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Master's Thesis

Riku Aalto

Logistics Cost Optimization of Road Freight Shipments in a Consumer Goods Company

Examiner: Associate professor Petri Niemi

Instructors: Associate professor Petri Niemi, Richard Lindroos

ABSTRACT

Author: Riku Aalto
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In the industry of the case company, transportation and warehousing costs account for more than 10% of the total cost which is more than on average. A Finnish company has an understanding that by sending larger shipments in parcels, they could save tens of thousands of euros annually in freight costs in Finland's domestic shipments. To achieve these savings and optimize total logistics cost, company's interest is to find out which is the cost efficient way of shipping road shipments of certain volumes; in parcel boxes or on pallets, and what should be the split volume determining the shipment type. Distribution center (DC) costs affect this decision and therefore they need to be also evaluated to determine the total logistics cost savings.

Main results were achieved by executing activity-based costing-calculations including DC and road freight costs to determine the ideal split volume with which the total logistics cost is optimal. Calculations were done for Finland's DC, separately for two main road freight destinations, Finland and Sweden, which cover 50% of road shipment spend. Data for calculations was collected both manually and automatically from various internal and external sources, such as the company ERP system and logistics service providers' (LSP) reporting. DC processes were studied in practice and compared to model processes. Currently used freight rates were compared to existing pricing models and freight service tendering process was evaluated by participating in the process and comparing it to the models based on literature.

The results show that the potential savings are not as significant as the company hoped for, mainly because of packing work increasing DC labor cost. Annual savings by setting ideal split volume per country would account for 0,4 % of the warehousing and transportation costs of shipments in scope of this thesis. Split volume should be set separately for each route, mainly because the pricing model for road freight is different in each country. For some routes bigger parcels should be sent but for some routes pallets should be used more. Next step is to do these calculations for remaining routes to determine total savings potential. Other findings show that the processes in the DC are designed well and the company could achieve savings by executing tenders more efficiently. Company should also pay more attention to parcel pricing and packing the shipments accordingly.

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Eräällä kansainvälisesti toimivalla suomalaisella yrityksellä on näkemys, että se voisi säästää rahtikustannuksissa vuositasolla kymmeniä tuhansia euroja maantielähetyksissä Suomessa. Tämä säästö saavutettaisiin lähettämällä enemmän lähetyksiä paketteina lavalähetysten sijaan. Päätös lähettää joko paketteina tai lavoina perustuu lähetyksen laskennalliseen tilavuuteen. Yrityksen tavoitteena on selvittää, mikä tämän tilavuusrajan tulisi olla optimitilanteessa, jossa rahtikustannuksien lisäksi huomioon otetaan pakettilähetysten määrän lisäämisen vaikutus jakelukeskuksen työ-, materiaali- ja tilakustannuksiin. Käytännössä tämä tarkoittaa sen tilavuusrajan määrittämistä, jossa lavalähetyksen kokonaislogistiikkakustannukset ovat pakettilähetyksen vastaavia pienemmät.

Eri lähetystapojen kokonaiskustannukset laskettiin hyödyntäen toimintolaskentamenetelmää. Nämä laskelmat laadittiin Suomen jakelukeskuksesta lähteville toimituksille erikseen eri reiteille, koska jo projektin alkuvaiheessa havaittiin, että määränpäällä on suuri merkitys kustannuksiin. Määränpäämaat ovat Suomi ja Ruotsi, jotka kattavat 50 % kaikista lähetyksistä. Data laskelmia varten kerättiin useasta yrityksen sisäisestä lähteestä, sekä kuljetusyrityksiltä ja ulkopuolisen palveluntarjoajan raportointityökalusta. Laskelmien lisäksi jakelukeskuksen prosessit arvioitiin ja yrityksen kilpailutusprosessista tehtiin huomioita ja kehitysehdotuksia. Nämä vaikuttavat myös logistiikan kustannuksiin ja laskelmiin.

Päätuloksina todetaan, että mahdolliset vuosisäästöt jäävät pienemmiksi kuin yritys oli olettanut, johtuen pääosin pakkaustyön lisäyksestä. Asettamalla rajat laskelmien mukaan, yritys saavuttaisi 0,4 % vuosisäästöt tämän työn lähetysten jakelukeskuksen ja rahtauksen kustannuksissa. Tilavuusraja tulee määrittää erikseen jokaiselle reitille. Rajan nostaminen ei ole itsestään selvää, sillä joillain reiteillä pakettilähetyksiä tulee lisätä, mutta toisilla reiteillä vähentää. Yrityksen tulee laatia laskelmat myös muille reiteille, jotta kokonaissäästöpotentiaali saadaan määritettyä. Säästöt riippuvat hyvin pitkälti reittikohtaisista eroista, kuten pakettikuljetusten hinnoittelusta. Muina havaintoina jakelukeskuksen toimintojen todetaan olevan riittävissä määrin optimoituja. Sen sijaan yrityksen tulisi panostaa entistä enemmän rahtipalvelujen kilpailutukseen. Lisäksi huomiota tulisi kiinnittää rahdin hinnoitteluun ja toiminnan muokkaukseen tämän mukaan.

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Helsinki, 9th of November 2015

Riku Aalto

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

3PL	Third-Party Logistics
ABC	Activity-Based Costing
B2B	Business-to-Business
B2C	Business-to-Consumer
DC	Distribution Center
COGS	Cost of Goods Sold
ERP	Enterprise Resource Planning
FSC	Fuel Surcharge
FTL	Full Truckload
KPI	Key Performance Indicator
LSP	Logistics Service Provider
LTL	Less than Truckload
RFI	Request for Information
RFQ	Request for Quotation
SKU	Stock Keeping Unit
SOP	Standard Operating Procedure

1 INTRODUCTION

Introduction chapter presents the background of the thesis. Main objectives and targets for the project are discussed along with the scope of the project and its limitations. Chapter also includes the description of the project execution with different project phases. Report structure is explained in the end of the chapter.

1.1 Background

Because of globalization and longer and more complex supply chain, logistics plays a more critical role in developing a successful supply chain. Total logistics cost has become one of the most important economic indicators of supply chain efficiency. (Zeng & Rossetti 2003) The costs included in logistics activities are: transportation, warehousing, order processing/customer service, administration, and inventory holding (capital) costs. (Lambert et al. 2006, Zeng & Rossetti 2003)

In Finnish industrial and commercial companies, logistics costs have been rather stable during the last ten years, accounting for 12-14% of companies' total costs. Transportation costs are the biggest single logistics cost element with 4,4% of total cost on average. (Solakivi et al. 2014, p. 15, Swenseth & Godfrey 2002) Along with warehousing costs, they account for 60-70% of logistics cost and almost 8% of total cost. (Solakivi et al. 2014, p. 15) The logistics costs' share of total costs during last ten years in Finnish companies is presented in figure 1.

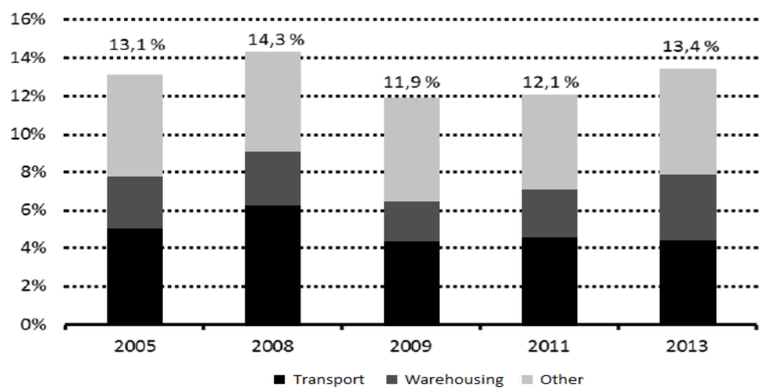

Figure 1. Logistics costs in Finland. (Solakivi et al. 2014, p. 15)

On the other hand, in the major business areas of the case company, the logistics costs can be as high as 15 % of total costs. In these companies the transportation and warehousing costs account for more than 10% of the total costs. (Salanne et al. 2005, p. 17) When logistics costs share is that big part of total costs, it is necessary to evaluate logistic processes and their cost efficiency. Optimizing the processes and costs related to warehousing and transporting goods is the key to better logistics cost efficiency. Especially the activities related to outbound logistics, which account for a major part of warehouse and transportation costs, have to be examined. This thesis project takes a closer look in one individual case in the case company's supply chain and examines ways of optimizing total logistics cost through solving this problem and optimizing the costs related to it.

The case company (later the Company) has an understanding that just by increasing the share of parcel shipments it could save up to tens of thousands of euros in domestic shipments' freight costs per year. This could be achieved by sending larger shipments through parcel network instead of using palletized shipments. These evaluations however haven't taken into account the added costs in distribution center functions which are caused because of extra work, package materials and facilities needed. This lack of wider perspective is one of the problems in the Company. Reducing costs from another activity can add costs to the other and therefore it is important that all the calculations and development actions are viewed from total logistics cost –point-of-view, keeping in mind the costs related to warehousing and transportation.

