centre of Finland (VTT) has developed a calculation system called LIPASTO. LIPASTO is calculation system that calculates traffic exhaust emissions and energy consumption in Finland. Figure 7 presents the transportation mode specific unit emissions. In Figure 7 highways, urban and delivery stand for different transportation environments. Delivery means deliveries in city area from distribution centre to retailers, grocery stores, etc. Percentages after delivery types stand for fill rate of the cargo space of the vehicle.

Emissions of road traffic in Finland per tonne-kilometre

Transportation Vehicle	Diesel Vans	Delivery Truck (6t)	Delivery Truck (15t)
Highway 50%-load	385	181,56	117
urban 50%-load	466	208	135
delivery 50%-load	442	200	130
Highway 100%-load	202	97,11	64
urban 100%-load	254	119	81
delivery 100%-load	239	112	76

Transportation Vehicle	Semi trailers	Full trailers
Highway 70%-load	56	43
urban 70%-load	92	74
delivery 70%-load	0	0
Highway 100%-load	43	33
urban 100%-load	73	60
delivery 100%-load	0	0

Emissions of waterborne traffic in Finland per tonne-kilometre

Freight Transport

Unit emissions [g/tkm]	CO2
Corgo Ferriers	33
Car Ferries	33

Emissions of air traffic in Finland per tonne-kilometre

Freight Transport

Unit emissions [g/tkm]	CO2
Europe in Average	1699
Intercontinental flights in average	719

Figure 7 Unit Emissions for Different Transportation Modes (LIPASTO).

EU has stated that air traffic will be the first one of traffic modes to be included in emission trade in the year 2012. This means that CO_2 emission will be valued based on the market price of one emission right. One emission right is defined as price of right to release one ton of CO_2 gases. (Bureau Veritas Finland).

2.2 Physical Distribution

Logistics includes three performance cycles. First is a procurement cycle, which takes care of procuring raw materials to manufacturing plant. Second is a manufacturing support cycle that considers of converting raw materials into finished products. Third and last cycle is a physical distribution cycle. Physical distribution performs the physical-fulfilment activities. Activities of physical distribution cycle are customer order, order entry, order processing, order selection, order transportation, and customer delivery. Figure 8 illustrates the basic physical distribution performance cycle. (Bowersox and Closs, 1996:48-50).

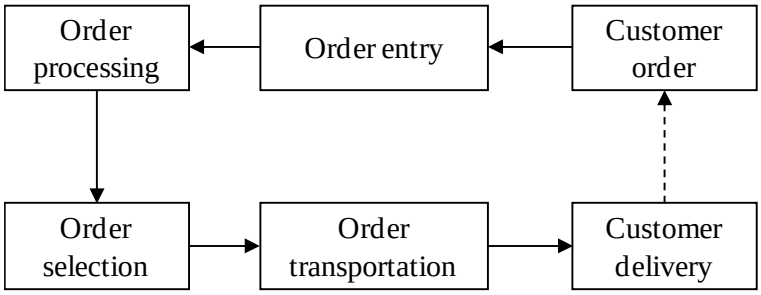

Figure 8 Basic Physical Distribution Performance-Cycle Activities. Applied from Bowersox and Closs (1996:50)

Physical distribution concerns movement of finished products to customer. Physical distribution links a marketing channel with its customers. All physical distribution systems have one common feature: they link manufacturers, wholesalers, and retailers into marketing channels that provide product availability as an integral aspect of the overall marketing process. (Bowersox and Closs, 1996:35).

Bowersox and Closs (1996) present the specific operating concerns for physical distribution. Activities of physical distribution relates closely to providing customer service. Physical distribution has to perform order receipt and processing, deploying inventories, storage and handling, and outbound transportation within a channel. Physical distribution also includes the responsibility to coordinate with marketing planning in such areas as pricing, promotional support, customer service level, delivery standards, handling return merchandise, and life-cycle support. The key physical distribution objective is to assist in revenue generation by providing strategically desired customer service levels at the lowest total cost. (Bowersox and Closs, 1996:37).

2.2.1 Global Shipping Options

Christopher (1998:140) presented European options for shipments from Far East from multiple source points for different products. First option is direct ship from each source to final market in full containers. Second option is to consolidate in the supply region for final market in full container. Third option is to consolidate from each source for each theatre of operation with break bulk / intermediate inventory in the theatre for specific markets. Fourth option is to consolidate in the supply region and break bulk in the theatre of operations. The characteristics of the product and the

profile of demand will determine inventory holding, warehousing, customer service and freight cost balance in each case. (Christopher, 1998:125-146).

Christopher presents that an increasingly attractive option is the use of door-to-door transport providers. Christopher calls these providers also integrators. Perhaps the most active integrators are DHL, TNT, FedEx, and UPS. (Christopher, 1998:125-146).

2.2.2 Direct Shipment

Direct shipment strategies exist to bypass warehouses and distribution centres. Employing direct shipment the manufacturer or supplier delivers goods directly to retail stores. Direct shipments are common when the retail store requires fully load trucks. Advantages of direct shipment strategy are the cost savings generated, because there is no need to operate distribution centres and reduced lead-times. Disadvantage of direct shipment strategy increased manufacturer and distributor cost. Manufacturers and distributors' transportation costs increase, because they have to send smaller trucks to more locations. (Simchi-Levi et al., 2000).

Coldsby et al (2006) and Su (2007) present different approach towards direct deliveries. In their articles, they propose common central distribution centre from where finished goods travel to end customers. (Coldsby et al., 2006; Su, 2007) Coldsby's et al. (2006) link their approach to agile supply chain strategy. Su's presentation does not consider any linkages to supply chain strategies, but is a presentation of example companies and a framework how to implement global direct deliveries. Difference between Coldsby et al. (2006) and Su (2007) and Simchi-Levi et al. (2000) is the way to use trucks. Simchi-Levi et al. (2000) connect full truckloads to direct shipments when Coldsby et al. (2006) and Su (2007) connect small packet deliveries to direct shipments. Su's (2007) idea is to use direct shipment in global scale with help of third party logistics providers.

There are two major external preconditions to start using global direct deliveries. The custom procedures of the governments of consignor and consignee country have to be very efficient, allowing twenty-four hours and electronic cargo clearances. Then other issue is that these two governments have to facilitate the provision of good

international and domestic logistics infrastructure, including airports, seaports, inland warehouses, and easy-access road systems to these facilities. (Su, 2007).

Product is an essential factor influencing should a company consider global direct delivery or not. If company's products match the following criteria, it should take global direct deliveries into serious considerations. High-tech product in volatile markets, time-critical or high value-added goods in measures of high profit margin for example. The product is small sized, light, and easy to transport. A company trade its products globally. Internet-based trading tools are available to end customer for placing orders anytime, anywhere. A company is continuing to adapt of fast-cycle logistics and distribution. (Su, 2007).

2.2.3 Warehousing

The importance of inventory management and the need for the coordination of inventory decisions and transportation policies has been evident for a long time. Unfortunately, managing inventory in complex supply chain is typically quite difficult and may have a significant impact on the customer service level and supply chain system costs. In supply chains, inventories appear in several forms. From material point of view there are raw material, work-in-process (WIP), and finished product inventory. The difficulty in determining inventory control mechanisms for different types of inventories is that we have to take into account all the interactions of the various levels in the supply chain. There are several reasons why to hold inventory. Here are three of them: to protect the firm from unexpected changes in customer demand. Second reason is the presence of a significant uncertainty in the quantity and quality of the supply, supplier cost, and delivery times. Third reason is economies of scale in transportation. (Simchi-Levi et al., 2000).

Risk-pooling concept discusses centralizing supply chain distributions centres and the benefits of centralized warehouse compared between many local warehouses. Demand variation is the key factor in risk-pooling concept. All warehouses exposes to different demand pattern. Correlation between local warehouses' demands defines how great the benefit of risk-pooling can be. Lower inventory levels with same service requirements are the main goal of risk-pooling. If the demand patterns for local warehouses differ from each other or other words have negative correlation;

there is possibility to have great benefits from risk-pooling. (Simchi-Levi et al., 2000).

'Square root rule' provides an indication of the opportunity for inventory reduction that is possible through holding inventory in fewer locations. The 'Square root rule' states that the reduction in total system inventory can be expected as proportional to the square root of the number of stock locations before and after rationalization. An example of 'square root rule, if there were 25 stock locations and now there are only four, then the overall reduction in inventory would be in the ratio of square of 25 to square of 4. This will lead to a 60% reduction. (Christopher, 1998:135).

2.2.4 Cross-docking

Cross-docking is a strategy that Wal-Mart made famous. In the system, warehouses function as inventory coordination points rather than as inventory storage points. In typical cross-docking systems goods arrive at warehouse from the manufacturer, warehouse workers transfer goods to vehicles serving the retailers, and then vehicles deliver goods to the retailers as rapidly as possible. Goods spend very little time in storage. Usually goods spend less than 12 hours at the warehouse. Cross-docking systems limits inventory costs and decrease lead-times by decreasing storage time. On the other hand, cross-docking systems require significant start-up investments and are very difficult to manage. Successful cross-docking system has four requirements. To start with, it links suppliers, distribution centres, and retailers with advanced information systems to ensure that all pickups and deliveries are made within the required time windows. Second, a fast and responsive transportation system is necessary for a cross-docking system to work. Third, successful cross-docking system uses critical forecasts and shares the information. Fourth requirement is a large size of the system Cross-docking strategies are effective only for large distribution systems in which a large number of vehicles are delivering and picking up goods at the cross-dock facilities at any time. Reason why the system has to be large is that then trucks can be fully loaded from supplier to warehouses. The large numbers of retails ensure that all goods shipped to cross-docking facilities will continue their way immediately in full trucks. (Simchi-Levi et al., 2000).

2.2.5 Merge-in-transit

Kärkkäinen et al. (2003) describes merge-in-transit as a distribution method in which goods are shipped from several supply locations through one distribution centre where warehouse workers consolidate goods into one final customer delivery during transit. Merge-in-transit is similar to cross-docking, but is more flexible in the customer-end of the process. It refers to a process of uniting multiple component-shipments from several suppliers in one final customer to fulfil one customer order. Companies that use this kind of distribution method have capability to offer large variety of products and deliver them to the customer with one drop-off, without the need for centrally storing the products. The benefits are added customer value, reduced process cost due to lower total inventory levels, and reduced transportation cost. Key issue in merge-in-transit is to identify all the components of a single order in merging terminal and to ensure that all components end up into one shipment. The reason why merge-in-transit has not become a popular distribution method is the difficulty of managing it. Most significant requirement of managing merging-in-transit system is the vast amount of up-to-date information. Characteristics of high-tech industry fit well in the merge-in-transit. Inventory costs are high, products are often customized, and there are numerous product variants. Some authors consider that merge-in-transit to be prime candidate as an operating model for high-tech industry. (Kärkkäinen et al., 2003).

2.2.6 Transshipment

Transshipment stands for shipments where goods travel at the same level in the supply chain to meet some immediate need. Companies consider transshipments most often at the retail level. Transhipment capability allows retailers to meet customer demand from the inventory of other retailers. (Simchi-Levi et al, 2000). Real life example of transshipment is when a customer goes to clothing retail to buy a pair of jeans. In the particular retail they do not have the customer's size, but they can order it from the other retail located somewhere near. Another connection where companies use transshipments is a spare parts logistics. In automotive industry, the total service supply chain can contain billions of dollars in inventory. Saturn supply

chain uses transshipments to provide high customer service level in after-sales service. (Cohen et al., 2000).

Prerequisites for transshipments are visibility and rapid transportation between retailers. Retailers have to have visibility to other retailers' inventories and someone has to establish rapid way to ship the items either to store where customer originally tried to make the purchase or to the customer's home. To enable these preconditions company has to have advanced information system. If appropriate information system exists, shipment costs are reasonable, and all of the retails have the same owner, transshipments makes sense. In this way, system can efficiently take advantage of the risk-pooling concept, even if no central warehouse exists, because one can view inventory in different retail outlets as part of a large, single pool. Independently owned and operated retails may want to avoid transshipment because; they will be helping their competitors. (Simchi-Levi et al, 2000).

2.3 Performance Measurement

Every company has its own strategy how to do business. A top management of a company establishes company's strategy. The top management has to place a performance measurement system in order to tell how well their strategy is working. Performance measurement tells if the company is going to the wanted direction. Performance measurement system provides a yardstick by which to judge how closely management has been able to execute their declared strategy. This makes performance measurement a central issue, when companies try to achieve their strategic targets. (Morgan, 2004). From operational perspective it is also extremely important to measure processes, because of the constantly changing market environment. With the help of performance measurement, managers can allocate resources there where they are needed and keep processes up to date along with changing market environment. (Bowersox & Closs, 1996; Keeber et al., 1999).

Literature defines performance measurement as a process of quantifying action, where measurement is the process of quantification and action leads to performance (Neely et al., 1995). This research will use Morgan's (2004) definition for performance measurement. Morgan (2004) defines performance measurement as

"Performance implies predetermined parameters and measurement implies an ability to monitor events and activities in a meaningful way."

2.3.1 Characteristics for a Good Supply Chain Measurement System

In general, performance measurement frameworks highlight three important aspects. They say that performance measurement system has to be connected with corporate strategy. Next, they say that there has to be balance between financial and non-financial measures and third there should be only limited number of measures. The supply chain performance measurement frameworks emphasise also the same factors, but they also elicit that supply chain performance measurement system has to take the overall performance of supply chain into account. This research uses these four factors when defining the appropriate performance measurement system to measure the performance of Case Company's distribution network. Next, the present chapter discusses of these factors each at the time.

Measures have to be in line with corporate strategy

The research of big international companies indicates critical factors to implement successful performance measures. First factor is that logistics measures have to be connected with strategy. (Keeber et al., 1999: 5). "Built to Last" was one of the best-selling books at nineties. According to this book, companies with a clear understanding of who they are and what are trying to achieve also enjoy the greatest long-term success. Epstein and Manzoni explain this by saying that a clear and focused strategy enables a company to design its performance measurement and evaluation system to focus managers' attention on the strategic key success factors. (Epstein and Manzoni, 1997). Companies need to align overall business strategy and supply chain strategy. This way the impact of supply chain activities on corporate performance can be measured (Presutti and Mawhinney, 2007).

Balanced approach

Drucker (1954) already made the case for balance in measurement systems. He suggested that the appropriate performance criteria for organization were market standing, innovation, productivity, physical and financial resources, profitability,

manager performance and development, worker performance and attitude, and public responsibility. After Drucker Keegan et al. discussed about the balanced approach in performance measurement. Their frame work was Performance Measurement Matrix, which categorises measures as being cost or non-cost, external or internal, reflecting the need for greater balance of measures across these dimensions. (Neely, 2002). Other group of authors was Fitzgerald et al. who proposed framework that classifies measures in two basic types. First type of measures relates to results like competitiveness and financial performance, and the second type of measure relates to determinants of the first ones. Their idea also was to get balance between measures and to understand causality between results and determinants. (Neely, 2002).

Kaplan and Norton (1992) introduced balanced score card performance measurement system. Balanced scorecard gives a comprehensive picture from business from four different perspectives. The four different perspectives are customer, internal business, innovation and learning, and financial perspectives. Balanced scorecard can translate a company's strategy into specific measures. Kaplan and Norton have worked with many companies and they have found that senior executives do not rely on one set of measures to the exclusion of the other. The executives have realized that no single measure can provide a clear performance target or focus attention on the critical areas of business. Mangers want a balanced presentation of both financial and operational measures. In their studies, Kaplan and Norton found imbalance between focus on financial and non-financial measures. While other companies concentrate on financial measures, others concentrate on non-financial measures. (Kaplan and Norton, 1992). Epstein and Manzoni (1997) presented that Management Account and other publications have published numerous articles that emphasizing that performance measurement systems should contain many non-financial indicators to complement financial one, particularly with respect to customer perceptions and performance of internal process. So, why is there just a mess about balance between financial and non-financial measures? Kaplan and Norton (1992) state that financial accounting measures can give misleading signals for continuous improvement and innovation that are activities today's competitive environment demands. Maskell (1991) suggest that companies should understand that, while financial performance measurements are important for strategic decision and external reporting, day-to-day

control of manufacturing and distribution operations companies can handle better with non-financial measures. Eccles and Pyburn (1992) present that financial measures tell managers the consequences of decisions that already have been made but do little to predict future performance. Non-financial measures give to guidance what to do next to make the processes running smoothly. (Eccles and Pyburn, 1992).