1.2 Objectives and Scope

To achieve the cost savings, the Company's main practical interest is to figure out which is the cost efficient way of shipping shipments of certain volumes; in parcel boxes or pallets. Currently a rule of thumb is used; if the combined volume of shipment is over 0,2 m^3 then it is shipped as a pallet shipment and under 0,2 m^3 shipments are shipped in parcel boxes. This 0,2 m^3 is the current split volume which "splits" the shipments in two categories: parcels and pallets. Split volume is currently based on the freight rates and estimated distribution center costs. Making the decision to change this split volume must be based on better understanding of the underlying costs, which is why this project was initially launched. Optimization of split volume leads to savings in logistics costs.

Research questions are set for making the research problems and setting of the objectives concrete and easier to understand. Research questions consist of the main research questions (RQ1 & RQ2) which are answered by presenting the final results of the project, and help questions (RQ3, RQ4 and RQ5) which are answered on the way to the final results with the help of theoretical study. Research questions for the thesis project are set as follows:

Main research questions:

RQ1: *What is a cost efficient and practical way of delivering road freight shipments and what are the realistic cost savings with it?*

RQ2: *What should be the split volume limit in the distribution center?*

Help research questions:

RQ3: *What are the problems in current way of doing things?*

RQ4: *How could the Company affect logistics costs (freight rates and DC costs)?*

RQ5: *Which costs should be included in the analysis?*

The purpose of this thesis is to offer an in-depth analysis on the key elements that affect the choice of the split volume, cost of shipping goods and make development suggestions based on this analysis. The goal is to analyze the costs from a wide perspective which takes into account more than just one view of the costs. This means not only thinking about the mentioned freight costs but also the different costs caused by the distribution center functions. Theoretical framework is used as a base for evaluating the company procedures and offering the "backbone" for the thesis. Activity-based costing is used as a tool for evaluating costs, because it is an understandable way of recognizing the costs behind different activities related to road freight shipments. The main themes and actions can be summarized:

- DC processes studied in practice and compared to model processes from literature.
- Current, used freight rates evaluated and compared to pricing models available (especially parcel shipments).
- Freight service tender process evaluated by participating in the process and comparing to the "ideal" process based on literature (main point is to understand effect of the tender to the freight rates).
- ABC -calculation including DC and freight costs to determine the ideal split volume.

The scope of the thesis is part of the supply chain, including the main outbound processes in the distribution center (picking and packing) and the transportation costs (freight costs). In the scope are road freight shipments which are shipped from the Company's main distribution center in Finland to main destination countries: Finland and Sweden. Together these countries cover 50% of the total road freight spend in this DC. Remaining 50% is divided to approximately 50 other destination countries. The scope of the thesis is presented in the figure 2.

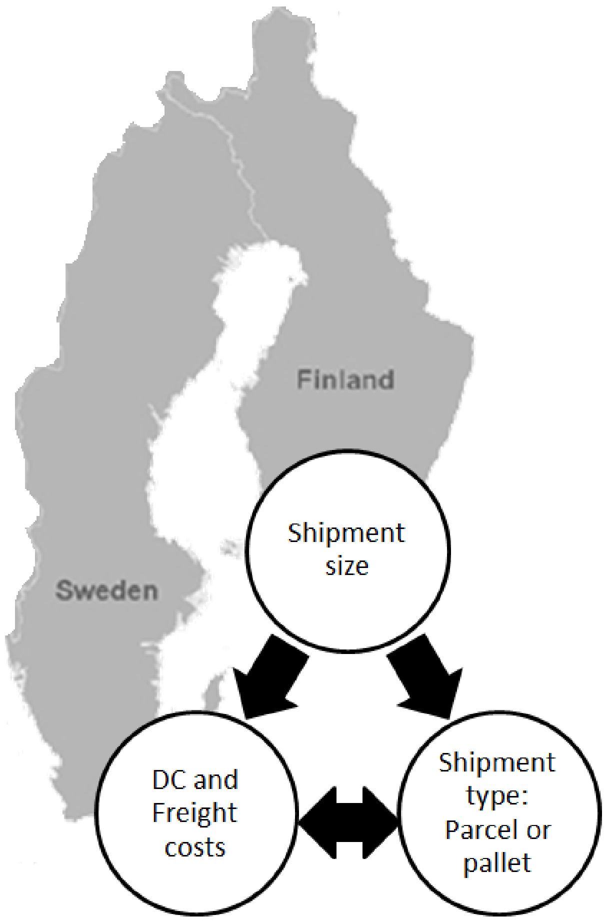

Figure 2. Scope of the thesis.

1.3 Thesis Project

Thesis project started in the end of May 2015. Before that there had been discussion with the Company about possible project topics and the timetable. Project was set to last 5,5 months from the end of May until the beginning of November 2015 and the topic was given by the Company supervisor. Thesis was done as a full-time employee of the company.

Project was carried out in the following phases:

1. Setting the scope for the project and understanding the background.
2. Getting to know the company and its culture and ways of working.

3. Getting to know the processes related to the thesis and collecting data about the processes.
4. Collecting quantitative data and making calculations about the current state.
5. Collecting and studying theoretical background material.
6. Presenting the development actions and results based on calculation, analysis and theoretical background.
7. Thinking possible future research related to the topic.

Writing of the report began immediately from the beginning of the project and continued as process writing during the whole project. Report was finalized after the project in the company was finished.

Main data for the calculations and analysis is quantitative, statistical data. Quantitative research is based on numerical information which is collected by statistical methods to be used as a tool in empirical study. (Töttö 2000, p. 33) Quantitative data used in the project included cost and spend data, data regarding the process efficiency, freight price rates, shipment volume data and different labor hour data. Data was collected for 12 months' time period (the calendar year 2014) from various sources: the Company's own ERP –system, distribution center's own manually collected data, data provided by the logistics service providers (LSPs) and data stored in a 3rd party reporting tool.

Descriptions of the DC processes and the tender process were done by following the DC workers as a by-stander, interviewing the DC manager and foremen and by participating in the tender process and making observations. Other observations and normal, everyday communication regarding the thesis project can also be seen as a part of the thesis research.

1.4 Structure of the Report

Report begins with the introduction of the project topic by presenting the background of the project, setting the objectives, research questions and scope for the project and presenting the project phases and research methodology. Introduction chapter is meant to give the reader an overview of the thesis project and define the desired results of it.

Chapters 2-5 are the theoretical part of the thesis. These chapters present the theoretical framework related to the thesis and explain the key concepts of the main topics. Theoretical background is used to evaluate the empirical findings and to compare the Company's procedures to the ideal ones presented in articles, books and webpages. Main theories that are discussed are related to distribution center functions, freight pricing, tendering and activity -based costing.

Empirical part of the thesis is discussed in chapters 6-9. Data and information collected during the project is presented, compared to literature and applied based on the theory. Analysis of current state is discussed along with some findings of possible development actions.

Chapters 9 and 10 are the ones where the results of the project are presented. Method and background of activity-based costing calculations and results of the calculations are presented in chapter 9. Chapter 10 gathers together all findings presented in the report and discusses also possible future actions and additional research to be done. These chapters are the core of the thesis project and answer to the research questions set in the beginning of the project. Chapter 11 is a short summary of the whole project, its findings and results. Structure of the thesis report is presented as an “input-output” –chart in the table 1.

Table 1. Structure of the thesis report.

CHAPTER	CHAPTER TYPE	INPUT	OUTPUT
1. Introduction	General	Task given by the company, scope and limitations.	Overview & background of the topic and the thesis project.
2. Warehouses & distribution	Theory	Literature	Key theories and concepts for chapter 7.
3. Road Freight Transportation	Theory	Literature	Key theories and concepts for chapter 8.
4. Tendering	Theory	Literature	Key theories and concepts for chapter 8.
5. Activity-Based Costing	Theory	Literature	Calculation model for chapter 9.
6. Case Company & Supply Chain	Application	Data & information from the company.	Presenting the company and its supply chain.
7. Distribution Center	Application	Data & information from the company, ERP and interviews. Key theories presented in chapter 2.	Presenting the DC activities and addressing the current state of DC processes based on data and theoretical background.
8. Freight Cost Optimization	Application	Data & information from the company ERP and LSPs. Key theories presented in chapters 3 and 4.	Analysis of current pricing models used and the tendering process of the company. Development actions discussed based on literature.
9. ABC-analysis	Application/ Results	Data gathered during the project. Application of the theories from chapter 5.	Calculations for determining the total cost for both shipment types and for setting the optimal split volumes.
10. Results	Results	Analysis done in chapters 6-10.	Results, findings and actions needed. Future study.
11. Summary	General	Chapters 1-10.	Summary of the thesis project.

2 WAREHOUSES & DISTRIBUTION

In this thesis the environment is a distribution center, so it is natural to go through the main concepts and terms relating to warehouses in general and distribution centers in more detail. In this chapter the necessary theoretical background is presented and explained. Main topics are the functions and activities in warehouses and order picking methods.

2.1 Warehouses in Supply Chain

Warehouses are critical in building a successful supply chain. The basic mission of the warehouse is to store the product and ship it to the next step in the supply chain. But as the technologies and economies develop, the old way of thinking warehouses as a place to store goods and shorten lead times is not comprehensive enough. Information technology and physical distribution of goods walk hand in hand but if one of them is not working well, the whole supply chain will not be optimized and will not work with full efficiency. (Tompkins et al. 2003, pp. 403-404) According to Lambert et al. (2006) warehouses exist for following purposes:

- Achieve transportation economies (e.g. combine shipment, full-container load).
- Achieve production economies (e.g. make-to-stock production policy).
- Take advantage of quantity purchase discounts and forward buys.
- Maintain a source of supply.
- Support the firm’s customer service policies.
- Meet changing market conditions and again uncertainties (e.g. seasonality)
- Overcome the time and space differences between producers and customers.
- Accomplish least total cost logistics commensurate with a desired level of customer service.
- Support the just-in-time programs of suppliers and customers.

- Provide customers with a mix of products instead of a single product on each order (consolidation).
- Provide temporary storage of material to be disposed or recycled
- Provide a buffer location for trans-shipments (cross-docking).

Warehouses can be divided in different types, based on their main function in the supply chain (figure 3). These are raw material warehouses, work-in-progress warehouses, finished good warehouses, fulfillment warehouses, local warehouses, value added service warehouses and distribution centers/warehouses. Warehouse as a term is not identical with distribution center (DC). Warehouse is the more generic term. (Frazelle 2002, p. 2)

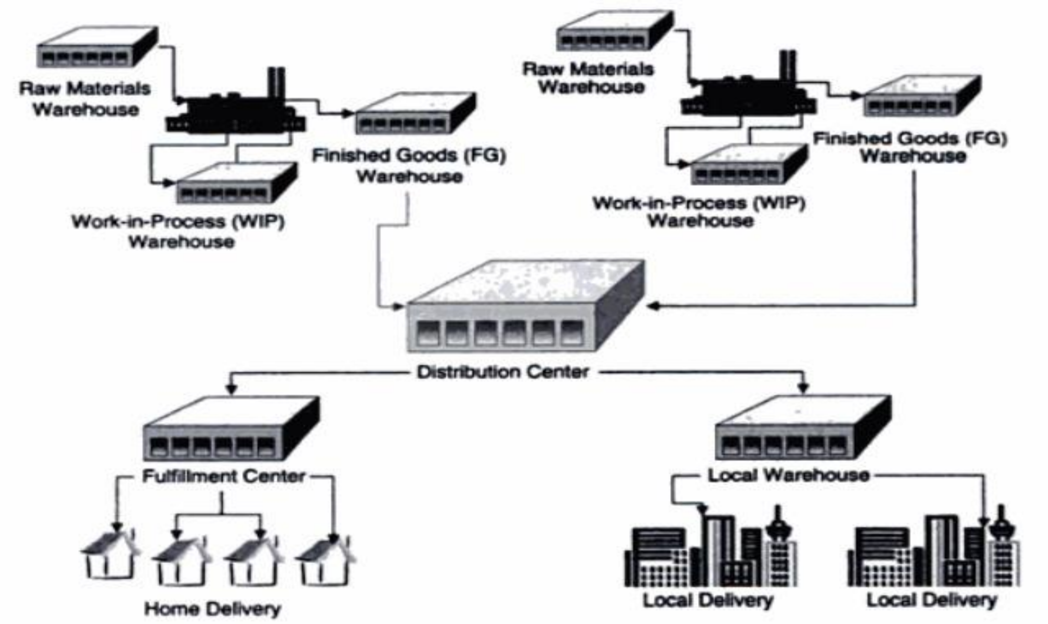

Figure 3. Warehouse types. (Frazelle 2002, p. 2)

In this thesis the focus is on the distribution center -type of warehouse. DCs gather and consolidate products from different manufacturing points and combine these to shipments for the final customers. The location of a DC is usually central in relation with the production location or the customers. Products are moved in to the DC on larger units (full trucks, pallets) and out as a smaller units (pallets, parcel boxes, cartons). (Frazelle 2002, pp. 2-3) According to Lambert et al.

(2006), the main differences between a “normal” warehouse and a distribution center are: Warehouses hold all products, when DCs hold minimum inventories of high demand products. On the other hand warehouses perform minimum of value-added services, when DCs perform a lot of value-added activities. DCs collect data in real-time, but in warehouses data is collected on batches

Two of the basic distribution models are point-to-point distribution and hub-and-spoke distribution. These have certain benefits and negative attributes which are discussed in the following section. Distribution models are presented in the figure 4. With m vendors and n stores (point-to-point) the transportation consists of m times n direct shipments, each usually small and likely to have higher, less-than-truckload rates. Hub-and-spoke distribution model gets its name from the bicycle wheel of one center hub and spokes connected to the hub. With using a hub there are only m + n shipments through a distribution center or cross-docking. Each shipment is larger and has lower, full-truckload rates. (Bartholdi et al. 2011, p. 7) A hub acts as a distribution center to hold large inventories for a region it is responsible for. This hub is connected to nodes, which serve the local factories/customers. The main driver behind this model is to be able to serve customer with short lead times and be able to respond to varying customer needs when there are clear business regions. Hub-and-spoke –model is efficient especially, when the goods are not transported by air freight but by using road transportation. (Weiskott 1999)

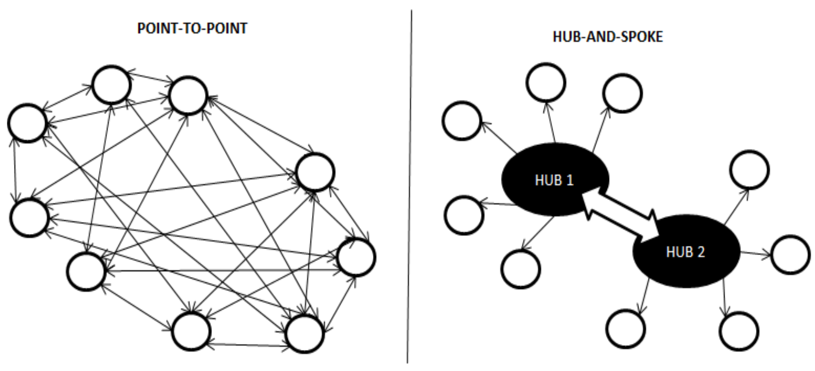

Figure 4. Basic distribution models. (Bartholdi et al. 2011, p. 7)

2.2 Warehouse Functions

Warehouses have three main functions: movement, storage and information transfer functions. (Lambert et al. 2006, p. 236) The movement function includes all the physical movement of goods in the warehouse area. According to De Koster et al. (2007) the main movement activities are:

- Receiving
- Transfer and put away
- Order picking
- Sorting
- Cross-docking
- Shipping

Receiving includes the activities of unloading the goods from the carrier and moving them inside the warehouse or to the designated place outside the warehouse. Inspection of received goods and updating the data to the system of the warehouse are also part of receiving. Transfer and put away means transferring the goods to their storage locations and it can include also repackaging of pallets to cartons for example. These activities are also known as inbound activities. (De Koster et al. 2007)

Order picking is in practice collecting the right amount of product/s according to the order from a customer. This is the most time consuming and studied activity in the warehouse, which is examined in more detail in the following chapters. If the warehouse uses batch picking then the orders have to be sorted. Cross-docking means moving goods straight from receiving to shipping, without put away and picking activities. Shipping is an activity of loading the goods onto a carrier to begin transporting them. These activities are known as outbound activities. (De Koster et al. 2007) Figure 5 presents the warehouse movement functions according to Tompkins et al. (2003)

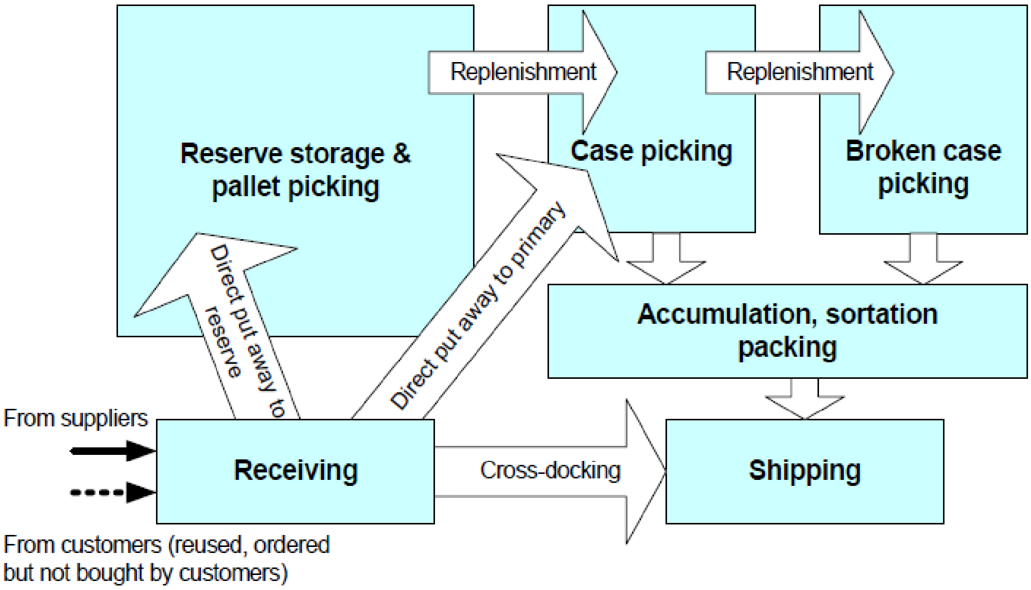

Figure 5. Warehouse movement functions. (Tompkins et al. 2003, p. 405)