Vital few vr. trivial many

Murray and Richardson (2002) identified in their research that critical few corporate initiatives has great impact on strategic effectiveness. They also noted that is not un-usual for a corporation to monitor upwards of 20 financial, market, operational, and other strategic indicators. The result of this all is a marked lack of focus among executives and managers. Managers and executives do not know which of these are critical in a given strategic time period. The result is often a lack of alignment in their activities. The lack of focus and overwhelming number of indicators just cause ineffectiveness in operations and cause frustrating among managers who have multiple indicators to follow. Critical few is closely related to shared understanding of goals. Management have to cascade formulated strategy to lower levels in hierarchy. If there is no common understanding of strategy and goals then the performance of a company will be lower than if there would be. Gunasekaran et al. (2004) point out another difficulty of having too many measures. Companies fail to realise that performance assessment can better addressed using a trivial few, they are not trivial, but instead are those few areas most critical to success. Baldwin and Clark conducted a study in the USA, which claims that a major cause of the USA's competitive decline is due to the mangers use of inappropriate performance measurement systems (Homlberg, 2000).

Overall Supply Chain performance

It is well know that the overall performance of a supply chain depends on the joint performances of its sites. The sites however are usually managed by fairly autonomous management teams. These teams have their own objectives and missions. These objectives and mission may have little to do with the supply chain's overall performance. In the worst case, they may even conflict with the overall performance. The consequence is that different sites may have operational goals that,

if met, results in inefficiencies for the overall chain. (Lee and Billington, 1992). Holmberg (2002) also identified sub optimization in his studies of Swedish based furniture manufacturer and retailer. Holmberg (2002) claimed that the sub optimization was reason of not seeing the big picture and how the system affects the performance.

Different authors have different approaches towards supply chain measurement, but the common factor is to include all-important aspects to performance measurement. Beamon (1999) points four characteristics for effective measurement system. The characteristics of effective measurement system are inclusiveness (measurement of all pertinent aspects), universality (allow for comparison under various operating conditions), measurability (data required are measurable), and consistency (measures consistent with organizational goals). PRTM consultants' Comprehensive Supply Chain Measurement includes four types of metrics that cover all-important aspects of supply chain. The integrated framework monitors both outcomes and diagnostics. The specific types are customer satisfaction/quality, time, cost, and assets. Idea is to monitor each metric on both an outcome and diagnostic basis. (Handfield and Nichols, 1999:61-66; Bowersox and Closs, 1996:669-691). Stewart and (1995) and Supply chain council (SCC) speak about same four key processes. The processes are plan, source, action, make and deliver. Although SCC has introduced it the latest version of SCOR one new process that is return. Through the all four key processes all important aspects will be taken into account when designing performance measurement system. In SCOR model, performance measurement is only one part of the whole model (Supply-Chain Council, 2008). One other possible approach to include all aspects in performance measurement is to build up financial measures and then relate them to actions taken in the processes. Dupont already started this idea with his pyramid of financial ratios. He did not link financial measures to actions taken in processes (Voorhis, 1981). Lambert and Pohlen (2001) provide a framework for developing supply chain metrics that translates performance into shareholder value. They build customer and supplier P&L statements to provide complete picture of how the relationship affects profitability of both firms.

2.3.2 Performance Measures of Distribution Network Evaluation

This research uses four factors to evaluate Case Company's distribution network. These factors are customer, inventory, cost, and environment. This research adapts PRTM consults' four types of metrics to cover all-important aspects in Case Company's distribution network. This chapter justifies the chosen perspectives and introduces the measures of each perspective.

Customer

Drucker (1954) already spoke about market standing, which indicates of the customer. In Kaplan and Norton's (1992) Balanced Scorecard framework one perspective is customer. PRTM consults also emphasize customer as one of the key issues what needs to be measured. Neely (2002) has the shareholder value as a focal point in his Performance Prism framework. In order not to ignore this important factor, this research will consider customer as one factor in distribution network analysis.

Total order cycle time is one important measure in supply chain, because reduction in this leads to a reduction in the supply chain response time. It is also major source of competitive advantage. (Bower and Hout, 1988; Christopher, 1998). This study will use total order cycle time as a measure of customer perspective. This study adapts Christopher's (1998) steps in order-to-delivery cycle to define total order cycle time. Steps in the order-to-delivery cycle are customer place order, order entry, order processing, order assembly, transport, and order received.

Inventory

With increasing inflation and decreased liquidity, pressure is on firms to make the assets sweat. It is essential to determine how the costs associated with each asset, combined with turnover, affects to the "total cash flow time". The average number of days required to collect the invested cash back from the customer tells to the company's "total cash flow time". (Stewart, 1995). Earlier presented cash-to-cash measure include total inventory days-of-supply element. This study holds total inventory days-of-supply as an indicator for inventories. In Parent Corporation,

commonly known measure for DOS is days sales inventory (DSI). Parent Corporation calculated the DSI using equation 1.

$$DSI = 360 * \frac{AVG\_Total\_inventory\_12\_month}{Sum\_of\_std\_COGS\_12\_month} \quad (1)$$

Cost

One of the four types of metrics PRTM consults present are costs. They say that total logistics costs have to be considered when making decision in which costs are related. (Handfield and Nichols, 1999:61-66; Bowersox and Closs, 1996:669-691). This research will consider all costs that are related to physical distribution. Physical distribution involves all packaging, warehousing, and transportation activities. The activities take care that products are on time at the customer. (Bowersox and Closs, 1996:48-50). Figure 8 presents the basic activities of physical performance-cycle indicator

Environment

In the future environmental issues are becoming more and more important, because of the deterioration of the environment. Diminishing raw material resources, overflowing waste sites and increasing level of pollution are the factors that force companies to start thinking of the environment. (Srivastava SK., 2007). This research's intention is to follow the current development of environmental issues. In order to do this it will include environment as one factor in the analysis.

This research takes into account also CO_2 emission. Emissions are calculated using transportation mode specific unit emission, distance, and transportation volumes.

$$CO_2 emissions = Unit\_emission * Dist * Vol \quad (2)$$

In the equation (2), Unit_emission represents unit emission for particular transportation mode. Dist represents the distance between departure and destination sites and Vol respectively volumes (LIPASTO).

2.3.3 Characteristics of a Good Measure

Keeber et al. (1999) conducted research concerning measurement of business value in supply chain. During the research, 10 characteristic of a good logistics measures emerged. Table 4 presents the findings of Keeber et al. Companies can use this list as a quick help guide, to determine whether company's measures are on target or need may need some help. This list also provides good reference guideline to design new performance measures. (Keeber et al. 1999). Author will present the results of the thesis to Case Company's management after research is completed. In order to increase the accuracy of results and build validity for measures, this thesis takes into account characteristics presented in Table 4

Table 4 Charasteristic of a Good Logistics Measure. Applied from Keeber et al. (1999:9)

A good measure	Description
Is quantitative	The measure can be expressed as an objective
Is easy to understand	The measure conveys at glance what is it measuring, and how it is derived
Encourages appropriate behavior	The measure is balanced to reward productive behavior and discourage "game playing"
Is visible	The effects of the measure are readily apparent to all involved in the process being measured
Is defined and mutually understood	The measure has been defined by and/or agreed to by all key process participants (internally and externally)
Encompasses both outputs and inputs	The measure integrates factors from all aspects of the process measured
Measures only what is important	The measure focuses on key performance indicator that is to real value to managing process
Is Multidimensional	The measure is properly balanced between utilization, productivity, and performance, and shows the trade-offs.
Uses economies of effort	The benefits of the measure outweigh the cost of data collection and analyses
Facilitates trust	The measure validates the participation among the various parties

3 CONCLUSION OF LITERATURE REVIEW

As a conclusion of the literature review, this chapter presents a framework for defining appropriate supply chain strategy and physical distribution network for a company. This chapter also reviews suitable performance measures that can be used to measure the performance of as-is and tentative states. Figure 9 presents the composition of the knowledge from literature review together, and the three steps that are included to devise optimal physical distribution network. Furthermore this chapter describes the steps toward optimal distribution network and performance measures that can be used to estimate the performance of as-is and tentative states of the physical distribution network.

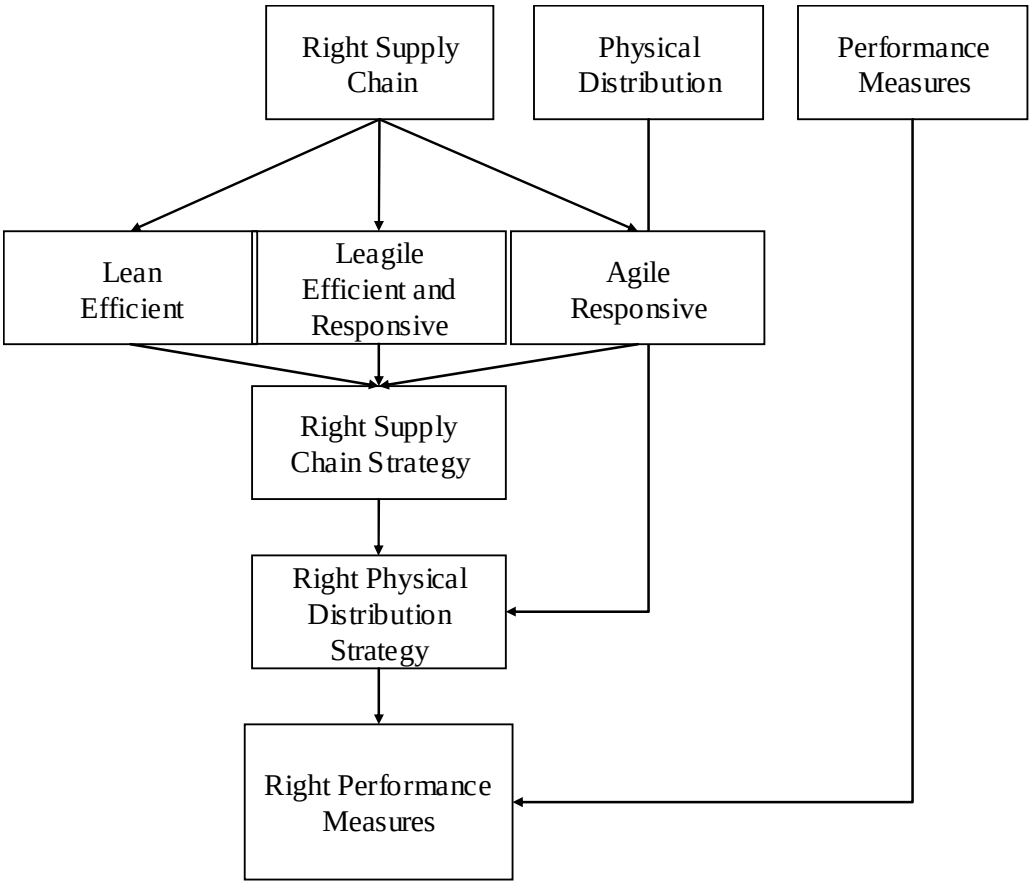

Figure 9 Framework for Choosing Appropriate Physical Distribution Network

3.1 Devising Right Physical Distribution Network

First thing is to define appropriate supply chain strategy. Companies can use Fisher's (1997) framework to define the right supply chain for their products. Fisher's framework includes a couple of steps. First companies have to identify the nature of the product. Second, they have to identify priorities for their supply chains and finally they can match products and supply chains. (Fisher, 1997). After devising the right supply chains for their products, companies can choose right distribution networks for their products. Last step is to evaluate the performances of as-is and to-be states of distribution networks. Next chapter presents performance measures that can be used to evaluate different states.

3.2 Appropriate Performance Measures

This research will use four factors to evaluate the performance of distribution network. The factors are customer, inventory, costs, and environment. The idea of multifactor analysis comes from PRTM consults' Comprehensive Supply Chain Measurement (Handfield and Nichols, 1999:61-66; Bowersox and Closs, 1996:669-691). The present chapter summarizes the factors each at the time.

Customer

This study will use total order cycle time as a measure of customer perspective. This study adapts Christopher's (1998) steps in the order-to-delivery cycle to define total order cycle time. Steps in the order-to-delivery cycle are customer place order, order entry, order processing, order assembly, transport, and order received.

Inventory

This study holds total inventory days-of-supply as an indicator for inventories. In Parent Corporation, commonly known measure for DOS is days sales inventory (DSI). Equation (1) shows the calculation of DSI.

$$DSI = 360 * \frac{AVG\_Total\_inventory\_12\_month}{Sum\_of\_std\_COGS\_12\_month} \quad (1)$$

Cost

This study includes in total cost analysis, costs that are related to physical distribution. Physical distribution involves all packaging, warehousing, and transportation activities. The activities take care that products are on time at the customer. (Bowersox and Closs, 1996:48-50). The Figure 8 presents the basic activities of physical performance-cycle.

Environment

This research takes into account also CO_2 emission. Emissions are calculated using transportation mode specific unit emission, distance, and transportation volumes.

$$CO_2 emissions = Unit\_emission * Dist * Vol \quad (2)$$

In the equation (2), Unit_emission represents unit emission for particular transportation mode. Dist represents the distance between departure and destination sites and Vol respectively volumes.

PART II: EMPIRACAL PART OF THE RESEARCH

Empirical part covers chapters 4 and 5. Chapter 4 focuses on analyzing Case Company's product and supply chain in order to devise a tentative proposal for optimal physical distribution network. Chapter 4 also presents the criteria and operationalization for performance measures. Chapter 5 presents the results of the performance analyses of as-is and tentative physical distribution networks, and a proposal for to-be physical distribution network.

4 CASE COMPANY ANALYSES

4.1 Case Company Presentation

Case Company is Finish-based sports instruments manufacturer. It is a part of bigger sports equipment Parent Corporation. Parent Corporation owns other sports equipment companies that produce sports equipment for end users. Different subsidiaries produce sports equipment for different purposes. In some occasions, products complement each other.

Case Company is a leading manufacturer of sports instruments for a variety of training, diving, and outdoor sports. Its mission is to provide guidance and inspiration for customers (Parent Corporation Annual Report 2007). Case Company has four product categories (Case Company Web Page). The turnover of the Case Company during year 2007 was ca. XX million Euros (Parent Corporation Annual Report 2007).

4.2 Current Distribution Network

Parent Corporation provides distribution network facilities that Case Company can use to deliver own products to retailers. Figure 10 presents the distribution network. Case Company owns headquarters and facilities in UK, Benelux, and FitzWright. Parent Corporation owns rest of the facilities. Parent Corporation has local sales offices in countries around the world. Case Company uses DC Europe to serve all EMEA (Europe, Middle East, and Africa) area customers except the ones in Finland and Estonia. Case Company serves customers in Finland and Estonia from its headquarters. In the USA, there is also a local sales company, which also runs a

distribution centre. The US sales company uses DC USA to serve customers in the USA and Middle America. The US sales company also manages the distribution centre in Canada. Mexico, Brazil, Malaysia, Australia, and Japan are sales companies that run their own warehouses. These local sales companies that run own warehouses also keep stock for Case Company's products. (Manager, Business Process Development 7.1.2008).

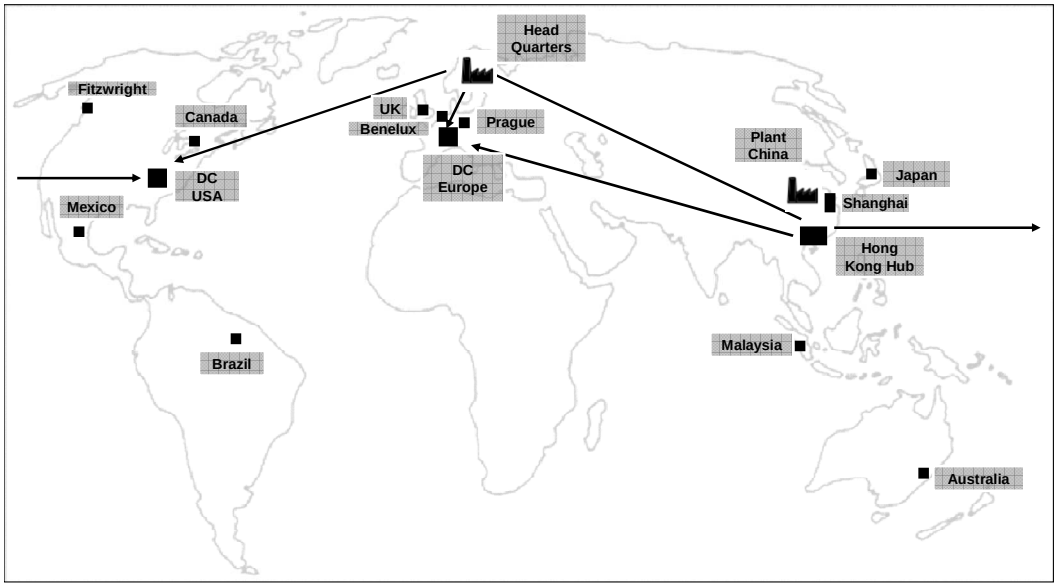

Figure 10 Case Company's Distribution Network

Parent Corporation's subsidiaries can choose if they need Parent Corporation's services in logistics. If Case Company decides not to use one of Parent Corporation's facilities then there will be no expenses for Case Company from this particular facility. Current situation is that Case Company has much faster clock speed than other brands. Down to this reason, Case Company's products do not fit so well in the Parent Corporation's warehouses and are hard to manage. (Manager, Business Process Development 7.1.2008).