Tompkins et al. (2003) explain that the storage function is literally storing the products before they are shipped to customers. Products can be storage in different units and forms which depend on the size, quantity and the product itself. Also the way in which the products are handled affects the form of storage. Usually products are stored in pallets or cartons as well as bigger units such as containers. The basic storage strategies include random storage, dedicated storage, class-based storage, and duration-of-stay based storage. (Gu et al. 2007) Commonly used storage method is class-based storage. In this method the stock keeping units (SKUs) are divided into classes based on their popularity and speed of movement. There are many ways of deciding the classes but in a popular version the fastest moving class accounts for 80 % of turnover but includes only 20% of the products. Often the goods are put in three classes: A, B and C. Classes can be determined by the demand of the products, pick volume or other suitable way. Each class is assigned to certain area in the warehouse. The fastest moving class (A) is situated so that the travel time and the time spent in order picking are as short as possible. (De Koster et al. 2007)

Third function of warehousing is information transfer. It happens at the same time with the movement and storage functions and it means keeping track of inventory levels, SKUs, SKU locations, customer data, shipment data etc. Information transfer plays a vital role in organizing and planning the warehouse activities and operations but also optimizing the whole supply chain. (De Koster et al. 2007)

2.3 Order Picking

One of the most common ways of optimizing the warehouse operations is by improving the order picking operations. Order picking is a vital part of warehouse success, warehouses are usually designed based on the picking system and supply chain requirements are driving companies to develop their order picking solutions. (Tompkins et al. 2003, pp. 403-405) Order picking is the most labor intensive and costly activity in the warehouse, the cost of order picking can be 55 % of the total operating expenses. Therefore any underperformance in order picking leads to high costs and affects the supply chain efficiency and order picking systems should be optimally designed and controlled. (De Koster et al. 2007)

Order picking (or just picking) includes the activities of scheduling the customer orders, assigning SKU locations to order lines, picking the SKUs from their locations according to orders and delivering the picked goods to the next step in the outbound process. Customer orders are created by order lines and each order line accounts for a desired quantity of certain SKU. (De Koster et al. 2007)

There are different picking systems depending on the characteristics of a warehouse. There can also be multiple picking systems in use within one warehouse. (De Koster et al. 2007) Different picking systems and their classification based on the usage of humans or machines and the method of picking are presented in figure 6.

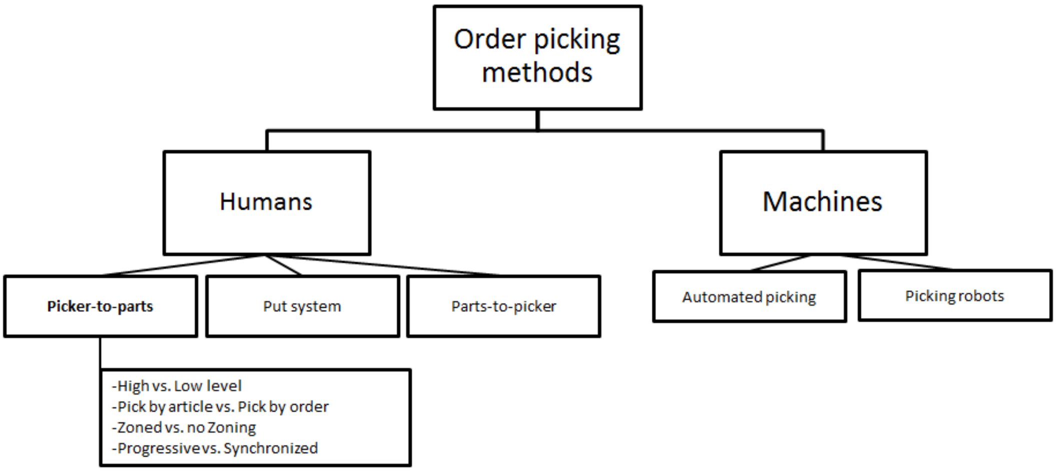

Figure 6. Order-picking methods (De Koster 2004)

Human employee picking is still the most common method of order picking. Discussion of robot picking is excluded from this thesis. Human picking methods can be divided into three categories based on how the goods are picked: picker-to-parts, put and parts-to-picker systems. (De Koster 2004)

Picker-to-parts is the most traditional method. In this methods picker walks or drives a fork lift (or equivalent) along the aisles of the warehouses and stops at the correct storage locations to pick orders. The two types of picker-to-parts picking are low and high level picking. In low level picking the picker takes goods from storage pallets or bins which are located on the floor. In high level picking the goods are picked from high level storage racks/pallets with the help of a crane which automatically stops at correct locations. (De Koster et al. 2007)

Parts-to-picker systems need automatic storage and retrieval systems that retrieve storage units (pallets, bins) and automatically transfer them to the pick position. There the picker picks correct amount of goods according to the customer order and the system takes the unit load back to its storage location. The automatic system usually uses automated cranes. (De Koster et al. 2007)

Put systems are systems are a combination of retrieving and distribution activities. Larger units of goods, not only one customer order, are first picked by using the parts-to-picker or picker-to-parts method. Then they are transferred to a picker who distributes (“puts”) them to different customers’ shipments (cartons or pallets). Put systems are popular when there is a little time for picking multiple shipments, for example in Amazon -web shop’s distribution center. (De Koster et al. 2007)

Even though the technology is advancing, low-level, picker-to-parts order-picking systems employing humans (and with multiple picks per route) systems form large majority of picking systems in warehouses worldwide. According to De Koster et al . (2007) over 80% of all order-picking systems in Western Europe are this type.

Figure 6 also shows other variants of picker-to-parts method. Most used version of picking is picking by order which means picking a full customer order in one picking assignment. The opposite of this is picking in batches (also known as picking by article). Batch picking means that the goods are picked for multiple customers at the same time based on the goods on the orders i.e. customers with similar orders are picked at the same time. In between these there are many ways of combining batch picking and sorting (sort-while-picking and pick-and-sort). (De Koster et al. 2007)

Another variant besides batching is zoning. Zoning means that the storage area is divided in multiple parts (zones) that each has different pickers. Each picker is in charge of picking their share of the complete order which reduces the need of travelling. In progressive zoning the picker must wait the previous picker to finish his task before beginning his own. Synchronized zoning (or wave zoning) is a system where the pickers start their picking task simultaneously and the order is combined after everyone has picked their part. Zoning is usually combined with batch picking. In practice zoning is in use according to the products properties such as size, weight and safety requirements. (De Koster et al. 2007)

Routing can be used as a mean of reducing travel times between picks. Six examples of routing methods are presented in the figure 7. These methods are: S-shape, return, mid-point, largest gap, combined and optimal. All the presented routing methods were developed for single-block warehouses but they can be used also for multiple-block warehouses with some modifications. (Roodbergen 2001)

The simplest model for routing is the S-shape. Picker travels through every aisle where there is a pick location and aisles without pick are not entered. The picker returns to the depot after completing the last aisle with a pick location. Return-method is also a simple one: the picker enters only aisles with a pick but doesn't go all the way to the other end of the aisle. The picker turns back from the furthest pick location on the aisle and returns to cross aisle. (De Koster et al. 2007)

In the midpoint method the aisles are divided in two areas. The aisles are entered from both cross aisles and the picks are made without crossing the midpoint (see figure 7). This method is more efficient than S-shape when there are only one or two picks per aisle. (De Koster et al. 2007)

The largest gap method is quite similar to midpoint method but the picker goes to the aisle as far as the largest gap within an aisle, instead of the midpoint. The gap is the difference in distance between any two adjacent picks, between the first pick and the front aisle, or between the last pick and the back aisle. If the largest gap is between two adjacent picks, the order picker returns from both ends of the aisle. Otherwise, a return route from either the front or back aisle is used (see figure 6 for clarification). The largest gap in each aisle is the part of the aisle that the order picker does not travel. (De Koster et al. 2007)

The largest gap method is always more efficient than the midpoint method but the midpoint method is simpler to implement. In the combined model, aisles with picks are either entirely travelled or entered and left at the same end. (De Koster et al. 2007)

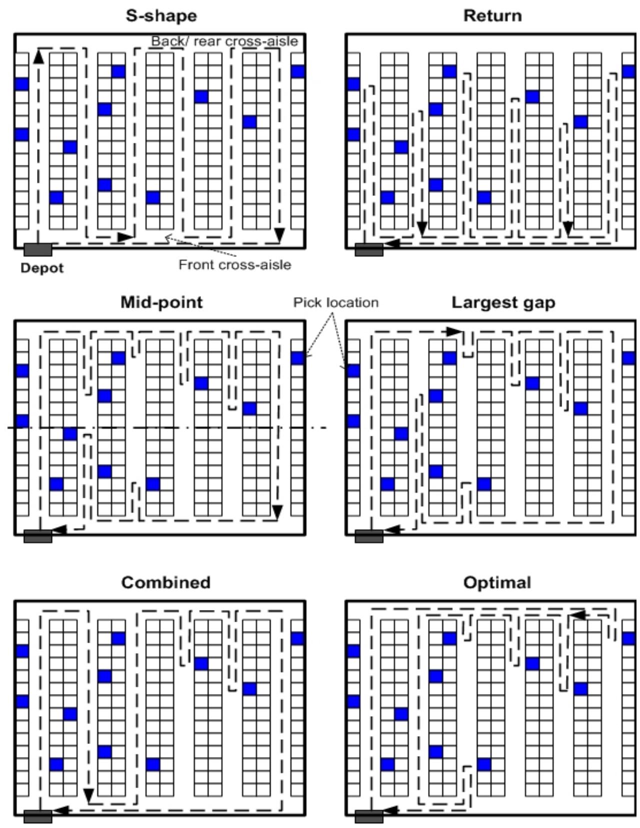

Figure 7. Different routing methods. (Roodbergen 2001)

The main objective of developing order picking systems is to maximize the service level with efficient use of resources such as employees, machines and capital. (Goetschalckx & Ashayeri 1989) Order picking links to the service level through the time used for picking: the faster the order can be picked, more likely it will ready for shipping at the planned date and time. Inefficient picking can lead to situations where the shipment misses it carrier and service level is not met (De Koster et al. 2007)

Short picking time allows also sudden changes in the orders if needed. Minimizing the order picking time is the major part of reducing warehouse costs and creating an efficient supply chain. (De Koster et al. 2007) Tompkins et al. (2003) point out that the main part of picking time in typical picker-to-parts system is in fact physical travelling to the storage locations (figure 8).

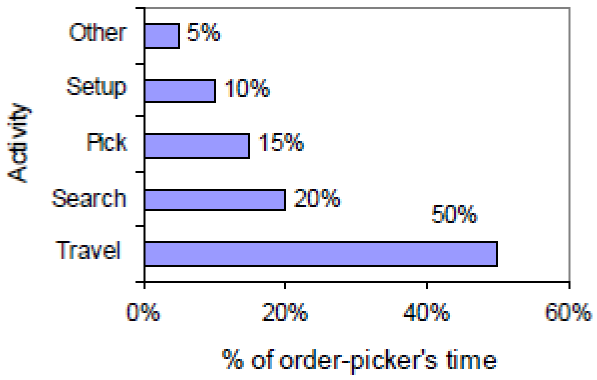

Figure 8. Picker's time usage. (Tompkins et al. 2003)

According to Bartholdi et al (2011) “travel time is waste. It costs labor hours but does not add value. It is, therefore, a first candidate for improvement.” This leads to conclusion that choosing the correct picking system with adequate batching, zoning and routing solutions leads to the desired warehouse environment which is supporting the development of the whole supply chain.

3 ROAD FREIGHT TRANSPORTATION

The goal of this thesis is to optimize the costs related to road freight shipments. Therefore it is important to understand the common concepts of road freight transportation but also the pricing logic and existing pricing models for road freight shipments.

3.1 Road Freight

Freight transportation is an important part of the economy, because it is a supportive function for production, trade, and consumption activities by ensuring the movement and availability of raw materials and products. For this reason, freight costs represent a significant part of the total cost of a product. (Crainic 2000) From all transportation modes, road transportation is the major transportation type in Finland (table 2). Measured in haulage (ton kilometers) or volume (million tonnes) it accounts for bigger share than the other modes combined. One tkm means shipping thousand kg's for a distance of one kilometer. Road freight shipments are the most important part of the whole transportation system and the most common way of shipping goods. Circa 90 % of the goods are shipped with trucks, vans and cars. This includes also the road shipments as a part of other transportation modes' pre- and after -transportation. Road transportation is easier and more efficient compared to other modes and enables door-to-door –shipping. Finland's geographically scattered structure addresses road transportation's role even more**.**

Table 2. Freight transportation in Finland 2004. (Salanne et al. 2005, p. 18)

Transportation mode	Haulage		Freight volume	
	Tkm	%	Mtonnes	%
Road	***27 800***	***68 %***	***393,2***	***88 %***
Railroad	10 000	25 %	43,5	10 %
Water	2 900	7 %	9,1	2 %
Total	40 700	100 %	445,8	100 %

Logistics service providers (LSP) are the logistics companies who handle the transportation of the goods, when the transportation is not done by the buyer or supplier. Synonyms for LSP are carrier, transport company, forwarding company and third-party logistics provider (3PL). In addition to transportation, LSPs can offer services for example in warehousing and order administration. (Fabbe-Costes et al. 2009)

Road transport can be divided in pre- carriage, line hauls, on-carriage, and transfers. Pre -carriage means the first phase of transport where the goods are transported from the shipper to a terminal, port or airport to be transported forward as line haul freight. Line haul is the “core” transport where the goods are moved between two ports, airports, distribution centers or warehouses. On -carriage means delivering the goods to the consignee, the party that has ordered the goods. Transfers are shipments which are transported inside the same organization. (Karrus 2001, pp. 261-262, Mäkelä et al. 2005, pp. 37- 38)

Full Truckload (FTL) means that all the goods filling a whole truck are part of the same shipment. FTL is transported from the shipper to consignee as it is. FTLs are used in large volume traffic between DCs and also in large deliveries from suppliers to DCs and other warehouses. Less-than Truckload (LTL) is a shipment that doesn’t cover the whole freight space in the truck. For economic and ecological reasons multiple LTL shipments with similar destinations are combined together to create as full trucks as possible. Groupage means shipping goods on mixed pallets (different customers on same pallets) through terminal network. LTL and groupage are used for shipping goods to mainly B2B but also to some consumers.

One shipment consists of one or multiple transport units. Units are used for achieving economies of scale when handling larger units of products instead of sales units. Unit can be for example a pallet, roll cage or a parcel box/carton (figure 9). Pallets are widely used units which are also standardized according to different needs. EU-pallet (800 mm * 1200 mm) is the most common pallet type.

Pallets make the handling of products easier for example for fork lifts. (Mäkinen et al. 1992, pp. 328-332)

Cartons/parcel boxes can be used as a part of pallet shipment, but they also create their own subcategory of shipment type. In parcel shipments, cartons are used for shipping smaller amounts (smaller than pallet) of goods through parcel network. One parcel shipment can consist of one or multiple cartons.

Figure 9. Parcel and pallet.

3.2 Freight Pricing & Rates

The decision of using pallets (FTL/LTL/Groupage) or parcels has a big effect on the price rates. Since the pallets and parcels are priced differently it is necessary to evaluate, which kind of shipments should be shipped in pallets and which in parcels. According to Haapanen & Oksanen (1986) and Swenseth & Godfrey (2002), the price for a road freight shipment is usually based on time/distance, freight weight, added services and fuel surcharge. These are all taken into account but the final rates are based on negotiated contracts between the carrier and shipper. Relationship of the two parties, things like customer classification (if one or another sees the partner as a strategical partner etc.) and freight volume can decrease the prices significantly. (Özkaya et al. 2010)

Because of globalization and increasing competition, the freight rates are decreasing while the shipping weight is increasing. FTL shipments are usually priced on a basis of distance travelled and €/truck. The LTL rates are stated €/ 100 kg, and the other factors affecting the rates are the same that were mentioned before: the contract, origin and destination locations etc. (Haapanen & Oksanen 1986, pp. 219-222, Swenseth & Godfrey 2002, Özkaya et al. 2010) It is common that when the price indicated in €/100 kg or €/shipment, the price varies according to the weight band. When speaking of pricing by weight band, it means that if price is stated e.g. 30 €/shipment for 100-200 kg (chargeable weight), the price for 120 kg and 198 kg shipments is the same. The price is then different for shipments of other weight, usually the price is relatively cheaper when the volume or weight increases.

Parcel shipments have multiple ways of pricing depending on the LSP and the type of goods that are transported. Traditionally the pricing has been based on the real weight of the parcel box and the transportation distance or destination. Usually the price is set per weight band and per carton. Setting the base price for a carton and then add price by €/kg (or €/100 g) according to weight is also quite common. One shipment can include multiple cartons, especially in B2B and large consumer shipments, and therefore it is also justified to price the shipment per total weight and number of cartons. Some pricing models don’t take into account the weight at all but only the number of cartons and the price is set €/carton. When there are so many ways of pricing parcels, the buyer has to have a good understanding of its parcel shipment’s structure, so it can request correct pricing models from LSPs. Most common pricing methods for each transport type is presented in the table 3.

Table 3. Typical pricing of road freight.