The current supply distribution network consist approximately 200 hundred active suppliers, two manufacturing plants, two distribution centres and 10 small local sales company warehouse combinations. Both plants have their own finished goods inventories. Then there are two distribution centres one in the USA and one in Europe. (Manager, Business Process Development 7.1.2008). DC USA mainly serves domestic customers, but there are also international customers (Director,

Global Logistics 22.5.2008; Analysis of Delivery Data 1.1.2007-31.12.2007). Figure 11 presents the parties in supply network and the material flows between the parties. Next, this chapter introduce the roles of each party in distribution network.

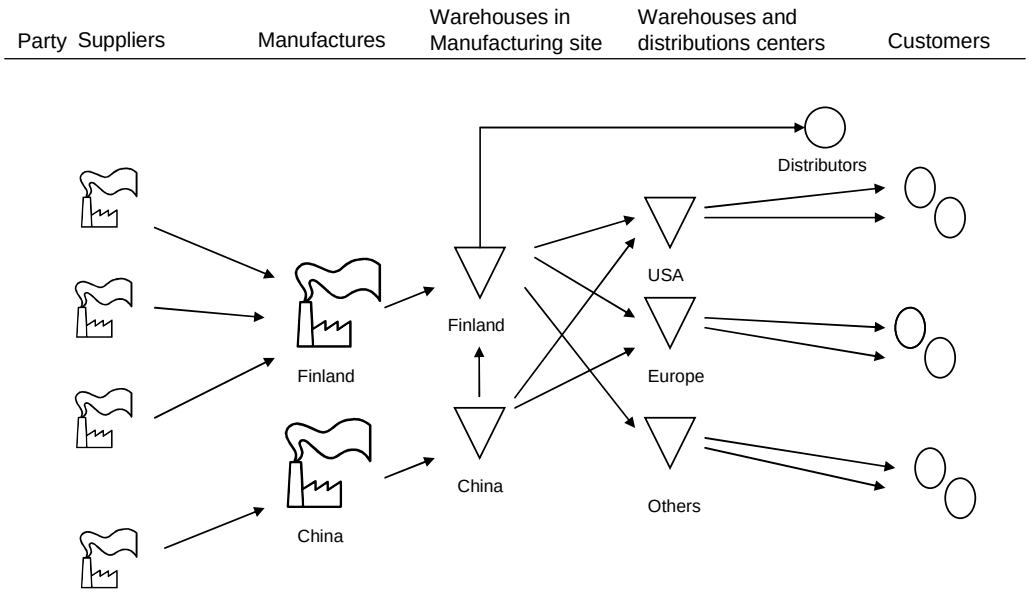

Figure 11 Design Picture of Case Company's Distribution Network

4.2.1 Case Company's Headquarters

Case Company's headquarters (HQ) is located in Vantaa, Finland. Facilities in Vantaa include offices, factory, and finished goods warehouse. There are ca. 160 office workers and same number of factory workers. Parent Corporation's sales office in Finland has a finished goods inventory. This inventory is located at Case Company's HQ. This warehouse serves domestic customers and Estonia but it will be closed in the summer 2008. Customers of this warehouse will be served directly from Case Company' finished goods warehouse. (Manager, Business Process Development 7.1.2008).

In the headquarters, there is a sales team that includes six sales coordinators who handle all the orders from distribution centres and local sales companies. These customers are internal customers, because they are part of Parent Corporation. Each internal customer has slightly different process how a sales coordinator handles it. Case Company uses vendor managed inventory (VMI) mode for DC Europe and DC

USA when other local sales companies order products to warehouse. (Manager, Sales Planning and Customer Service 28.2 2008).

One part of the sales organization is a shipping department. At the moment the shipping department is organized to ship large volume shipments. There are around 3000 shipments per year. Shipping department consist of foreman, packing team leader and four packers. Workers in shipping department claim that lack of working space makes the work harder and working inefficient. (Foreman, Shipping Department 5.5.2008).

4.2.2 Original Equipment Manufacturer

Original equipment manufacturer (OEM) is located in China. They manufacture large volume products for Case Company. Case Company provides sales forecast for OEM, which they use for production schedule. If Case Company orders products from China according their plan, there should always be products available. OEM delivers products from China to Case Company's head quarters, DC Europe and DC USA. Delivery process from OEM is following: Sales coordinators place the orders before Friday. During next week employees in OEM facilities pick, pack, and prepare all the shipping documents. Then OEM ships goods to Hong Kong. This process lead-time is one week. Next week freight carrier ships products from Hong Kong to their destination. Products travel time from China to Finland, DC Europe and DC USA in one week. Total order delivery time for ordering products from OEM is two weeks. (Manager, Commodity 29.4.2008).

4.2.3 Hubs in China and Hong Kong

Parent Corporation's hub in Hong Kong is an office that controls all traffic from China and Hong Kong to west. It is not physical distribution centre, but the goods travel directly from suppliers to Parent Corporation's companies around the world. The sales office and warehouse of Shanghai exist in order to import products to China. Shanghai facilities exist, because of the legislation of China. There is a law that only authorized firms can import products to China. Shanghai facility is the place where all goods arrive when they come to China. Products are not stored in Shanghai, but they continue their way to end customer after formalities have been

taken care. Case Company handles all Chinese customers as drop shipment customer. (Coordinator, Sales 28.2.2008)

4.2.4 Distribution Centres

Case Company uses two distribution centres. One is located in Europe and the other one is located in the USA.

DC Europe

DC Europe is the distribution centre of EMEA (Europe, Middle-East, and Africa) district. Case Company's factories in Finland and China replenish distribution centre once in a week. Principal mode of operation is that distribution centre delivers all orders to retailers. However, there is possibility to deliver bigger shipments directly from Finland. These days the distribution centre is full, there are requirements for extra space, and warehouse hotels have to be used. This is the situation for all Parent Corporation's companies except Case Company. (Vice President, Supply Chain Development 31.3.2008). During Year 2007, distribution centre shipped XX-customer deliveries in which Case Company products were enclosed. (Analysis of Delivery Data 1.1.2007-31.12.2007).

DC USA

Main task of DC USA is to deliver products for domestic markets, but it also delivers products for international markets. Factories in Finland and China replenish Distribution centre once a week. The USA covers XX % of total volumes measured in sales in Euros. In the year 2007 distribution centre shipped around XX-customer deliveries (Analysis of Delivery Data 1.1.2007-31.12.2007).

4.2.5 Sales Companies' Local Warehouses

There are nine local warehouses around the world. One clear categorization can be done. Six of the warehouses store all Case Company's products and three of them have concentrated purely on one specific product category. Fitzwright in Canada is Case Company's subsidiary and it is doing business in industry that is closely related to Case Company one product category. Fitzwright also operates as a distributor for

this closely related product category. UK and Benelux are also distributors for this specific product category in their own countries.

Canada

Canada is same kind of a distribution centre like DC Europe and DC USA, but the volumes are much smaller. Total sales in Canada are ca. X million Euros. Shipping products to Canada is straightforward, because no complicated custom procedures exist. Products flow nicely from Finland to Canada. In the year 2007, distribution centre shipped round XX customer deliveries (Analysis of Delivery Data 1.1.2007-31.12.2007).

Japan

Total sales in Japan are ca. XX million Euros. Japan and Canada are the two biggest warehouses of the small ones according to sales volumes. In Japan, everything has to be précis. The Japanese have wide range of rules how everything should be handled. Case Company sells products to Japan without manuals, and manuals are put in the product cases in Japan. Sales Company in Japan takes care of all-important things related to do business in Japan. According to Sales Coordinator, it is necessity to have local sales office and warehouse in Japan. However, some customers in Japan receive their orders directly from Case Company's head quarters. (Analyses of Case Company Delivery data 1.1.2007-31.12.2007).

Mexico

Sales were a little bit under XX€ in the year 2007(Analysis of Case Company Order Line Data 1.1.2007-31.12.2007). What is more interesting the average inventory value in the year 2007 was ca. XX€ (Assistant, Finance Controller 28.4.2008). Custom procedures make transportation to Mexico complicated. Sales coordinator in Finland controls the orders received from Mexico. This means that sales coordinator in Finland double checks all order quantities. This is a must thing to do in order to have some kind of control over the inventory. (Coordinator, Sales 28.2.2008). Sales office in Mexico does some selling also to surrounding countries. There are deliveries that where Mexico's Sales Office is customer, but the ship-to-party is in Brazil. (Analyses of Case Company Delivery and Order Line Data 1.1.2007-31.12.2007).

Brazil

Total sales in the year 2007 were near XX€ (Analyses of Case Company Order line Data 1.1.2007-31.12.2007). In the same time, average inventory has been some XX€ (Assistant, Finance Controller 28.4.2008). Sales company in Brazil has also particular sales coordinator who handles the orders in Case Company's headquarters. Custom procedures make transportation complex and slow and sometimes deliveries can even disappear (Coordinator, Sales 28.2.2008). Parent Corporation's Director of Global Logistics also supported this statement in his interview. He explained custom procedures and problems related to transporting products to Brazil and money out of Brazil. (Director, Global Logistics 5.5.2008). Local knowledge to handle customs is important to maintain fluent flow of goods, without paying too much customs. Sales coordinator in Finland controls the warehouse in Brazil in the same way as sales coordinator controls Mexico. The reason for extra control is the same as in Mexico, to avoid excessive inventories. (Coordinator, Sales 28.2.2008).

Prague

Sales Company in Prague has from some mysterious reasons inventory for Case Company's products. When they need products, they order them from DC Europe.

According to Sales Planning and Customer Service Manager in Prague, they have products stored, because of the difficulties in selling to surrounding countries.

Malaysia

Total sales of Malaysia's sales office in the year 2007 were near XX€ (Analysis of Order Line Data 1.1.2007-31.12.2007). Malaysia's sales office handles sales everywhere in South-East Asia. In Malaysia's warehouse, there are only products for marketing purposes. Malaysia sales office handles orders, and Case Company delivers products directly from Finland to customers. These customers are drop shipment customers. Figure 12 presents the drop shipment process. Case Company sells products to customers primarily as ExWorks basis, but if a customer does not have own contract with freight carrier Case Company will sell products as carriage paid to (CPT). (Coordinator, Sales 28.2.2007). Average inventory in Malaysia has been XX€ during year 2007 (Assistant Controller Informal Meeting, 2008). According to analyses of Case Company's delivery data, Parent Corporation's warehouse in Malaysia has sent shipments to end customers.

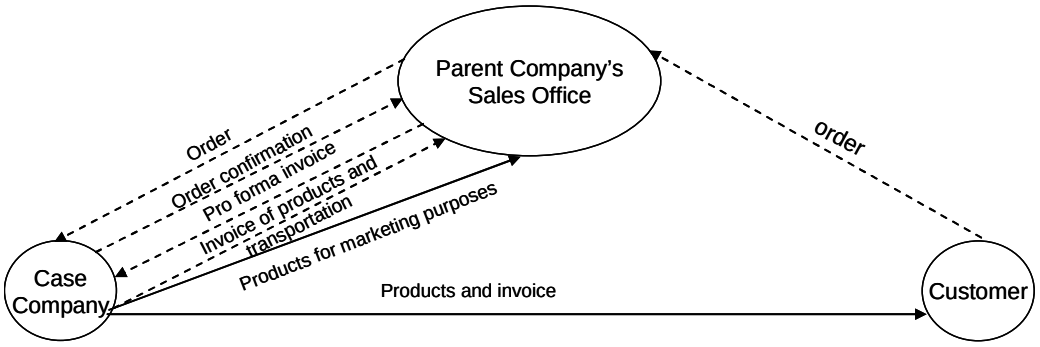

Figure 12 Drop Shipment Process

Australia

Sales in the year 2007 were around XX€ (Analysis of Order Line Data 1.1.2007-31.12.2007). Average inventory in the same period was near XX€ (Assistant, Finance Controller 28.4.2008). Sales to distributors in Australia were some XX€ in the same time (Analysis of Order Line Data 1.1.2007-31.12.2007). Total volume to Australia was ca. XX€. Case Company can handle customers of Australia's sales company as drop shipment customers (Coordinator, Sales 28.2.2008).

4.3 Nature of Product

This chapter presents three analyses that concern nature of Case Company's product. First analysis presents demand pattern for typical Case Company's product. Second analysis focuses functionality and innovativeness of products and third analysis discusses Case Company's products suitability for global direct deliveries.

4.3.1 Demand Pattern

Case Company has four product categories. Figure 13 presents typical demand pattern for Case Company's products. Case Company is operating in markets with unpredictable demand with short term variations. Volumes in markets are relatively low, but margin in premium price is high. (Case Company Presentation: Supply & Manufacturing Strategy). The product at the issue for example has 31 different models. Case Company delivered XX different final products to its customers in the year 2007. (Analysis of Delivery Data 2007). Case Company launches new products whenever they are ready. Usually this means a couple of big and small launches per year. Existing products can have new variants at the maximum once in a year. For example, new colour for a product is a change of variant. (Manager, Business Process Development 7.1.2008).

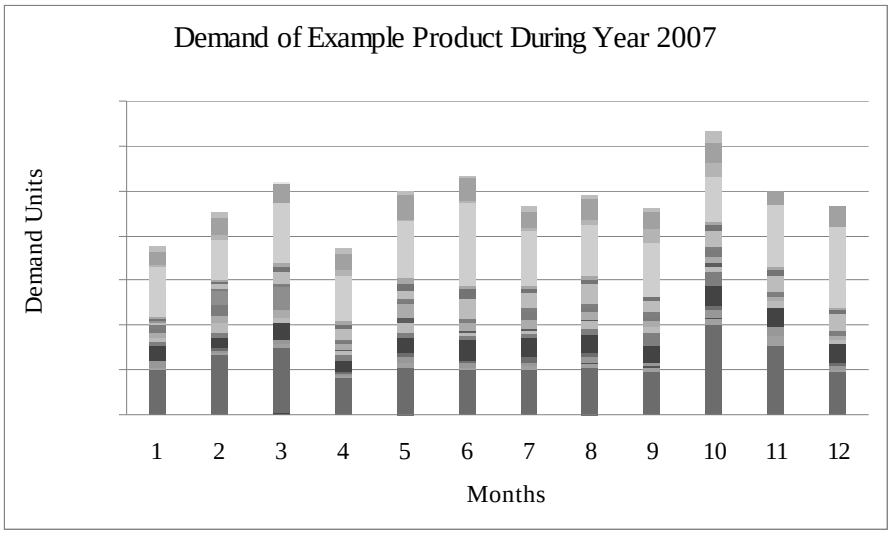

Figure 13 Demand of Example Product in the year2007

4.3.2 Functional Versus Innovative

This analysis bases on Fisher's (1997) aspects of demand. Table 5 presents summary of the analysis. According to Fisher (1997) it is not clear if Case Company's products are functional or innovative. Fisher claims that if the life-cycle of a product is more than two years product comes under functional class. Life-cycles of Case Company's products vary from one to ten years. This indicates functional products. Contribution margins of Case Company's products range from XX % to XX %. According to Fisher (1997) this indicates innovativeness of products. Case Company wittingly keeps the variety of products low and sells global products (Manager, Business process development, 7.1.2008). Case Company has fewer than XX variants per category that is a sign of functional product (Case Company Product Catalogue 2008). Fisher (1997) claims that a product with a low average of margin error in the forecast at the time production is committed, comes under functional class. Case Company has invested heavily to develop its sales planning. Case Company's investments have gained good forecasts with 12 % error (Case Company Sales Planning Reports). This is also a sign from functional product. Forecasting accuracy was the leading element to define whether the product is functional or innovative. For functional product average stock out rate is one or two percentages and for innovative product average stock out rate range from 10 % to 40 %. In Case Company, stock out rate is 14.8 % (Case Company Sales Planning Report). This on the other hand is a sign of innovative product. Fisher (1997) says that for functional products companies do not need to write end-of season markdowns and for innovative products end-of season markdowns range from 10 % to 25 % of full price. Case Company does not have accurate estimate of end-of season markdown percentage rate, but according to Manager of business process development Case Company comes under innovative category. Fisher's last aspect of demand is the lead-time required for made-to-order products. Case Company is competent to deliver orders for make-to-order products in two weeks. According to Fisher (1997) one day to two weeks is category for innovative product and 6 months to one year is category of functional product. According to lead-time requirement, Case Company's products are innovative. Summary of the analysis is three points to functional product and four points to innovative product. The implication of the

analysis is that it is not clear whether Case Company's products are functional or innovative.

Table 5 Aspects of Demand in Case Company According to Fisher's (1997) Categorization

Aspects of Demand	Functional (Predictable Demand)	Innovative (Unpredictable Demand)	Case Company
Product life-cycle	More than 2 years	3 months to 1 year	1-10 years
Contribution margin	5 % to 20 %	20 % to 60%	Profit margin XX % to XX %
Product variety	Low (10 to 20 variants per category)	High (often millions of variants per category)	< 30 variants per category
Average margin of error in the forecast at the time production is committed	10 %	40 % to 100 %	12 %
Average stock out rate	1 % to 2%	10% to 40%	14.8 %
Average forced end-of season markdowns as percentage of full price	0%	10 % to 25 %	No accurate estimate
Lead-time required for made-to-order products	6 months to 1 year	1 day to 2 weeks	2 weeks

4.3.3 Preconditions of Global Direct Deliveries

Su (2007) presented preconditions for a product concerning its suitability towards global direct deliveries. According to Su's (2007) criteria Case Company's products suit well for global direct deliveries. Five criteria of the six match up to Case Company's products. The only one that does not match is criterion of Internet-based trading tools. Su (2007) says that company should have Internet-based trading tools available for a customer to place order anytime and anywhere. Case Company does not provide this service for its customers. To other preconditions, Case Company's products match well. Case Company sells high-tech products in volatile market, profit margins of products are high, products are small sized, light, and easy to transport. Case Company trades its products globally, and Case Company is continuing to adapt of fast-cycle logistics and distribution. Table 6 presents Su's factors and how Case Company's products match up to this category. Implication of this analysis is that Case Company's should use direct retail deliveries.

Table 6. Su's (2007) Criteria Should a Company Consider Global Direct Deliveries

Factors	Case Company	Confirms
High-tech product in volatile markets	High-tech sports instruments in volatile markets	✓
Time-critical or high value-added goods in measures of high profit margin	Profit margin XX % to XX %	✓
Products are small sized, light and easy to transport	Deliveries out of distribution centers are small and light weight	✓
Company trade products globally	Case Company has global distribution network	✓
Internet-based trading tools are available to end customer for placing orders anytime anywhere	No internet-based trading tools are available for customers	
Company is continuing to adapt of fast-cycle logistics and distribution	Case Company is putting effort to decrease cycle times in distribution	✓

4.4 Priorities in Supply Chain

Case Company continuously looks for new sales channels for existing products and design new products in order to hit new sales channels. Case Company's objective is to establish most responsive and effective demand-supply network in its peer group (Case Company Presentation: Supply & Manufacturing Strategy). At the end of the year 2007, Case Company introduced new innovative products. Result was that all the new products Case Company could produce were sold. In this case, demand exceeded Case Company's ability to produce finished products and Case Company experienced some amount of loss of sales in the beginning of year 2008. To avoid these cases Case Company has focus on supply chain responsiveness. Case Company evaluates its suppliers with scorecard that considers other issues apart from cost like flexibility, willingness to serve etc.

4.5 Tentative Proposal for new physical distribution network

Tentative proposal for new physical distribution strategy is direct retail deliveries from Case Company's headquarters to retails around the world. Figure 14 presents the tentative proposal for new physical distribution system. In the proposed model, Case Company works with freight carrier that delivers finished products directly from Finland to retails in destination countries. Next chapter presents evaluations for as-is and tentative physical distribution networks.

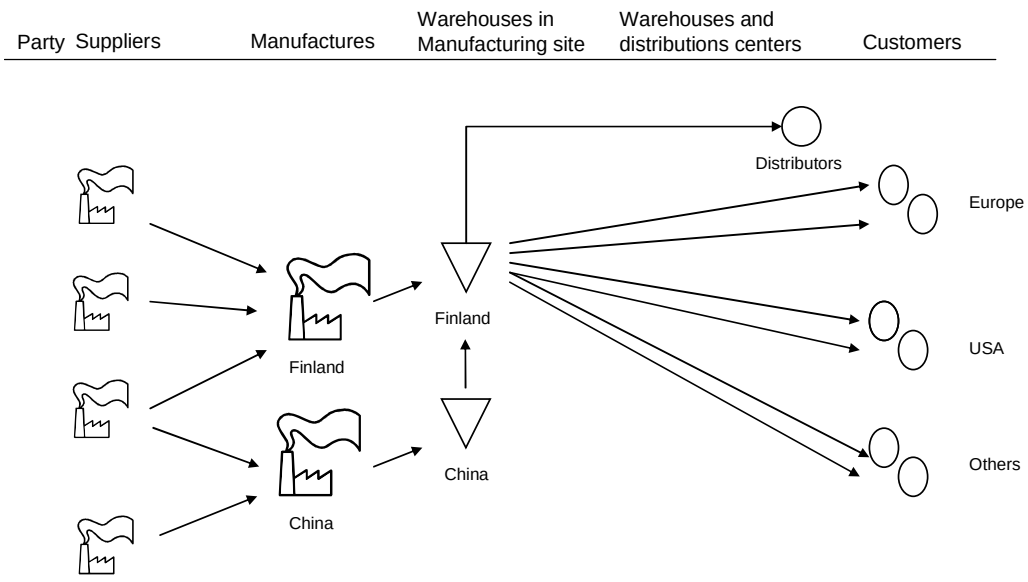

Figure 14 Tentative Proposal for a New Physical Distribution Network

4.6 Criteria and the Operationalization of Performance Measures

The present chapter introduces criteria for performance measures and explains the operationalization of the performance measures. The present chapter discusses of the performance measures each at the time. First, it presents the criterion for measure and then the operationalization.

4.6.1 Customer

Case Company's supply chain strategy says that delivery times to customer have to be kept in existing level (Case Company Presentation: Supply & Manufacturing Strategy). In the conclusion of literature review, I chose to use Christopher's order-cycle-time as a performance measure for customer perspective. Down to this selection, order-cycle-time now represents customer's requirements. The result of as-is physical distribution network analysis for order-cycle-time will then set the criteria for tentative direct delivery model.

Christopher (1998:158) presented major steps, which are included to order fulfilment lead-time. Christopher calls order fulfilment lead-time as order-to-delivery cycle time. The steps in order-to-delivery cycle are customer places order, order entry, order processing, order assembly transport, and order receiving.

Case Company does not record data e.g. how long does it take to place orders by customers. Case Company's order line data includes dates when sales personnel creates sales orders and when packers make the goods issues for the sales orders Case Company's delivery data includes route information. Route information includes information of used delivery times from distribution centres to customers.

For Case Company I calculated the time between sales personnel types the sales order into ERP system and packers do the goods issue for the sales order. In Christopher's model, the time I calculated represent the time that is a sum of order processing and order assembly time. This research calls this time as an order-to-goods issue time. I used weighted average and median to estimate the order-to-goods issue time.

Next step in Christopher's list is transport. The time goods spend in transport is the transport time. I estimated time for transport time using delivery times from route data. I used weighted average to estimate transport time. With Case Company, order-to-delivery cycle time is then a sum of order-to-goods issue time and transportation time.

4.6.2 Inventories

One target of Case Company's supply strategy is to reduce DSI from existing XX to XX days. (Case Company Presentation: Supply & Manufacturing Strategy) Boundary condition for inventory levels is that they must not increase due to changes in physical distribution network.

"Square root rule" analysis used information from three inventories. These inventories were inventories in the DC USA and DC Europe and inventory in Case Company's headquarters. As-Is state in square root analysis were three inventories with their total value in Euros. Tentative state in square root analysis was two inventories. Using the two inventories in tentative state leads to inventory value if Case Company dispenses with one distribution centre. Risk-pooling calculation bases on the idea to cut the cycle stock of products made in Finland from the distribution centre and use risk-pooling approach for the products made in China. Reduction in inventory levels is then extraction between the average amount of inventory in

distribution centre and the amount risk-pooling gives for products made in China after Case Company dispenses with distribution centre. Headquarters inventory confront the demand products made in China. This is the demand risk pooled with the demand that distribution centre faces. Earlier Koskenvuo (2005) calculated optimal service level for Case Company. The calculated service level was 98 %. Order lead-time from China is two weeks (Manager, Commodity 29.4.2008). Inventory level calculations use these parameters to approximate consolidated inventory levels. This research uses the equation (1) to calculate DSI for inventories.

To commensurate inventories with logistics cost and pollution cost this study uses inventory carrying-cost. Case Company uses 30 % inventory carrying cost (Manger, Business Process Development, 7.1.2008). Inventory carrying-cost is then product of inventory value and inventory carrying cost percentage.

4.6.3 Cost

One instruction of Case Company's management was that the total cost of logistics must not increase. If some new supply chain structure brings other benefits and cost de-crease or remains at the current level then this kind of reengineered supply chain structure is feasible in Case Company. (Manager, Business Process Development 7.1.2008).

Total cost is a sum of ten different cost elements. Some cost elements are historical cost data while other are calculated using financial and transactional data. Cost elements in total cost analysis are

- Rent income from Parent Corporation's local warehouse
- Goods receipt department
- Selling & Distribution cost
- Transportation Hong Kong – DC
- Transportation cost DC – retail
- Transportation cost Hong Kong - Finland
- Shipping department
- Transportation cost Finland – DC
- Transportation cost Finland - retail
- DC operating cost (Case Company allocation)

Rent income from Parent Corporation's local warehouse

Parent Corporation's sales company pays monthly rent for Case Company. Archives of finance department contained the invoices to Parent Corporation's sales company. The monthly rent was XXX €. This is the tax-free amount. Total rent income for the year 2007 was XX Euros.

Transportation cost Hong Kong - Finland

In the beginning of the year 2007, all products made in China were first delivered to Finland and then from Finland to distribution centres. This changed in the autumn 2007 and OEM in China started to deliver products directly to DC Europe and DC USA. (Manager, Commodity, 29.4.2008). In order to compare current as-is state to tentative state, I decreased the kilos of products made in China from the connection between Finland and distribution centres, and added these kilos to connections between Hong Kong and distribution centres. I got the price for transporting one kilo from Hong Kong to Finland using average price for kilo from existing deliveries in this connection. Average price gives good estimation when calculating with total sums, but when all deliveries are known it is better to use freight carrier's rate table to calculate transportation costs.

Case Company used single freight carrier for this connection during Year 2007. The freight carrier provided detailed information to Case Company about shipments for the year 2007. This list contains numbers of deliveries, kilos, and prices. Estimation for price to transport one kilo Case Company's products from China to Finland is the total cost per total kilos.

Goods Receipt Department

Receiving products from China gives a lot of work to goods receipt department. Case Company uses airfreight to bring products from China to Finland. Freight carrier unpacks and repacks pallets during the transportation in order to fit in the pallets into first possible flight. Because of this extra unpacking and repacking, each pallet might contain multiple products when it arrives to Case Company's headquarters. Warehouse workers then have to realign the pallets in a way that one pallet contains

only products with same material code, before they can move the pallets to shipping department. Warehouse workers spend one and a half hours to realign seven pallets. Then the time used for one pallet is 0.21 hours. Depending on the product, one pallet contains 20 or 40 packets and one packet 20 or 40 products. One-hour work in warehouse cost 20 Euros for Case Company. (Manager, warehouse 2.6.2008). I calculated the price for realigning pallets in shipping department by using equation (3). Demand($product_i$) was demand for product (i) made in China in the year 2007.

$$\sum_i \left[\frac{Demand(product_i)}{(Packet\_size_i * Pallet\_size_i)} \right] * XX € * 0{,}21h \quad (3)$$

Shipping Department

In Case Company, expenses of shipping department are part of sales department. Case Company's P&L and payroll computation provided the expenses of shipping department during year 2007. P&L contained all other expenses except salaries. Case Company's wages clerk calculated the wages for this research. Shipping department cost classifies to sales companies according to kilos shipped to each sales company.

Cost of one activity in DC Europe is XX Euros. Activity means one line pinking in Europe's distribution centre. (Controller, Finance Europe 28.1.2008). This calculation uses price of one activity as a price of one order line. In tentative case, approximated cost for distribution centre was the order lines delivered from distribution centre multiplied by the price of one activity.

Selling & Distribution cost

Case Company invoices all its Selling & Distribution (S&D) from sales companies. Archives of personal ledger contain all invoices from the year 2007. S&D cost for each sales company was the sum of invoices pointed to particular sales company. S&D cost of HQ included among other the cost of shipping department. S&D cost in calculations is the extraction of S&D costs and cost of shipping department. S&D cost of HQ was same for as-is and tentative states.

Transportation cost Finland – DC

Case Company's policy is to sell all products as ExWorks to sales companies. Because of this policy, there is no single freight carrier that handles all freight between intermediaries in distribution network. All sales companies have their own contracts with different freight carriers.

Finance Controller of Europe had exact figures of transportation cost between Finland and Europe's distribution centre. Calculations based on the Parent Corporation's freight contract lead to same figures.

Financial Analyst who is responsible of North America was not as accurate as the financial controller of Europe. In the USA, they add 6 % into products price to offset inbound logistics costs and custom fees. Freight Carrier representative provided us a list of deliveries to the USA's distribution centre and the cost of deliveries. From the USA, they provided us a total cost of transportation.

Transportation cost Hong Kong – DC

The financial controller of Europe provided exact numbers from transportation cost and duties. In the USA case situation was a little bit different. In the USA, they add 6 % on the price of the product to cover transportation and duties costs. This rule of thumb provided the best approximation for transportation cost.

In the year 2007, products made in China travelled two routes to distribution centres (Analysis of delivery data 1.1.2007-31.12.2007). These routes were through Case Company HQ and directly to DC Europe and DC USA. In as-is state products travel directly to distribution centres. Therefore, the kilos rotated trough Case Company's HQ had to be added to these direct connection between Hong Kong and DC Europe and DC USA. This increased the cost of direct connections and decreased the cost between Hong Kong and Finland.

Transportation cost Finland – Retail

Freight carriers provided freight contract proposals for direct retail delivery. Transportation costs base on the rates that freight carriers proposed. Two carriers

provided rates based on the size and weight of the packet. One freight carrier provided a flat rate. The flat rate means that Case Company pays the same price for each kilo that it sends to retail.

In the flat rate model, freight carrier will pick up deliveries everyday from Case Company's HQ and measure the total weight of packets. The price of all packets is the sum of weight multiplied with the transportation rate. The other model with changing rates works the same way, except the pricing procedures are much more complicated. Case Company and Freight carrier have to measure the dimensions and weight of each packet to calculate the price of transportation. The maximum of real weight and volumetric weight defines the final price for each packet.

Transportation cost DC – Retail

Parent Corporation provided its freight contracts, which DC Europe uses. I used these rates to calculate the cost of transportation from DC Europe to retailers in Europe. Parent Corporation's financial analyst provided me the exact number of outbound logistics cost in the USA. Case Company's financial information system contains this same amount in logistics expenses account of the USA.

DC operating cost (Case Company Allocation)

Financial Controller of Europe provided his model how to calculate the allocation of distribution centre costs to Parent Corporation's companies. This calculation model provided the cost of distribution centre of Europe. The financial analyst of Parent Corporation provided me the cost of using the USA's distribution.

4.6.4 Environment

No strict boundary condition exists from Case Company's side towards CO_2 emissions. The users of some Case Company's products however are closely related to nature and from this reason, Case Company wants to give good image in environmental issues. Case Company will prefer solutions that do not increase CO_2 emissions. (Manager, Business Process Development 7.1.2008).