	FTL	LTL	Groupage	Parcel
Pricing	€/truck	€/100 kg	€/shipment	€/kg €/shipment €/shipment + €/kg €/carton €/carton + €/kg

Chargeable weight is the weight that is used for calculating the price of the shipment. Traditionally the chargeable weight has been the real weight of the shipment. Recently it has become more and more common to use a chargeable weight that is based on how much room the shipment is taking from the truck, instead of its real weight. This is done by LSPs to better cover the costs caused by light but large shipments (low density shipments) that take a lot of room. There are multiple ways for calculating the chargeable weight: pallet weight, loading meter weight or dimensional weight. Pallet weight and loading meter weight are used in pallet freight transportation and dimensional weight in both pallet and parcel shipments. Even if the chargeable weight differs from the real weight, the real weight of the shipment needs to be informed to the LSP for calculating the weight load on the truck and its axis.

Pallet weight can be used as chargeable weight when you can’t load goods on top or under a pallet. Pallet weight is different for different pallet types but for example FIN -pallets it is standardized as 925 kg/pallet. This means that each shipped FIN -pallet is charged based on the freight rate of 925 kg shipment even if the pallet and the goods on it weigh less. (Posti Oy 2015a)

Loading meter is used as a chargeable weight when the shipment takes the whole width and height of the freight space in the carrier. For example, when using FIN-pallets, each meter that the shipment covers, is charged by the weight of two FIN –pallets, 1850 kg. (Posti Oy 2015a) Loading meter weight can vary according to the LSP.

Dimensional weight (volumetric weight or DIM weight) is a calculation of a theoretical weight of a package by measuring the volume of the package by multiplying the largest dimensions of the package's length, width and height (in centimeters). This volume is then divided by a dimensional weight factor which represents the minimum density chosen by the LSP. Dimensional weight can be also calculated by multiplying the package volume with factor of x kg/ m^3. (Huang & Chi 2006). If the dimensional weight is bigger than real weight, it is used as chargeable weight. The use of dimensional weight targets the lighter, larger boxes that take up more space with less weight or density (Boyd et al. 2006)

The volume that is used for calculating the dimensional weight of a shipment is not always the real volume. In the cases when the package is not cubic, the volume used for determining the dimensional weight is measured by the largest dimensions. This means that the product/package is seen taking the space of a parcel box of its dimensions.

Dimensional weight factors vary according to the shipment type and LSP. For example in pallet shipments as the density of one pallet (and as the dimensional weight factor) 333 kg/m^3 (Posti Oy 2015a) is commonly used when it is possible to load goods on top of or under the pallet The dimensional weight is set as the true volume multiplied by 333 kg/m^3. (Posti Oy 2015a)

In parcel shipments the dimensional weight factor is usually 5000 (DHL Express 2015, UPS 2015) or 4000 (Posti Oy 2015b). Other way around , this means that the theoretical density of the package is 200 kg/m^3 (DHL Express 2015, UPS 2015) or 250 kg/m^3 (Posti Oy 2015b) . This means that the parcel shipments are considered not as dense as pallet shipments, which is because of empty space and protective materials in parcels that add a lot of volume but little weight.

Dimensional weight as chargeable weight is being used more and more by the transportation industry worldwide. Previously dimensional weight was only use for parcels of certain size but in these days the chargeable weight will be determined by greater of the actual weight and dimensional weight a package in all parcel sizes by many LSPs. (Boyd et al. 2006)

4 TENDERING

In the context of this thesis it is important to evaluate the tendering and RFx processes' effect on the freight rates, which are recognized as the other main part of the logistics cost with DC costs. The strategic procurement and tendering processes are presented step-by-step to give a clear picture of an ideal process. In later chapters this process is used as a reference in comparison with the Company's own tendering process.

4.1 Tendering Process

The way of finding best suppliers and achieving competitive prices is through strategic procurement and tendering**.** An essential part of the process is the RFX phase. Same basic strategic procurement process is used for freight service tendering as for product tendering. The simplified process with main process steps is presented in figure 10.

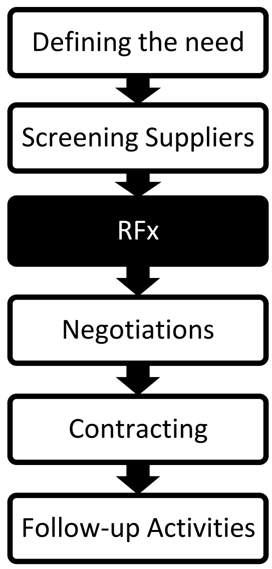

Figure 10. Strategic procurement process. (Adapted from Iloranta & Pajunen-Muhonen 2012)

Defining the need means that the company has to evaluate based on its strategy and make-buy decisions, if it needs new suppliers. Also part of defining the need is to start thinking of requirements for suppliers: whether there is need for multiple suppliers, which kind of supplier is preferred (small, big, specialized etc.) After these evaluations the company has a picture of what it wants, where and how. (Iloranta & Pajunen-Muhonen 2012, p. 251) Next step is to start screening the potential suppliers who meet the set requirements. The information is gathered of potential suppliers through own experience, supplier databases, exhibitions, networks and other sources. (Iloranta & Pajunen-Muhonen 2012, pp. 255-257)

Next process step is essential: the RFxs. In these phases the chosen suppliers are asked to provide desired information and prices. The main RFx phases include Request For Information (RFI) and Request For Quotation (RFQ). (Iloranta & Pajunen-Muhonen 2012, pp. 258-260, 272) Request for Information is used to gather relevant information to decide which suppliers would be chosen to proceed to the RFQ phase. According to Coburn & Mhay (2007) the information requested from suppliers in the RFI phase are usually related to the general information of the supplier company; their size, factory locations, product/service offerings, personnel, manufacturing processes, financial information etc. RFIs are usually used as a pre-round for the actual pricing related RFQ and therefore RFI is rarely the final round of tenders. RFIs can also be seen as a tool used for building a database for later negotiations, supplier evaluation and strategical reasons. Information gathered in the RFI can be used in further evaluation of the following topics: (Coburn & Mhay 2008)

- The suppliers’ facilities, finances, attitudes, and motivations
- The state and dynamics of the supply market
- Trends in the market
- Supplier competition
- Alternative pricing strategies
- Breadth and width of product/service offerings by supplier
- Suppliers’ strategic focus, business, and product plans

RFIs can be used for requesting a detailed list of pricing the desired products or services but these prices should not be used as a base for any buying decisions, more as a comparative and guiding information on which suppliers to focus on. Analysis of RFI responses can provide useful information about strategic options and lower cost alternatives that can be utilized to achieve cost reductions. (Coburn & Mhay 2008)

Request for Quotation is the concrete price-related phase of tendering process. RFQs are suitable for all kind of tendering but they are utilized optimally when the products or services are as standardized as possible. This is because the price quotes from suppliers have to be easily comparable before launching the bidding and negotiations. For making the quotes as comparable as possible, the buyer should send detailed information related to the RFQ. (Coburn Mhay 2008, Ng et al. 2007) According to Coburn & Mhay (2007) and Ng et al. (2007) the RFQ's sent to the supplier should include detailed information about:

- Quantities/Volumes
- Quality levels
- Delivery requirements
- Part descriptions and specifications
- Descriptions or drawings
- Term of contract
- Terms and conditions
- Other value added requirements or terms
- Draft contract

Price/product or price/service unit is the main outcome of RFQ. The quote received from the supplier should be delivered in the requested form so the analysis and comparison of the responses is easier. Price quote is the most important one but also the information about mentioned quality levels, requirements and terms are important things that offer a base for supplier analysis and affect the bidding phase and final negotiations. Supplier decision can be made according to the RFQ results, but usually RFQs lead to decision of choosing suppliers for bidding rounds. Bidding the suppliers send their sealed bids in single or multi-round bidding which can be executed by phone, e-mails, letter or by e-auctioning. (Coburn & Mhay 2008)

After the RFxs and bidding, the final negotiations are held with the chosen supplier. In these negotiations the focus drifts more from prices to the operational things. Strategic procurement/tendering addresses the win-win- thinking where the stakeholders are aiming to find an agreement from which the both parties benefit. After implementing new suppliers it is important, in addition to daily procurement work, to actively monitor their performance and arrange new RFxs when needed. (Iloranta & Pajunen-Muhonen 2012, pp. 285-286)

4.2 E-Tendering

Manual tendering process is usually time-consuming and labor intensive with multiple bidding rounds and material preparation involved. It can take months of turn-around time by preparing papers, calling through suppliers and having multiple meetings and negotiations. Spending resources on executing tenders manually is costly for all the stakeholders that are involved, both the buyer and the supplier. There are multiple approaches for tackling this waste of time. As the technology is developing rapidly, one of the most well-known approaches is e-tendering. E-tendering is trying to solve the problem by replacing paper-, telephone- and meeting-based tendering processes with electronically advanced processes where all the exchange of documents is done centrally and efficiently. (Ng et al. 2007)

Typical e-tendering system has the following steps (Adapted Ng et al. 2007):

1. E-tender solution provider (ETSP) creates the tender project together with buyer in external IT environment, usually a cloud service accessed through a webpage, and gives access to the buyers contact persons.