I calculated the distances between different places by using equation (4). Geometric function does not consider the real flight or truck routes, but it calculates the distance as the crow flies. Other issue what equation 4 does not consider is the direction that the transportation moves, equation 4 calculates the shortest way. Google Earth provides a tool to draw a route and then to receive the distance for route. I used this tool to measure differences between the parties in distribution network. No tool to measure exact flight routes was available and this level of accuracy is enough for the analysis.

$$Distance = 6380km * \arccos(\sin(Orign.Lat) * \sin(Destn.Lat)) + \cos(Orign.Lat) * \cos(Destn.Lat) * \cos(Orign.Long - Destn.Long)) \quad (4)$$

Orign.Lat means the latitude value in radians of place of departure. Destn.Lat means the latitude value in radians of the place of destination. Orign.Long and Destination Long are the longitude values in radians of the place of departure and destination.

The equation 5 presents the calculation of CO_2 emissions. The common unit to present green house gas emissions is tons. This research will also use tons as presentation type for CO_2 emissions. Earlier steps of cost calculation provide the volumes of shipments. Database of LIPASTO provides the unit emissions for each mode and the first step of emission calculation provides us the distance. I used equation six then to calculate CO_2 emissions for each connection in Case Company's distribution network.

$$CO_2 emissions = \left(\frac{1}{1000000}\right) \times UnitEmission[g/ton, km] \times Distance[km] \times weight[ton] \quad (5)$$

5 DISTRIBUTION NETWORK PERFORMANCE ANALYSES

Figure 14 presents the tentative direct delivery proposal. Tentative direct delivery proposal includes three separate cases. First case is DC Europe. Second case is DC USA and the third case is other small local warehouses. Chapter 5 presents the results of the analyses of as-is and tentative states for the three different cases. In conclusion, chapter 5 presents a proposal for to-be physical distribution network.

5.1 As-Is Performance of Europe's Pipeline

5.1.1 Customer Perspective

DC Europe delivers orders to 5116 Case Company's customers. Some of the customers have multiple shipping addresses that increase the number of ship-to-parties to 5420. Total number of order lines delivered from DC Europe is 73854. Weighted average for order order-to-goods issue time was 14 days. Weighted average was not good measure for order-to-goods issue time. This is due to fat tail in the distribution of order-to-goods issue time.

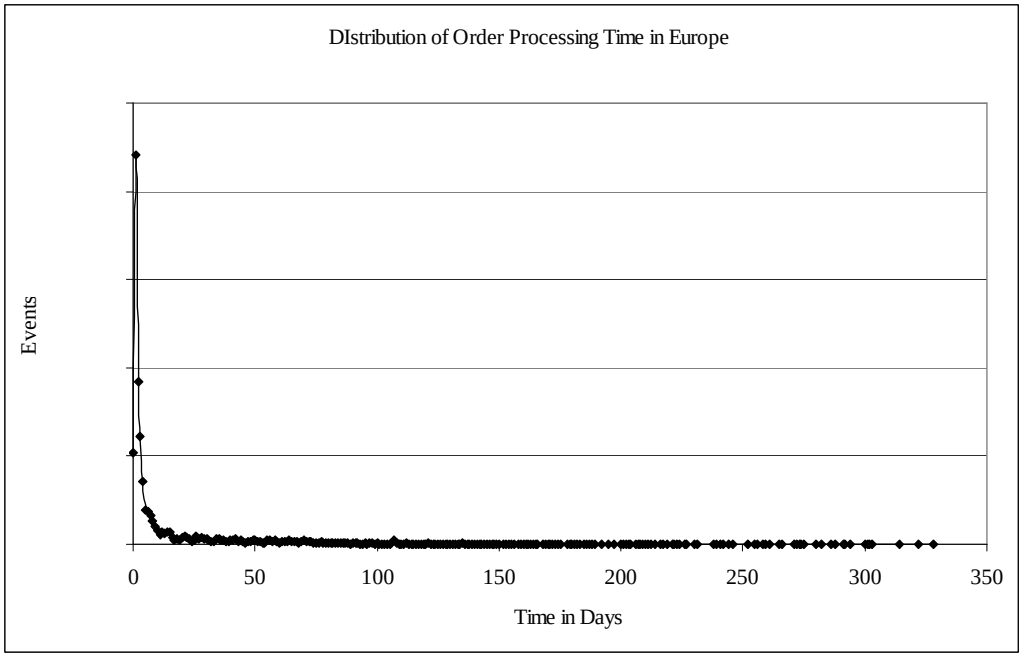

Figure 15 presents the distribution of order-to-goods issue time. With this kind of distribution, it is better to estimate order-to-goods issue time with median. Median

for order-to-goods issue time was 2 days. (Analysis of Delivery Data 1.1.2007-31.12.2007).

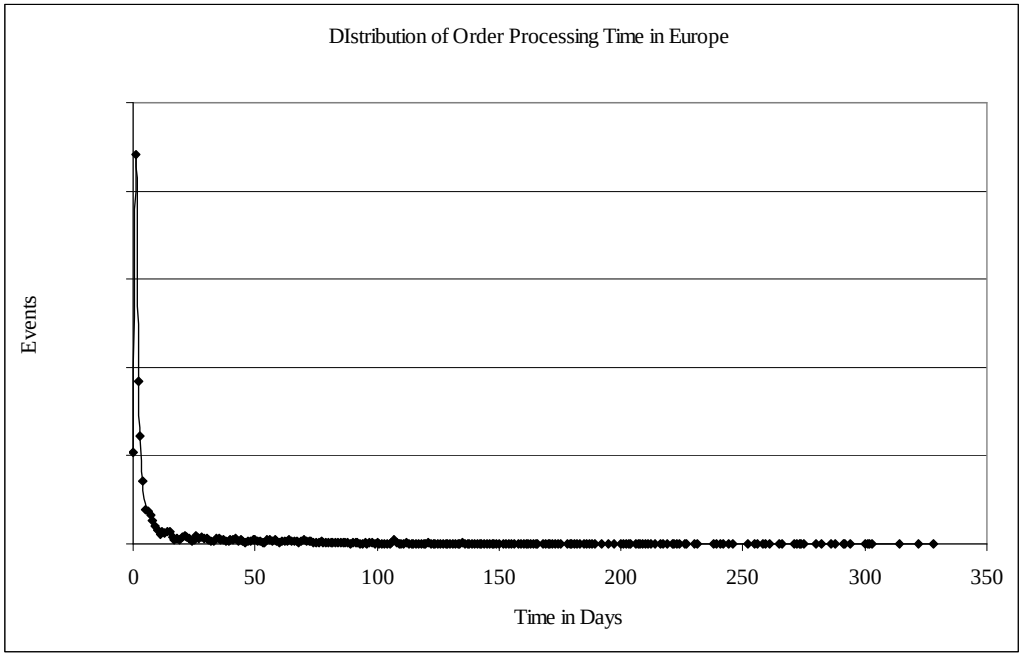

Figure 15 Distribution of Order-to-Goods Issue Time in Europe

From DC Europe, Case Company delivers products to 36 countries (Analysis of Delivery Data 1.1.2007-31.12.2007). Table 7 presents these countries excluding the ones where no delivery time data was found. Current freight contracts in Europe covers 20 countries (Parent Corporation's freight contracts in Europe). The countries that are missing from freight contracts are the ones where volumes are low and deliveries to these countries are random (Analysis of Delivery Data 1.1.20007-31.12.2007). Ten biggest countries that Europe's distribution centre serves generate 94 % of total value (Analysis of Case Company Order line Data 2007). These countries are Country A, Country B, Country C, Country D, Country E, Country F, Country G, Country H, Country I, and Country J. Table 7 presents the countries, volumes, and delivery times for 31 countries. There is no accurate delivery time to any of the countries, but the delivery time varies with one or two days in each country depending of the freight carrier (Analysis of freight Contracts). This study calculated the delivery time using the delivery times stored in Case Company's ERP system.

Table 7 Delivery Times from DC Europe

Country	Number of shipments	Value of shipments	Transport Time
Country A	19 %	17 %	3
Country B	10 %	16 %	2
Country C	17 %	14 %	1
Country D	7 %	11 %	3
Country E	13 %	10 %	2
Country F	14 %	8 %	3
Country G	9 %	6 %	2
Country H	0 %	5 %	3
Country I	7 %	5 %	3
Country J	0 %	2 %	6
Country K	0 %	1 %	3
Country L	1 %	1 %	2
Country M	0 %	1 %	3
Country N	0 %	1 %	3
Country O	0 %	0 %	5
Country P	0 %	0 %	2
Country Q	0 %	0 %	5
Country R	0 %	0 %	2
Country S	0 %	0 %	5
Country T	0 %	0 %	2
Country U	0 %	0 %	5
Country V	0 %	0 %	2
Country W	0 %	0 %	2
Country X	0 %	0 %	5
Country Y	0 %	0 %	5
Country Z	0 %	0 %	2
Country Å	0 %	0 %	5
Country Ä	0 %	0 %	5
Country Ö	0 %	0 %	3
Country AA	0 %	0 %	5
Country AB	0 %	0 %	2
Weighted Average			2,4

The median for order-to-goods issue time is 2 days in Europe. Estimated transport time weighted average is 2.4 days. Total order-to-delivery cycle time in Europe is then 4.4 days.

5.1.2 Inventories

In the year 2007, average inventory in DC Europe for Case Company's products was XX Euros. From this amount products made in Finland generate XX Euros and

products made in China XX Euros. Inventory carrying cost for Case Company's products with 30 % inventory carrying cost percentage is XX Euros. Case Company's DSI has been varying from XX to XX with average as XX(Analyses of Case Company Financial Data). DSI for total inventory value in Europe is around 7.8 days in DSI. Value of products made in Finland was XX Euros which is 5.6 days in DSI and the value of products made in China was XX Euros which is 2.2 days in DSI. (Analyses of Case Company Financial Data). Table 8 summarizes the figures presented in this chapter.

Table 8 As-Is Inventory Values and DSI in DC Europe

	Value in Euros	DSI in days
Europe Total	XX	7,8
Products made in Finland	XX	5,6
Products made in China	XX	2,2

Case Company has launched new products during fall 2007. OEM manufacturer produces all new products that Case Company launched during the fall 2007. Figure 16 presents the inventory values for products made in China. Figure 16 shows the increasing trend in inventory values toward the end of the year. Case Company expects the demand of these products to increase in future, what means also that inventory levels will increase in the compared to past.

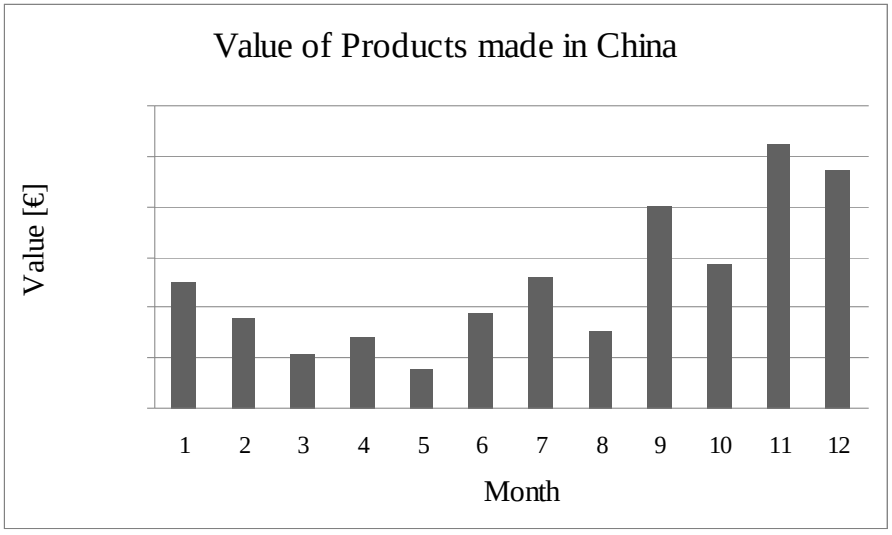

Figure 16 Value of Products Made in China in DC Europe

5.1.3 Cost

Table 9 presents the items of expenditure and their values. Total costs for Europe's pipeline are XX Euros, which does not include inventory carrying cost. Inventory carrying cost were XX Euros with 30 % inventory carrying cost. This chapter presents the costs without inventory carrying cost, because one of the criteria was that tangible expenses should not increase. Case Company's management wanted to compare expenses without inventory carrying cost. The greatest items of expenditure are distribution centre operating cost, transportation from distribution centre to retail, and selling & distribution cost of Finland concerning Europe. Selling and distribution cost of Finland includes the salaries and other expenses generated by office workers in sales department. Parent Corporation surcharges transportation cost from distribution centre to retail from customer. Current setup is that Parent Corporation charges list price of freight carrier from customer, which is more than what Parent Corporation pays for a freight carrier. Parent Corporation charges Case Company for using the distribution centre. Parent Company makes the allocation for its brands in three parts. First part is on the square foot used. Second is on activities. One activity is line pick in distribution centre. Third part is inventory reserve. Inventory reserve covers expenses that occur due to obsolescence etc.

The items of expenditure, which have no value in as-is state are transportation cost Hong Kong – Finland, Goods receipt department and transportation cost Finland – Retail. Transportation cost Hong Kong – Finland is zero, because no products that are manufactured in China come first to Finland and then from Finland to DC Europe. Goods receipt department cost refers to cost that emerge from handling goods made in China for distribution centre. Transportation cost Finland – Retail is the cost generated from direct deliveries from Finland to retailers.

Table 9 Total Cost of Europe's As-Is Pipeline

Cost Elements	Europe as-is
Rent Income from Parent Company's Local Warehouse	-2 %
Transportation cost Hong Kong – Finland	0 %
Goods Receipt Department	0 %
Shipping Department	8 %
Selling & Distribution cost Finland	17 %
Transportation cost Finland – Distribution Centre	7 %
Transportation cost Hong Kong - Distribution Centre	5 %
Transportation cost Finland – Retail	0 %
Transportation cost DC – Retail	31 %
DC operating cost (Case Company Allocation)	34 %
Grand Total	X€

5.1.4 Environment

Table 10 presents transportation steps that generate CO_2 emissions. Case Company transports its products from HK to DC Europe by using airfreight. For transportation between Finland and DC Europe Case Company uses combined ground and sea freight. From DC Europe to retailers Parent Corporation mainly uses ground freight. Some remote distances Parent Corporation uses airfreight. Price of one emission right for one ton of CO_2 gas was 25.5 Euros on Tuesday 7 of July 2008 (European Energy Exchange). Total amount of CO_2 emissions is 279 tons, which is 7110 Euros.

Table 10 CO_2 Emissions of Transportation in Tons for Europe's As-Is Pipeline

Transportation steps	Europe as-is
Pick Up From Vantaa	0
Transportation HK - Finland	0
Transportation HK - DC	250
Transportation Finland - DC	6
Transportation DC - Retail	23
Transportation Finland - Retail	0
Total	279
CO2 emissions in tons	

5.2 As-Is Performance of the USA's Pipeline

5.2.1 Customer

DC USA delivers orders to 941 customers. Some of these customers are chain stores and have multiple stores around the country. DC USA has delivered products to 2021 different ship-to-parties. Customer data in ERP system contains transportation zone data for all the customers in the USA. Using the transportation zone data, this study aggregates ship-to-parties on the state level. Case Company's delivery data contains route information for each delivery. Route data for one contains the delivery time data.

Result of customer perspective analysis was an order-to-goods issue time. In the USA, sales personnel and warehouse workers tend to spend four days for handling one order. Four days is a median for the order-to-goods issue time. Median gives a good estimate for order-to-goods issue time. Figure 17 presents the distribution of order-to-goods issue time. The distribution shows that lot of events times under ten days. The peak of events is on one-day order-to-goods issue time, but the tail of the distribution is long and has huge impact. Because of the impact of fat tail, average was not good estimate.

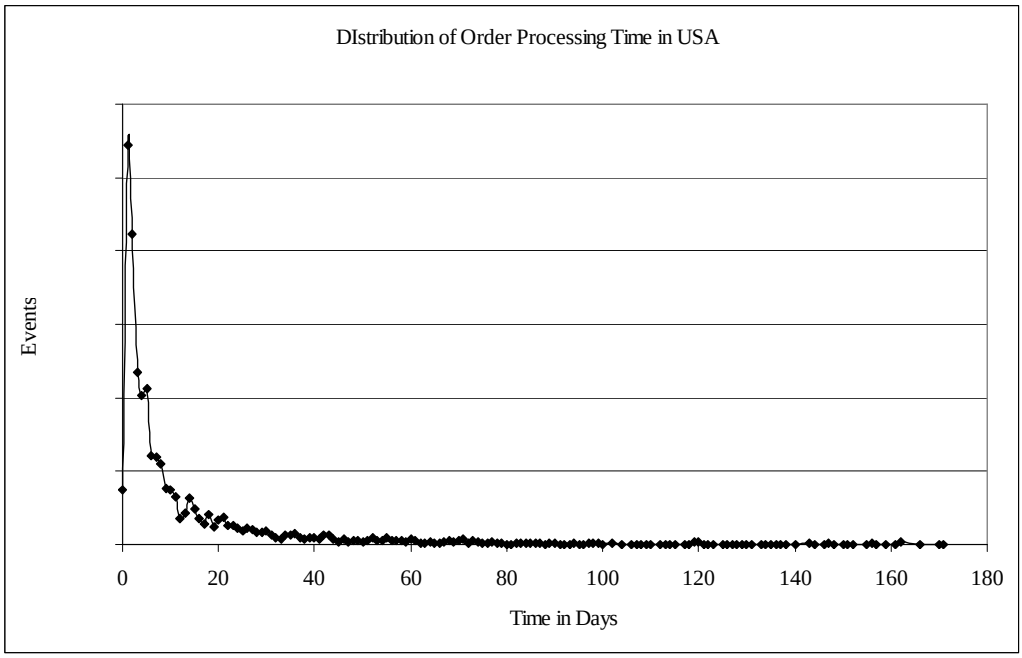

Figure 17 Distribution of Order-to-Goods Issue Time in the USA

The USA sales company uses two different transportation modes ground deliveries and airfreight. Ground deliveries have four transport times. Transport times of ground deliveries vary from two days to five days. Transport time for ground delivery depends on the customer's location. The greater the distance between customer and DC USA the longer the transport time is. The USA sales company uses airfreight to get packets next day to customer. Table 11 presents the current transport times and how many deliveries have been with in each category in the year 2007. Weighted average of finished goods transport time in the USA is 3 days. Total order cycle time is then 7 days in current mode.

Table 11 As-Is Delivery Times and Number of Deliveries in the USA

Delivery Time	Number of Shipments	% of total
Next Day	X	7 %
Two Days	X	21 %
Three Days	X	41 %
Four Days	X	21 %
Five Days	X	10 %

5.2.2 Inventories

Exchange rate between the US dollar and Euro has great impact on the inventory value. This study converted inventory value of each month from the US dollars to Euros using the exchange rate of the first day of the month (Web-data Base of Oanda). In the year 2007, average inventory in the DC USA for Case Company's products was XX Euros. From this amount products made in Finland generates XX Euros and products made in China XX Euros. Inventory carry cost for DC USA with 30 % inventory carrying cost percentage was XX Euros in the year 2007. Case Company's DSI has been varying from XX to XX with average as XX. Total inventory value in DSI is around 7.8. Value of products made in Finland was XX Euros, which is 6.7 days in DSI and the value of products made in China was XX Euros which is 1.1 days in DSI. Table 12 presents the different inventory values and respectively DSI values.

Table 12 As-Is Inventory Values and DSI in DC USA

	Value in Euros	DSI in days
USA Total	XX	7,8
Products made in Finland	XX	6,7
Products made in China	XX	1,1

Case Company has launched new products during fall 2007. OEM produces these products in China. Figure 18 presents the inventory values for products made in China. The figure shows the increasing trend in inventory values toward end of the year. Case Company expects the inventory levels to be higher in the future than in past.

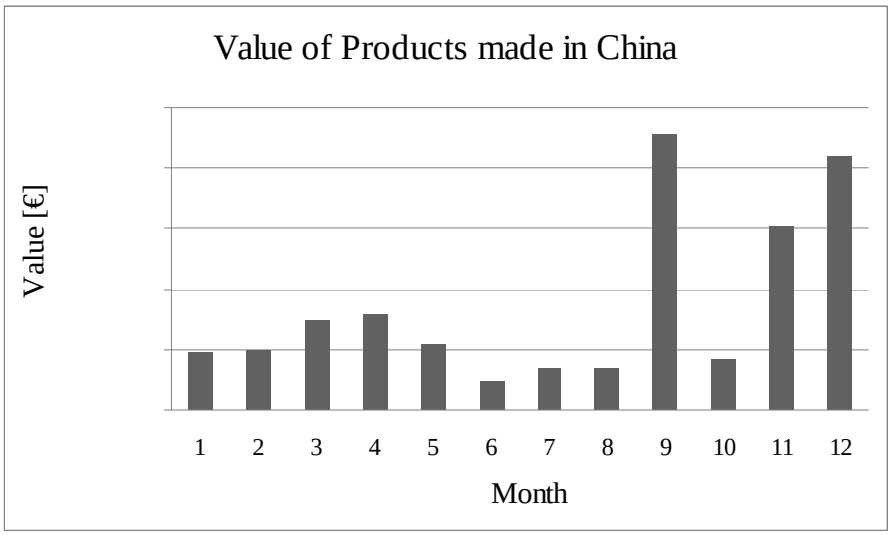

Figure 18 Value of Products Made in China in DC USA

5.2.3 Cost

Table 13 presents the items of expenditure and their values. Total cost for the USA's pipeline are XX Euros which does not include inventory carrying cost. Inventory carrying cost were XX Euros with 30 % inventory carrying cost. This chapter presents the cost without inventory carrying cost, because the one of the criterion was that tangible expenses should not increase. Case Company's management wanted to compare expenses without inventory carrying cost. Three largest items of expenditure are distribution centre operating cost, transportation from Finland to distribution centre, and transportation from distribution centre to retail. Parent Corporation charges transportation cost from distribution centre to retail from customer. Current setup is that Parent Corporation charges list price of freight carrier from customer that is more than Parent Corporation pays for a freight carrier. Transportation from Finland to distribution centre is approximation based on three approaches: numbers received from the USA, freight carrier Y's list of shipments, and calculation based on value of products. Parent Corporation charges Case Company brand for using the distribution centre. In the case of the USA, the allocation is not that clear as in the case of Europe. Office workers in the USA had done some allocation based on the usage of square foots. Contact person in the USA did not give any explanations how labour and packet material costs were calculated.

Table 13 Total Cost of the USA's As-Is Pipeline

Cost Elements	USA As-Is
Rent Income from Parent Company's Local Warehouse	-2 %
Transportation cost Hong Kong – Finland	0 %
Goods Receipt Department	0 %
Shipping Department	6 %
Selling & Distribution cost Finland	10 %
Transportation cost Finland - Distribution Centre	30 %
Transportation cost Hong Kong - Distribution Centre	10 %
Transportation cost Finland – Retail	0 %
Transportation cost DC – Retail	14 %
DC operating cost (Case Company Allocation)	32 %
Grand Total	X€

5.2.4 Environment

Result from environment analysis is an estimate of CO_2 emission generated in transportation to deliver finished goods from plants to retailers. Table 14 presents the results of environment analysis concerning the pipeline of the USA. Total CO_2 emissions for pipeline of USA are 642 tons. Case Company uses third party freight carrier who picks up the goods from Case Company's plant by diesel lorry. Then freight carrier moves goods to its terminal in Vantaa. From airfreight terminal, goods fly to USA. Customer deliveries are ground shipments in USA.

Table 14 CO_2 Emissions of Transportation in Tons for the USA's As-Is Pipeline

Transportation steps	USA as-is
Pick Up From Vantaa	0,2
Transportation HK - FINLAND	0
Transportation HK - DC	210
Transportation Finland - DC	424
Transportation DC - Retail	7
Transportation Finland - Retail	0
Total CO2 emissions in tons	642

5.3 As-Is Performance of the Small Local Warehouses

Small local warehouses do not use the common ERP system. From this reason, no delivery or customer data of sales companies that run small warehouses exist. Case Company delivers all products to small warehouses from Finland. Therefore, only delivery data from Finland to small local warehouses was available. Canada is an exception in its peer group, because it uses the common ERP system.

5.3.1 Customer Perspective

Parent Corporation's warehouse in Canada delivers orders to 182 customers. Some of the customers have multiple shipping addresses that increase the number of ship-to-parties to 259. Total number of order lines delivered from Parent Corporation's warehouse in Canada is 6381. Weighted average for order-to-goods issue time was 10 days. Weighted average was not good measure for order-to-goods issue time. This is due to heavy tail of distribution of order-to-goods issue time. Figure 19 presents the distribution of order-to-goods issue time. With this kind of distribution median is better estimate for order-to-goods issue time. Median for order-to-goods issue time was one day.

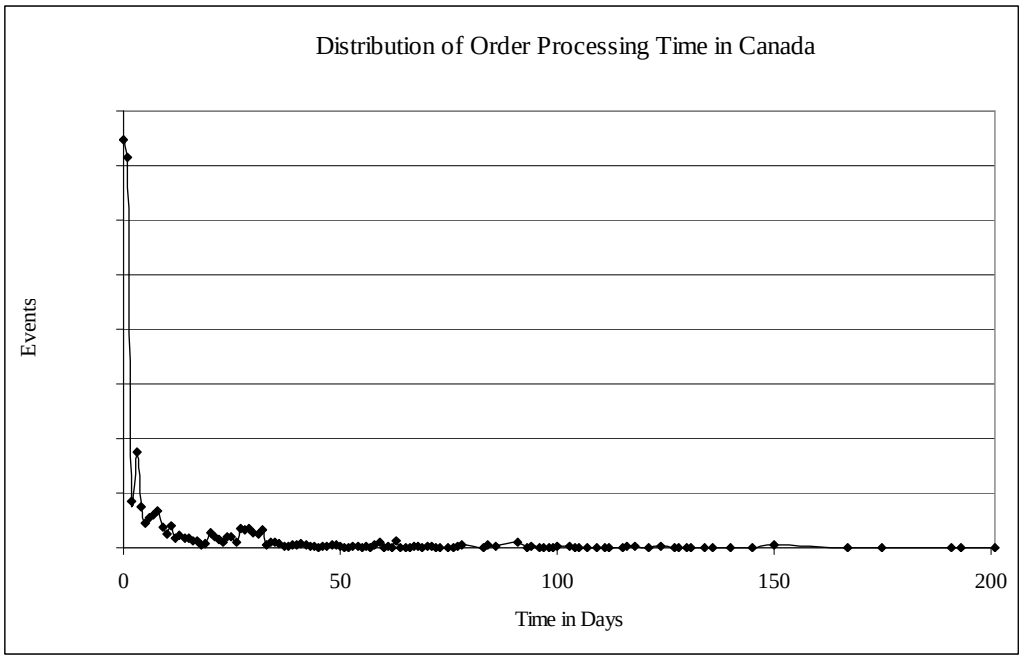

Figure 19 Distribution of Order-to-Goods Issue Time in Canada

Transport times in Canada range from 1 day to 6 days. Table 15 presents transport times, and volumes. The case is the same as it is in the USA. Customers who are located near warehouse receive their products faster than customers in remote distances do. Weighted average for transport time in Canada is around 3.2 days. Summing up the order-to-goods issue time and transport time gives a result of 4.2 days. Estimate for total order cycle time is then 4.2 days.

Table 15 As-Is Delivery Times and Number of Shipments in Canada

Delivery Time	Number of Shipments	% of total
Next day	X	27 %
Two days	X	27 %
Three days	X	1 %
Four days	X	16 %
Five days	X	3 %
Six days	X	26 %

Because the other small warehouses do not use the common ERP system order-to-goods issue times and transport times could not be calculated. Only information received concerning delivery times were that the promised delivery time to local warehouses from Finland is two weeks.

5.3.2 Inventories

Total inventory value for small local warehouses is XX Euros. Table 16 presents the inventory values for each warehouse. These values are average inventory values from year 2007. Case Company has financial information system where all local warehouses have to report every month the inventory values. (Assistant Controller Finance 28.4.2008). From small local warehouses, only total inventory values were accessible.

Table 16 Inventory Values of Small Local Warehouses in the Year 2007

Country Warehouse	Average Value
Country A	28 %
Country B	16 %
Country C	14 %
Country D	14 %
Country E	12 %
Country F	8 %
Country G	6 %
Country H	1 %
Country I	1 %
Grand Total	X€

5.3.3 Cost

Table 17 presents logistics expenses for sales companies that run local warehouse. Case Company's financial system provided the logistics expenses. Numbers are not reliable due to differences in book entries of different sales companies. (Manager, Accounting). Author asked via email the logistics expense information from sales companies presented by Table 17. Unfortunately, author did not receive any response concerning logistics expenses. In Table 17 the logistics expenses of Canada are XX Euros. According to financial Analyst of Parent Corporation the turnover of Canada is about XX Euros, inbound & customs as part of GOGS XX CAD, and warehouse & logistics XX CAD. Total amount of expenses is XX CAD which is around XX Euros. Conversion is calculated by using one Canadian Dollar is 0.62221 Euros (Exchange rate 14th of July 2008, Oanda).

Table 17 Logistics Expenses of Sales Companies

Sales Company	Logistics expenses
Country A	36 %
Country B	3 %
Country C	9 %
Country D	31 %
Country E	11 %
Country F	1 %
Country G	8 %
Grand Total	X€

5.3.4 Environment

The small local warehouse environment calculation includes two parts. First part is the calculation of CO_2 emissions for pipeline of Canada and the second is for the other small local warehouses. Calculation is in two parts because for Canada full calculation was possible while for the others CO_2 emissions for customer delivery was impossible to calculate. Table 18 presents the CO_2 emissions for pipeline of Canada. Total CO_2 emissions are 63 tons. Cost of pollution is then 1610 Euros.

Table 18 CO_2 Emissions of Transportation in Tons for Canada's As-Is Pipeline

Transportation steps	Canada as-is
Pick Up From Vantaa	0,03
Transportation HK - Finland	10
Transportation HK - DC	0
Transportation Finland - DC	52
Transportation DC - Retail	1
Transportation Finland - Retail	0
Total	63
CO2 emissions in tons	

Total CO_2 emissions generated in transport to small local warehouses is around 200 tons. Price of the pollution for 200 tons of CO_2 emissions is 5100 Euros. Table 19 presents the $C0_2$ emission in tons for all small local warehouses. Pick up from Finland and Hong Kong Finland connection is small compared to transportation between Finland and warehouse.

Table 19 CO_2 Emissions of Transportation in Tons for Others' As-Is Pipelines

Sales Company	Pick up From Finland	Transp. HK - Finland	Transp. Finland - Warehouse	Total
Country A	0,01	5,2	18	23
Country B	0,02	8,1	57	65
Country C	0,01	5,0	21	26
Country D	0,00	0,5	4	5
Country E	0,01	0,0	14	14
Country F	0,01	4,6	27	32
Country G	0,02	0,1	35	35
Total				200
CO2 emissions in tons				

5.4 Tentative Performance of Europe's Pipeline

Chapters 5.4 and 5.5 discuss about the tentative distribution model. The case in tentative model is direct retail deliveries from Finland to retailers in destination countries. This chapter discusses direct retail deliveries to European countries and next chapter discusses direct retail deliveries to the USA.

5.4.1 Customer

In Europe, there are two possible transportation modes. Case Company can use either ground deliveries or airfreight to ship products to retailers. However, ground deliveries are not an option for Case Company because if Case Company would use direct ground deliveries from Finland to European retailers, it would increase the transport time. Transport time of airfreight is one day to all-important European countries. With airfreight, Case Company can maintain the existing service level in transport time.

5.4.2 Inventories

With the "square root rule", the approximated reduction in inventory level is 25 %. In Euros 25 % decrease means XX Euros. With 30 % inventory carrying cost percentage inventory carrying cost will decrease by XX Euros. XX Euros converted in to DSI represents 5.7 days.

Considering that all cycle stock that consist of products made in Finland can be cut off and products made in China would be stored in Finland then the decrease in inventory would be XX Euros. This inventory value measured in DSI would be 5.9 days. Savings in inventory carrying cost would be XX Euros.

5.4.3 Cost

Table 20 presents the cost elements and total cost of direct retail delivery mode in Europe. Direct retail deliveries will eliminate four items of expenditure. There will be no cost of operating distribution centre, transportation from distribution centre to customer, transportation from Hong Kong to distribution centre, and transportation from Finland to distribution centre. Case Company also will not receive any rent

income from Parent Corporation's local warehouse. The rent income is internal money inside Parent Corporation, but still increases Case Company's revenues. The greatest cost expenditure will be transportation from Finland to retail. The amount of transportation cost is XX Euros. This was the best offer from freight carriers. Author asked prices for direct delivery in Europe from different three freight carriers.