2. The buyer needs to decide if there are multiple RFx rounds or just one RFQ and the plan the schedule of the project accordingly.
3. The buyer and ETSP create the tender documents together in adequate format (Excel –files, PDFs etc.).
4. ETSP publishes the electronic documents online.
5. Access to tender documents is sent to all the parties involved in the approval process such as finance and legal departments.
6. Tender documents are published in the e-tendering system and they are available online for chosen suppliers for checking the details.
7. Suppliers access the e-tendering system to view the tender documents via the e-tender website.
8. Suppliers respond by sending their bids using secure e-mail or uploading the requested information straight to the e-tendering system.
9. When the tender deadline is reached, the buyer can view the tenders and perform evaluation analysis of the submitted bids. This can be done manually or semi automatically by bid evaluation tools.
10. The supplier of the winning bid is notified of the award via the e-tendering system.

Currently available tools offer various levels of sophistication. The simplest versions of solutions are applications on a web server where the electronic documents are posted. Then buyer can view and evaluate these documents via internet connection. These types of simple solutions rarely have any automated supplier evaluation tools and the user has to download Excel –spreadsheets and compare them manually. These solutions reduce the time usage, but not significantly. The real benefits of e-tendering tools come into picture with more sophisticated solutions. In these solutions there are multiple functions available: automatic visualization of tenders, multiple users accessing the data, predefined templates and files used and notifications and messages sent to suppliers through the solution. Usually even the more sophisticated applications are set up as a cloud service. (Ng et al. 2007, Noventia Oy 2015)

A tool that can be also used as a part of the bidding phase is e-auctions. Basically e-auction works the same way than normal auctions. In e-auctions the bidders compete in real-time against each other via the e-tender solution. The buyer can decide the settings of the auctions: what auction type is used according to the product /service market which is tendered and what kind of dynamics are desired. The typical type used in procurement is reverse English auction where the bidders lower their prices as the auction moves on. In Dutch version the price is increased in decrements until one LSP offers the requested price. (Teich et al. 2003) Also the visibility of other suppliers' bids and the overall auction situation to suppliers can be decided. E-auctions are typically fast-paced and last 15-60 minutes. The winner of the tender is announced based on the final rates offered in the e-auction together with other requirements (transit times, service levels etc.) (Teich et al. 2003, Noventia Oy 2015)

5 ACTIVITY-BASED COSTING

Activity-Based Costing (ABC) is a costing method that measures the cost of a product or service through the performance of related activities and resources used for executing these activities. Resources (also known as cost elements) are assigned to activities and activities are assigned to cost objects, which can be products or services, based on the usage of each activity. (Becker & Glad 1995, p. 26)

In other words products consume activities, which in turn, consume resources. Therefore activities cause costs. This leads to a conclusion that activities should be the base of cost, not the products or services, hence the term "activity-based costing". (Becker & Glad 1995, p. 20) The simplified ABC model is presented in figure 11.

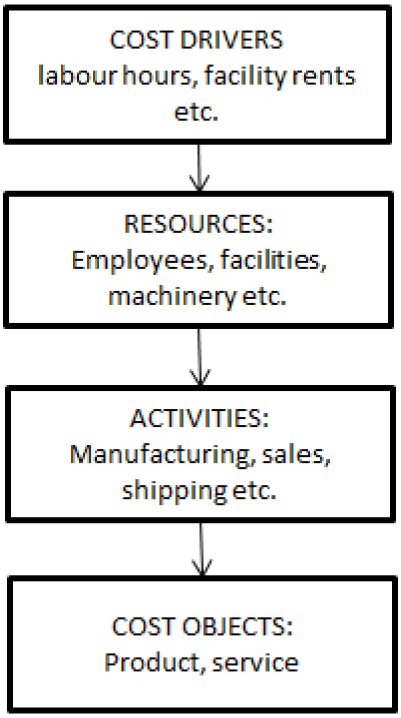

Figure 11. Activity-based costing. (Becker & Glad 1995, p. 24)

ABC is used to recognize the causal relationship of cost drivers (reasons causing the cost to exist or change) and product/service total cost. Resources (cost elements) are traced to related activities by using the cost drivers. (Becker & Glad 1995, p. 26) In practice this means that ABC tries to find the reasons that cause the costs of different activities.

First step in determining the activities' costs is to cost the resources to the appropriate activities. (Becker & Glad 1995, p. 20) In other words this means allocating the costs of resources related to each activity, based on activities usage of resources. Table 4 presents a practical example of activity cost matrix which explains the use of resources by different activities.

Table 4. Activity cost matrix. (Adapted from Becker & Glad 1995, p. 20)

Resource	**Activity**	
	Receiving	*Warehousing*
Salaries	6 530	18 600
Power	360	1 230
Rent	300	10 400
Insurance	130	7 970
Depreciation	690	590
TOTAL	**10 010**	**42 710**

Next step is to determine, how the activity costs are traced to the cost objects (product or service). Some products use only some of the activities when some products are traced to all of the activities. The total cost of a cost object is a combination of activity-based costs and direct cost such as raw materials used for manufacturing a product. (Becker & Glad 1995, p. 20)

ABC differs from conventional costing systems in its way of dealing with non-production-volume-related overhead costs (indirect costs). When compared to traditional costing models, ABC assigns indirect costs more in direct costs and therefore it is useful in the context of this thesis. (Innes & Mitchell 1998, p. 21) Base of ABC is the evaluation of the cost of activity (Becker & Glad 1995, p. 24), which is the main topic of this thesis (activity of shipping goods). Therefore it is justified to use ABC as a costing model.

6 CASE COMPANY & SUPPLY CHAIN

The case company is a large, international Finnish company which operates in multiple business areas offering its customers a large variety of consumer goods. The Company's headquarters is in Helsinki, Finland but it has multiple offices, production plants and warehouses/distribution centers worldwide. Main business regions are Europe, North-America and Asia. The Company has an organizational structure based on "Business Regions" which are formed around geographical areas and "Business Units" which are based on the product type. These together form a matrix organization where the units are responsible for offering the product range and value to the customers and the regions take care of the supporting functions in each geographical area. Strategical, financial and steering decisions are made in Helsinki headquarters.

Company's supply chain is a typical supply chain based on material flow from the raw material suppliers to the customers (figure 12). The Company has many factories around the world but it uses also sourced finished goods from external suppliers to widen the product variety and strengthen its product portfolio. Customers vary from retailers and third party sellers to individual customers through web shop and company's own outlet shops and stores.

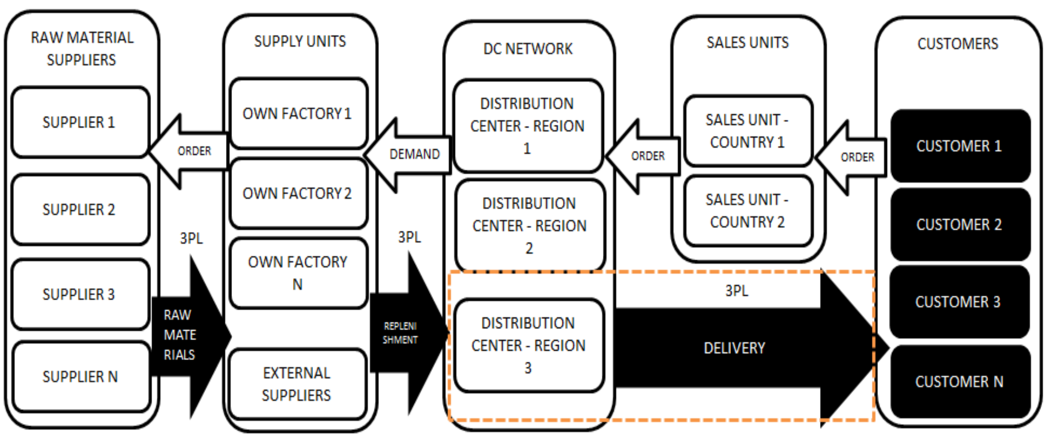

Figure 12. Case Company's supply chain.

The Company’s distribution is a model example of a “hub and spoke” distribution model. The Company has multiple distribution centers which serve the regional sales units and their customers. This enables shorter lead times and better service level. Distribution model is also suitable especially for road freight shipments, which the majority of company’s shipments are. This project takes into consideration the costs related to the DC outbound processes of the main distribution center and freight transportation costs on the chosen routes. The scope is highlighted in figure 12 with orange color.

7 DISTRIBUTION CENTER

Distribution center is the place where the ultimate decision of using either parcels or pallets in shipping is made. Many of the processes and costs related to DC processes affect this decision. Therefore it is important to understand the main processes and recognize things that can be improved. In the following chapter the main outbound processes are presented and evaluated based on theory presented in the chapter 2. Also the logic of setting the split volume is explained more in detail.

7.1 The Role and Features of the Distribution Center

The distribution center, which is the scope in this thesis, is Company's main distribution center domestically and internationally. It serves web shop customers, B2B customers, retail customers and wholesale customers in Finland. Also export to some countries is done, along with intercompany replenishment shipments. Finland DC is one of four main distribution centers but there are also few smaller local DCs. DC stores only finished goods.

The DC has 23 000 pallet storage locations in 6 levels. Ground level is the picking location and five upper levels are used for storing goods. DC sends out around 65 000 parcel shipments and 30 000 pallet shipments per year. In handling units this means 200 000 cartons and 74 000 pallets. In practice this means that 5-10 trucks bring and pick up goods each day. DC employs 25 full time warehouse workers and uses 20-30 rental employees according to the season and changes in demand. Office and management consists of 10 employees.