Table 20 Total Cost of Europe's Tentative Pipeline

Cost Elements	Europe as-is	Europe tentative
Rent Income from Parent Company's Local Warehouse	-2 %	0 %
Transportation cost Hong Kong - Finland	0 %	3 %
Goods Receipt Department	0 %	0 %
Shipping Department	8 %	12 %
Selling & Distribution cost Finland	17 %	13 %
Transportation cost Finland - Distribution Centre	7 %	0 %
Transportation cost Hong Kong - Distribution Centre	5 %	0 %
Transportation cost Finland – Retail	0 %	72 %
Transportation cost DC – Retail	31 %	0 %
DC operating cost (Case Company Allocation)	34 %	0 %
Grand Total	X€	X€

5.4.4 Environment

Table 21 presents the steps of transportation that generate CO_2 emissions in the direct retail delivery case. Case Company transports its products from HK to Finland by using airfreight. Case Company has to use also airfreight in customer deliveries to meet the delivery time requirements. Price of one emission right for one ton of CO_2 gas was 25.5 Euros on Tuesday 7 of July 2008 (European Energy Exchange). Total amount of CO_2 emissions is 494.3 tons and the cost of pollution is near 13 000 Euros.

Table 21 CO_2 Emissions of Transportation in Tons for Europe's Tentative Pipeline

Transportation steps	Europe As-Is	Europe tentative
Pick Up From Vantaa	0	4,3
Transportation HK - FINLAND	0	210,0
Transportation HK – DC	250	0,0
Transportation Finland – DC	6	0,0
Transportation DC – Retail	23	0,0
Transportation Finland - Retail	0	280,0
Total	279	494,3
CO2 emissions in tons		

5.5 Tentative Performance of the USA's Pipeline

5.5.1 Customer Perspective

In Finland, sales personnel and shipping department process the orders in zero days as a median. This means that from the point sales personnel types order in ERP system to the time shipping department makes goods issue are zero days in half of the orders. There is no reason why in direct delivery mode the same time could be the order processing time for the USA retailers' orders. To give a précis estimate for what will be the order processing time in direct delivery mode, we have to divide the order processing time in two different times. The time sales personnel take to handle each order line and to the time used in warehouse. This was not possible because the data concerning the USA does not include all confirmation steps from order processing.

The promised finished goods transport time for direct delivery mode is 2 working days from Finland to everywhere in the United States. Because the average transport time in current mode is 3 days and order processing time is 4 days it is possible to cut off one day from transportation lead-time by using direct retail deliveries. This means that customer service will be better in direct retail delivery mode than in current mode.

5.5.2 Inventories

With the "square root rule", the approximated reduction in inventory level is 25 %. In Euros 25 % decrease means XX Euros. Case Company uses 30 % inventory

carrying cost. With 30 % inventory carrying cost percentage inventory carrying cost will decrease by XX Euros. XX Euros converted into DSI represents 5.7 days.

Considering that all cycle stock that consist of products made in Finland can be cut off and products made in China would be stored in Finland then the decrease in inventory would be XX Euros. This inventory value measured in DSI would be 7.0 days. Savings in inventory carrying cost would be XX Euros. Saving are calculated using 30 % inventory carrying cost.

5.5.3 Cost

Table 22 presents the cost elements and total cost of direct delivery mode in the USA. Direct retail deliveries will eliminate four items of expenditure. There will be no cost of operating distribution centre, transportation from distribution centre to customer, transportation from Hong Kong to distribution centre, and transportation from Finland to distribution centre. In addition, there will be no rent income from Parent Corporation's local warehouse. The greatest cost expenditure will be transportation from Finland to retail. The amount of transportation cost is XX Euros. This was the best offer from freight carriers. Parent Corporation's director of global logistics negotiated the price for direct retail delivery contract. He conducted negotiations with two different freight carriers in the USA. In the case of the USA, some expenses origin in Euros and some in the US dollars. The author conducted a sensitivity analysis against the US dollar movements. This chapter presents the sensitivity analysis below.

Table 22 Total Cost of the USA's Tentative Pipeline

Cost Elements	USA As-Is	USA tentative
Rent Income from Parent Company's Local Warehouse	-2 %	0 %
Transportation cost Hong Kong - Finland	0 %	7 %
Goods Receipt Department	0 %	0 %
Shipping Department	6 %	11 %
Selling & Distribution cost Finland	10 %	11 %
Transportation cost Finland - Distribution Centre	30 %	0 %
Transportation cost Hong Kong - Distribution Centre	10 %	0 %
Transportation cost Finland - Retail	0 %	70 %
Transportation cost DC - Retail	14 %	0 %
DC operating cost (Case Company Allocation)	32 %	0 %
Grand Total	X€	X€

When the US dollar value rises compared to EUR direct retail delivery mode becomes more lucrative. In the case, one EUR becomes one Dollar then direct delivery mode would generate 16.2 % less expenses in Euros. In the case, the US dollar value dives compared to EUR direct delivery would generate more expenses in Euros. In the case, one EUR equals 2 Dollars then direct retail delivery would generate 4.2 % less expenses than current mode. Appendix 1 presents the sensitivity analysis in more detailed level. This kind of behaviour exist in sensitivity analysis, because the amount of costs origin in Euros is greater in direct retail delivery mode than in current setup.

5.5.4 Environment

Table 23 presents the steps of transportation that generate CO_2 emissions in the direct retail delivery from Finland to retails in the USA. Case Company transports its products from HK to Finland by using airfreight. Case Company has to use also airfreight in customer deliveries to meet the delivery time requirements. Price of one emission right for one ton of CO_2 gas was 25.5 Euros on Tuesday 7 of July 2008 (European Energy Exchange). Total amount of CO_2 emissions is 1540 tons and the cost of pollution is around 39 000 Euros.

Table 23 CO_2 Emissions of Transportation in Tons for the USA's Tentative Pipeline

Transportation steps	USA as-is	USA tentative
Pick Up From Vantaa	0,2	0,3
Transportation HK - FINLAND	0	120
Transportation HK – DC	210	0
Transportation Finland - DC	424	0
Transportation DC - Retail	7	0
Transportation Finland - Retail	0	1540
Total	642	1660
CO2 emissions in tons		

5.6 Tentative Performance of Small Local Warehouses

For Canada, proposed transport time for direct retail delivery was 2 days anywhere in Canada. Transportation costs for Canada's tentative pipeline would be XX Euros. The tentative environment analysis abuts to Canada. New source of pollution is transportation from Finland to retail. Table 24 presents the summary of CO_2 analysis. Total amount of CO_2 emission in tentative mode are around 100 tons. Total amount of CO_2 emissions is 100 tons and the cost of pollution is around 2550 Euros using price of one emission right.

Table 24 CO_2 Emissions of Transportation in Tons for Canada's Tentative Pipeline

Transportation steps	Canada as-is	Canada tentative
Pick Up From Vantaa	0,03	0,3
Transportation HK - Finland	10	10
Transportation HK - DC	0	0
Transportation Finland - DC	52	0
Transportation DC - Retail	1	0
Transportation Finland - Retail	0	89
Total	63	100
CO2 emissions in tons		

5.7 Conclusion of Performance Analyses

Customer analyses point out that direct retail deliveries are feasible in Europe, USA, and Canada. For other small warehouses, not enough reliable data was available to make decision about direct retail deliveries. Inventory analyses show to us that Case Company can reduces inventories by using direct retail deliveries. In this light, direct retail deliveries are feasible solution for Case Company. Cost analyses state that Europe is not feasible and the USA is. In the case of Europe, total logistics costs

increase, and in the case of the USA, total logistics costs decrease. Data concerning small local warehouse is inadequate to give any suggestion of their feasibility. Environment analyses show to us that use of direct retail deliveries will increase the CO_2 emissions. CO_2 emissions will increase because Case Company has to use airfreight instead of ground freight.

Based on the four factors this thesis proposes direct retail deliveries to USA. Case Company should also consider Europe. Other small warehouses need more research to make reliable decisions. Figure 20 presents the to-be distribution network for Case Company.

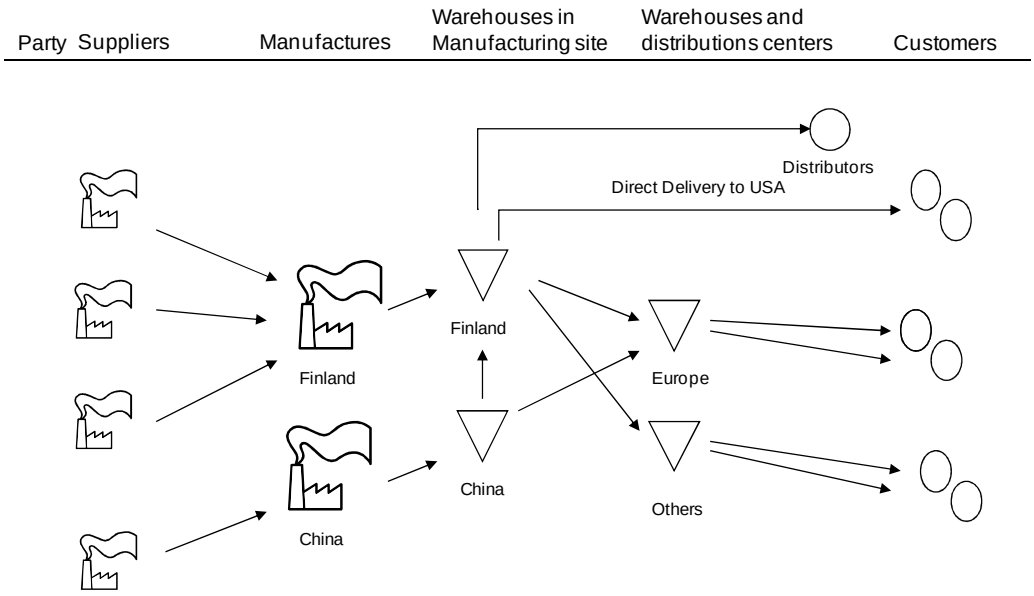

Figure 20 Proposed To-Be Distribution Network

In the to-be distribution network distributors, Europe, and others continue to function as they are. With the USA, Case Company starts using direct retail deliveries. Table 25 presents high-level cost comparison between as-is state and to-be state for Case Company's distribution network. As-is cost of pollution includes pollution cost from Europe, the USA, and Others. To-be state is combination of Europe and Others' as-is states and the USA's tentative state. Inventory carrying cost includes inventories from Finland, Europe, and the USA. The as-is state it is the sum of the inventory levels of these inventories and in to-bee state it is the 'square root rule' estimation of these same three inventories. Logistics costs are calculated from the total cost tables

presented earlier. As-is state includes Europe and the USA's as-is states and to-be state includes the as-is states of Europe and tentative state of the USA. If Case Company implements proposed to-be distribution network, expected cost savings are XX€ per year.

Table 25 Comparison of Case Company's As-Is and To-Be Physical Distribution Networks

Cost Element	As-Is	To-Be
Cost of Pollution	1 %	2 %
Inventory Carry Cost	35 %	33 %
Logistics Cost	65 %	65 %
Total	X€	X€

PART III: DISCUSSION AND CONCLUSIONS

6 DISCUSSION

This chapter discusses of issues that emerged during the research, but are not results asked in research objectives. Chapter 6 ponders some fundamental differences between the USA and Europe, then it discusses challenges related to implementation of proposed to-be distribution network, and finally discusses of reliability and validity of the research.

6.1 Differences between USA and Europe

Geographical location of market area has great impact on delivery time. Finland time zone is GMT plus two hours. The USA time zone varies GMT -5 to -10 hours. This is one reason why it is possible to ship packets from Finland in one or two days to the USA. Another nice feature of the time difference is that when people sell in USA, people sleep in Finland. This means that Case Company's packers know the workload for the coming day early in the morning. This way Case Company can define capacity requirements for shipping department to meet some certain time when all packages have to be ready. In Europe Case Company's markets live the same day with Case Company. Time difference is plus one hour, but this is not enough to give same kind of time advantage as in the case of USA. Companies around the world need to consider time difference when designing global direct retail delivery systems.

One issue that emerged during the discussion over freight carriers was the custom procedures. In Europe it is easy to deliver packets from Finland to anywhere inside the EU, because there exist no complex custom procedures. In the case when Case Company ships packets outside EU, the goods need to be declared. To avoid any delays in deliveries freight carrier must start the declaring process already when goods are in transport (Director, Global Logistic 22.5.2008).

In the current mode, distribution pipelines in Europe and the USA contain Case Company's HQ, Parent Corporation's DC, and customer. In the direct retail delivery mode the pipelines are the same expect freight carrier's terminals replace Parent

Corporation's distribution centres. The difference between Europe and the USA is the transportation mode used between Case Company's HQ and Parent Corporation's DC. In the as-is state products travel from Case Company's HQ to DC Europe by truck and ferry and to USA products travel by plane. In direct retail delivery mode, products will fly from Case Company's HQ to freight carrier's terminals. Therefore, in the case of Europe transportation mode has to change and in the case of the USA transportation mode remains the same. From this reason, transportation costs increase more in the case of Europe compared to the case of the USA, and this results in that Europe is not feasible in cost wise and USA is. This shows that the structure of the system has impact on the current and future performance.

6.2 Challenges in Implementation

During the research several things emerged, that consider the implementation of direct retail deliveries and not the study of optimal distribution network. The greatest impact of direct retail deliveries will be in shipping department. Case Company has engineered the shipping department in a way that it is optimal for shipping large size shipments to distribution centres, local warehouses, and distributors. Figure 21 presents the weight profile of shipments from the DC USA in the year 2007. The weight profile shows that the typical shipment is small less than two kilos. Therefore Case Company has to reengineer the shipping department in order to meet the new requirements that different shipments sizes place. In the year 2007, the shipping department delivered around 4000 shipments. In the proposed model the number of shipments will be something around 34 000 shipments annually. (Analysis of delivery data).

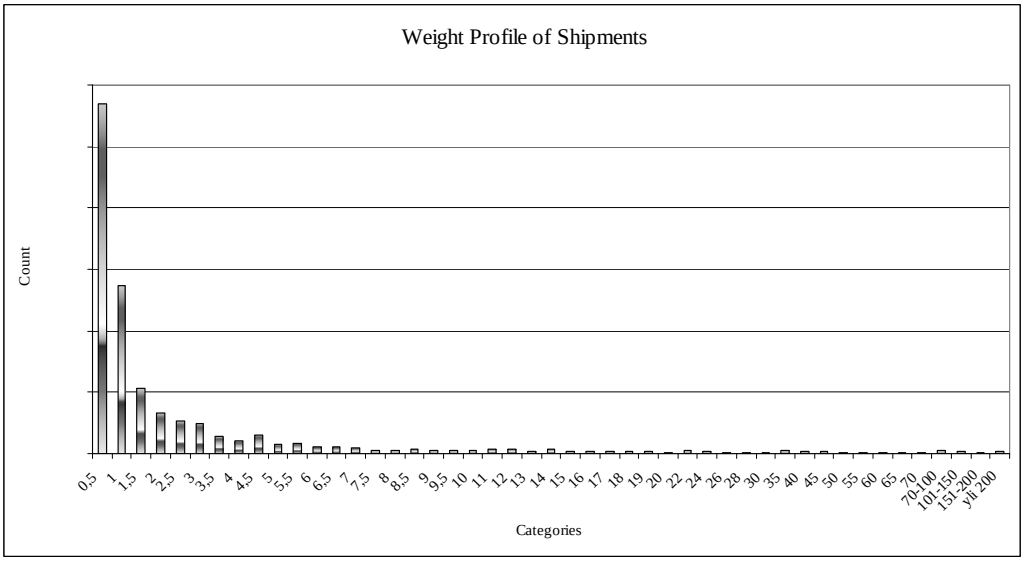

Figure 21 Weight Profile of Shipments out of DC USA

To have 30 000 shipments more annually it means two packers in shipping department have to focus solely on shipments to the USA. In a year, there are about 200 workdays. This means 150 shipments for each day. 6 hours is approximately the efficient work time in shipping department (Manager, Business Process Development). This means that there is 2.4 minutes for each delivery. Other issues related to shipping department are space requirements and new packing materials. These three issues were part of the shipping department cost estimation.

In the proposed to-be distribution strategy, the amount of Chinese products will increase in Finland. This will increase the work of goods receipt department. When the amount of products coming in and going out increase drastically, Case Company has to streamline the goods receiving processes. Now the process is everything else than smooth. Case Company has to reengineer the processes of receiving goods and storing them in a way that workers in shipping department can efficiently pick the goods from storage.

Other issues are information system integration with freight carrier, invoicing process with the USA's sales company, pro form invoices to customs, and custom codes. Currently the accounting manager makes invoices to the USA's sales company manually. This process has to be automated, because there will be ca. 30

000 invoices annually. Customs will require pro form invoices and custom codes for smooth operation.

When IT consults make the integration of information systems, Case Company should ask if it is possible to receive customer reception date from freight carrier's system. This way Case Company could really measure the performance of the supply chain. This kind of integration of information systems will enable Case Company to measure total order cycle time.

6.3 Reliability and Validity

According Yin (1990:40-41), evaluation of reliability and validity is an integral part of any academic research. Reliability means that if some other researcher repeated the study in completely same way the results and conclusion should be the same. The goal of reliability is to minimize the errors and biases in a study. (Yin, 1990:45).This thesis report documents in detail the actions taken during the research, presents the collected data and data sources. Thus, it is possible for other researcher to repeat the study in exactly same way. One method to evaluate reliability of the study is to evaluate the data sources and analysis (yin, 1990:45). The data collected truthfully presents the actual business situation. However it is good to remember that analysis based on historical data do not exactly represent the future. Interviews of course may include errors caused by various reasons. Author was working during the research in Case Company that enabled to review issues that look biased. This behaviour minimizes bias in interviews. If some other researcher would repeat the study thoroughly, the same core data would most likely to be found. This indicates that the study is reliable. However, before we can truly say is the study reliable some other person has to conduct this research.

Yin (1990) identifies three types of validity construct validity, internal validity and external validity. Construct validity refers to use of correct operational measures for the concept in focus. Internal validity evaluates explanatory and causal studies. External validity refers to the extent results of the research can be generalized. (Yin, 1990:40-41). This research builds construct validity by using large amount of selected references from literature. This research builds the internal validity by using existing theory and quantitative analysis or existing theory and qualitative analysis.

Case Company has evaluated the results of the research and decided to implement the propositions of the research. The external validity in a case study is always questionable. In this research, it is however obvious that changes in costs, inventory levels, and pollution cannot be generalized to other companies or industries. However, other researchers can use the framework this research proposes to analyse other companies.

7 CONCLUSION

7.1 Main Results of the Study

The research problem was to find out the optimal distribution network for Case Company. This research divides the main research problem into five sub research questions in order to answer the main research problem. The sub research questions were

- What is the right supply chain strategy for Case Company?
- What is the appropriate physical distribution strategy for Case Company?
- What are the appropriate supply chain performance measures for Case Company?
- What are the criteria for performance measures for Case Company?
- What are the performances of as-is and to-be physical distribution networks for Case Company?

In order to answer the research questions and solve main research problem framework for devising optimal physical distribution network was developed. Case Company was analysed using the developed framework. Based on the results this research gives a proposal for optimal physical distribution network.

The findings of empirical part show that a company, whose products' demand patterns are unpredictable and supply chain requires agile and flexible performance, direct retail deliveries can be lucrative choice, when considering physical distribution structure. Depending on the as-is state of physical distribution there is possibility to

shorten total order cycle time and cut inventory levels. When managers consider company's visibility to customer the physical distance may not be any more the case but the time how rapidly company serves its customer. This research shows that Case Company can be nearer to customer in time when the location of distribution centre is further. Direct retail delivery is possible to implement without increasing logistics cost. Direct retail deliveries will increase the costs of pollution, because companies need to resort more airfreight to meet the customer requirements.

7.2 Theoretical and Practical Contribution of the Research

Su (2007) claims that global direct deliveries increase effectiveness and efficiency of supply chain. Company that deploys global direct delivery benefits from lower inventory and faster customer response time. The results of this research are similar to findings Su (2007) points in his article. This research's theoretical contribution is that it strengthens Su (2007) findings.

Representative of Case Company's management team accepted the proposal for new distribution network of this research. Case Company will implement the proposed construction in fall 2008. Case Company's decision to implement construction of the research means that construction has passed the weak market test. This implies that this research has real practical contribution.

7.3 Future Research

Suggestion for future research topics continue and complement the work started in this thesis. First, it would be very interesting to analyse companies similar to Case Company and compare these results to results gained in this research. Cross checking the result with other cases would give us valuable knowledge of reliability of the research. Then studies could be expanded to other industries. This would give us more information of what type of distribution system suits for different products.

Future research could also focus on issues emerged during this research. As this report shows, shipping department requires major changes to meet the new requirements. How to reengineer shipping department to be efficient simultaneously with small and large size shipments would stand for good future research area.

8 REFERENCES

Academic Literature:

Beamon, M; 1999. Measuring supply chain performance. International Journal of Production Management, Vol. 19, No. 3, pp. 275-291

Bower, J.L.; Hout, T.M.; 1988. Fast cycle capability for competitive power. Harvard Business Review, Nov. 1, pp. 110-118

Bowersox, Donald J.; Closs David J.; (1996) Logistic Management: The Integrated Supply Chain Process. McGraw-Hill , Singapore.

Christopher, Martin; 1998. Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service. Pitman Publishing, London.

Christopher, Martin; 2000. The Agile Supply Chain: Competing in Volatile Markets. Industrial Marketing Management, Vol. 29, No.1, pp. 37-44

Christopher, Martin; Towill, Dennis; 2002. Developing Market Specific Supply Chain Strategies. The International Journal of Physical Distribution and Logistics Management, Vol. 31, No. 4, pp. 235-246

Cohen, Morris; Cull, Carl; Lee, Hau; Willen, Don; 2000. Saturn's Supply-Chain Innovation: High Value in After-Sales Service. Sloan Management Review, Vol. 41, No. 4, pp. 93-101

Drucker, Peter; 1954. Practise of Management. Harper, New York (NY).

Eccles, Robert; Pyburn, Philip; 1992. Creating a Comprehensive System to Measure Performance. Management Accounting, Vol. 72, No. 4, pp. 41-44

Eisenhardt M.; 1989. Building Theories from Case Study Research. Academy of Management Review Vol. 14, No. 4. pp. 532-550

Epstein, M.J.; Manzoni, J.F.; 1997. The balanced Scorecard and Tableau de Bord: Translating strategy into action. Management Accounting (US) Vol. 79, No. 2, pp. 28-36

Feitzinger, Edward; Lee, Hau; 1997. Mass Customization at Hewlett-Packard: The Power of Postponement. Harvard Business Review, Vol. 75, No. 1, pp. 116-121.

Fisher, Marshall; 1997. What is the Right Supply Chain for Your Product? Harvard Business Review, Vol. 75, No. 2, pp. 105-116

Goldsby, Thomas; Griffis, Stanley; Roath, Anthony; 2006. Modelling Lean Agile, and Leagile Supply Chain Strategies. Journal of Business Logistics, Vol. 27, No. 1, pp. 57-80

Gunasekaran, A.; Patel, C.; MCGaughney, R.; 2004. A Framework for Supply Chain Performance Measurement. Internal Journal of Production Economics, Vol. 87, No. 3, pp. 333-347

Handfield, Robert; Nichols, Ernest; 1999. Introduction to Supply Chain Management. New Jersey, Prentice Hall.

Holmberg, Stefan; 2000. A Systems Perspective on Supply Chain Measurements. International Journal of Physical Distribution & Logistics Management, Vol. 30, No. 10, pp. 847-868

Jick, Todd; 1979. Mixing Qualitative and Quantitative Methods: Triangulation in Action. Administrative Science Quarterly Vol. 24

Kaplan, R.S.; Norton, P.D.; 1992. The balanced scorecard measures that drives performance. Harvard Business Review, Vol. 70, No. 1, pp. 71–79

Kasanen, Eero; Lukka, Kari; Siitonen, Arto; 1993. The Constructive Approach in Management Accounting Research. Journal of Management Accounting Research Vol.5, No. Fall, pp. 94-102

Keeber, James; Manrodt, Karl; Durtsche, David; Ledyard, D.; 1999. Keeping Score: Measuring the Business Value of Logistics in the Supply Chain. Council of Logistics Management, Oak Brook.

Koskenvuo, Ville; 2005. Master's Thesis: Designing and Managing Demand-Supply Network in Sports Equipment Industry. Helsinki University of Technology, Espoo.

Kärkkäinen, Mikko; Ala-Risku, Timo; Holmström, Jan; 2003. Increasing Customer Value and Decreasing Distribution Costs with Merge-in-Transit. International Journal of Physical Distribution & Logistics Management, Vol. 33, No. 2, pp. 132-148

Lambert, Douglas; Stock, James; 1993. Strategic Logistics Management. Irwin, Boston.

Lambert, Douglas; Pohlen, T.L; 2001. Supply Chain Metrics. International Journal of Logistics Management, Vol. 12, No. 1, pp. 1-19

LIPASTO is a calculation system for traffic exhaust emissions and energy consumption in Finland. Available at http://lipasto.vtt.fi/indexe.htm. Last accessed 15th July 2008.

Lee, H.L., Billington, C., 1992. Managing supply chain inventory: Pitfalls and opportunities. Sloan Management Review Vol. 33, No. 3, pp. 65–73.

Maskell, B.H., 1991. Performance Measurement for World Class Manufacturing. Productivity Press, Inc., Portland, OR.

Mason-Jones, Rachel; Naylor, Ben; and Danny Berry; 1997. Engineering the Leagile Supply Chain. International Journal of Agile Management Systems, Vol. 2, No. 1, pp. 55-61

McAfee, Andres; Brynjolfsson, Erik; 2008. Investing in the IT That Makes a Competitive Difference. Harvard Business Review, Vol. 86, No. 7/8, pp. 98-107

Morgan, Chris; 2004. Structure, speed and salience: performance measurement in the supply chain. Business Process Management Journal, Vol. 10 No. 5, pp. 522-536

Murray, Elpsbeth; Richardson, Peter; 2002. The Critical Few: First Among Equals as parameters of strategic effectiveness, in Business Performance Measurement. Cambridge University Press, Cambridge.

Naylor, J.; Naim, Mohammed; Berry, Danny; 1997. Leagility: Integrating the Lean and Agile Manufacturing Paradigms in the Total Supply Chain. MASTS working

paper No.47, Republished in International Journal of Production Economics 1999, Vol. 62, pp. 107-118

Neely, A.D.; 2002. Business Performance Measurement: Theory and Practice. Cambridge University press, Cambridge

Neely, A.D.; Gregory, M.J.; Platts, K.W.; 1995. Performance Measurement Systems design. International Journal of Operations & Production Management, Vol. 15 No. 4, pp. 80-116

Neely, A.D.; 2007. The Search for Meaningful Measures. Management Service, Vol. 51, No. 2, pp. 14-17

Neilimo, Kari; Näsi, Juha; 1980. Nomoottinen tutkimusote ja suomalainen yrityksen taloustiede: Tutkimus positivismin soveltamisesta. Tampere, Yrityksen taloustieteen ha yksityisoikeuden laitoksen julkaisuja. Sarja A 2: Tutkielmia ja Raportteja 12

Persson, F.; Olhager, J.; 2002. "Performance simulation of supply chain design", International Journal of Production Economics, Vol. 77, No.3, pp. 231-245

Presutti, D.; Mawhinney, R.; 2007. The Supply Chain-Finance Link. Supply Chain Management Review, September.

Simchi-Levi, D.; Kaminsky, P.; Simchi-Levi, E. 2000 Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies. McGraw-Hill, New York, NY.

Srivastava SK., 2007. Green supply-chain management: A state-of-the-art literature review, International Journal of Management Reviews. Vol. 9, No. 1, pp. 53-80

Stewart, G., 1995. Supply chain performance benchmarking study reveals keys to supply chain excellence. Logistics Information Management Vol. 8, No. 2, pp. 38–44

Su, Shong-Iee; 2007. The Emerging Global Direct Distribution Business Model: Industry and Research Opportunities. Transportation Journal, Vol. 46, No. 4, pp. 58-65

Voorhis, Kenneth; 1981. The DuPont Model Revisited: A Simplified Application to Small Business. Journal of Small Business Management, Vol. 19, No. 2, pp. 45-51

Vorst, Jack; Tromp, Seth; Zee, D.; 2007. Simulation modelling for food supply chain network redesign; Integrated decision making on product quality, sustainability and logistics. working paper.

Wilkerson, T. (2005). Can One Green Deliver Another? Harvard Business School Publishing Corporation (available at: http://www.supplychainstrategy.org/).

Yin, R.; 1990. Case Study Research Design and Methods. United States of America, Sage publications.

Zinn, Walter; Bowersox, Donald; 1988. Planning Physical Distribution with the Principle of Postponement. Journal of Business Logistics, Vol. 9, No. 2, pp. 117-136

Other Material:

Bureau Veritas Finland.
http://www.bureauveritas.fi/wps/wcm/connect/bv_fi/Local/Home/bv_com_serviceSheetDetails?serviceSheetID=6840&siteID=36&industryID=12&serviceCategoryID=-1&preciseObjectID=-1&divisionID=-1&businessScopeID=-1
Last Accessed 15th July 2008

Department of Industrial Engineering and Management: Master's Thesis Guide. Available at
http://www.tuta.hut.fi/studies/undergraduates_diem/Elektroninen_julkaisu/Valm.ohj_31.8.2007.pdf
Last accessed 11th July 2008

European Energy Exchange's web page. Accessed for checking the price for one emission right for CO_2 ton.
http://www.eex.com/en/
Last accessed 9th July 2008

Oanda's web page. Accessed for checking currency exchange rates.
http://oanda.com
Last accessed 10th July 2008

Supply-Chain Council (SCC); 2008. SCOR 9.0 Overview Booklet. Available at
http://www.supply-chain.org/cs/root/scor_tools_resources/scor_model/scor_model
Last accessed 9th July 2008.

Case Company Order Line Data 2007.1.1-2007.12.31

Case Company Delivery Data 2007.1.1-2007.12.31

Case Company Presentation: Supply & Manufacturing Strategy

Case Company Financial Data (Inventory levels 2006-2007, GOGS 2006-2007)

Case Company Product Catalogue 2008

Case Company Sales Planning Reports

Parent Corporation Annual Report 2007

Parent Corporation's freight contracts in Europe

Parent Corporation's freight contracts in Europe

Case Company Interviews:

Manager, Business Process Development 7.1.2008

Manager, Accounting 28.1.2008

Manager, Sales Planning and Customer Service 28.2.2008

Coordinator, Sales (areas: countries in South East Asia, Australia, New Zealand, China) 28.2.2008

Coordinator, Sales (areas: Japan, Mexico, Brazil, Russia, Israel, Turkey, Slovakia, Argentina, Cyprus, Greece, Hungary, Bulgaria, Egypt) 28.2.2008

Coordinator, Sales (USA, Canada, Malta) 28.2.2008

Manager, Commodity 29.4.2008

Foreman, Shipping Department 5.5.2008

Manager, Warehouse 2.6.2008

Financial Analyst, Parent Corporation Spring 2008

Parent Corporation Interviews:

Controller, Finance Europe 28.1.2008

Vice President, Supply Chain Development 31.3.2008

Director, Global Logistics 22.5.2008

APPENDIX 1

Cost Elements	1 EUR = 1 USD Case Usa Current	1 EUR = 1 USD Case USA Direct	1 EUR = 2 USD Case Usa Current	1 EUR = 2 USD Case USA Direct	Cost Origins
Rent Income from Parent Company's Local Warehouse	-1 %	0 %	-2 %	0 %	EUR
Transportation cost Hong Kong - Finland	0 %	6 %	0 %	10 %	EUR
Goods Receipt Department	0 %	0 %	0 %	0 %	EUR
Shipping Department	4 %	9 %	9 %	15 %	EUR
Selling & Distribution cost Finland	7 %	8 %	14 %	15 %	EUR
Transportation cost Finland - Distribution Center	31 %	0 %	28 %	0 %	USD
Transportation cost Hong Kong - Distribution Center	10 %	0 %	9 %	0 %	USD
Transportation cost Finland - Retail	0 %	0 %	0 %	0 %	USD
Transportation cost DC - Retail	15 %	0 %	13 %	0 %	USD
DC operating cost (Case Company Allocation)	34 %	0 %	30 %	0 %	USD
Total	X€	X€	X€	X€	
Change		-16,2 %		-4,2 %	