The main activities and simplified material flows are presented in figure 13. The products are brought in and received through the inbound and quality section area, where the workers check the goods and input their information in to the warehouse ERP –system (SAP). Then the goods are moved to their storage locations or in the case of cross-docking combined straightly to new shipments.

When customer order arrives, the products are picked by using fork lift from the pallet storage according to the order. Goods can be picked in two ways: pallet or parcel picking. When the order is picked and it is ready, it is either packed (parcels) or wrapped in protective plastic and cardboards (pallets). Then the needed address labels and packing lists are printed and the order is moved to the outbound shipment's waiting queue. From here the shipments are moved to LSPs trucks and shipped to destination (can include multiple terminals and sortation etc.).

DC also performs some value-added activities such as creating displays and packing seasonal product combinations. These are quite labor intensive services but still the major cost component in DC's variable costs is the outbound related labor (picking and packing).

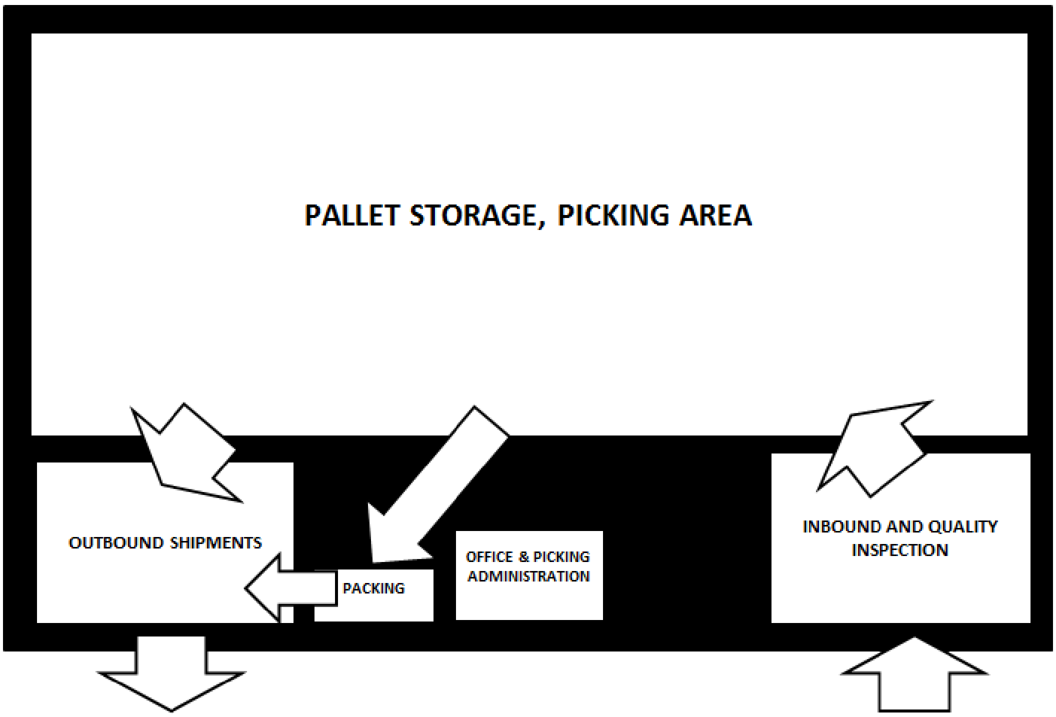

Figure 13. Main distribution center layout and material flows.

The stock-keeping units (SKUs) are stored in their locations with class-based storage –method. This means that the most often picked SKUs are located so that the picker's travel distance is minimal, which leads to shorter travel time and reduced costs. Storage locations are optimized four times each year based on the picking data.

Optimization has also been taken into account by setting the replenishment locations usually above the picking location. When the actual picking location runs out of goods, the worker can quickly and easily take a new pallet from the higher level and save time. In some cases this is not possible, but also then the replenishment location is the closest free location from the picking location, so the time to fulfill the empty picking location is shortest possible.

There are few acute problems in handling the storage. The storage locations are full often and the Company needs to use external warehousing. DC management has also recognized some slow moving SKU's which have not moved at all since the SAP system was set up few years ago. These slow movers block around 300 storage locations. All in all, the storage related and general issues are handled well in the DC. There are no major savings achievable from these so it is important to take a closer look at the most cost intensive processes: the outbound processes.

7.2 Outbound Processes

The main outbound processes to be examined are picking and packing. This is because they have been recognized as processes which differ from each other when shipping goods in parcels or pallets. This simplification is also done to make later ABC calculations easier and more accurate when comparing the two shipment types.

The main IT systems used in picking process are SAP and Voicelink. There are also other transactions in use, but they are not that relevant. SAP is the ERP –system which is used to receive orders and generate deliveries according to the orders. Voicelink is a system that guides the picker through the picking process and uses automated voice commands to make sure that the picker performs correct actions and picks correct products and quantities. The process before the physical picking process has the following steps:

1. Sales order is received and set to SAP.
2. SAP generates deliveries based on orders.
3. DC assistants manually move deliveries to Voicelink –system.
4. Deliveries in Voicelink are manually grouped to picking batches to create "picking list".
5. Picking process starts.

When the picking process starts, the Voicelink system automatically guides the picker to pick either parcel or pallet shipment. This decision is made according to volume -based logic which is set in SAP. This volume which is set for dividing the shipments to parcels and pallet is called the split volume. Optimal split volume is the result of later activity-based costing calculations. It determines the costs related to the shipment to a great extent because the costs are highly related to the decision of shipping goods in parcel or on pallets.

Currently the logic is (at the beginning of the thesis project): if the sum of volume of the SKUs in the shipment is below 0,2 m^3, the shipment is picked as a parcel shipment on a roller cage. If the volume is over 0,2 m^3, the shipment is picked on a pallet In other words the split volume is set to 0,2 m^3. If the shipment includes full pallets of certain product, these are picked from the replenishment locations (higher levels) instead of the actual picking location. This speeds up picking and reduces costs.

The sum of volume means the sum of theoretical volume set for each SKU in SAP environment. This means that if shipment consists of one individual product, the shipment volume is the volume based on the product's largest measurements (length, width, height) or its individual packaging. If the shipment consists of retail or other boxes of products, then the shipment volume is the total volume of these boxes combined.

The general setting for picking is the same for both pallet and parcels. The picking area within the pallet storage space and the general setting of picking is presented in figure 14.

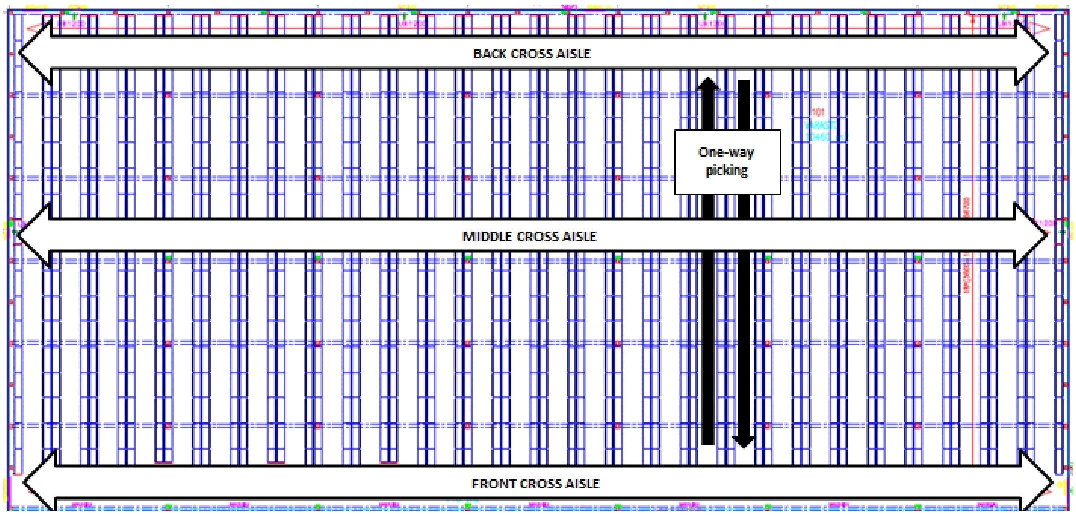

Figure 14. Picking area.

The picking area is set up in 28 picking aisles and three cross isles. The truck lifts are allowed to travel each picking isle in one way only, to make picking safer and instructions clear. Since the picking area is quite small and the aisles are one way aisles, it is natural that the DC is using simple S-routing. The middle cross aisle also supports this by offering the picker a useful shortcut to the next aisle when needed. There would not be major savings achievable by setting more sophisticated routing method.

Also the small size of the DC makes it more practical to not use any zoning solutions. That would complicate things too much and possible increased efficiency (if achievable at all) would not be significant. Simple but practical solutions work well in DC this size.

For understanding the differences between the pallet and parcel DC processes, it is logical to look at each of them in more detail. Pallet and parcel outbound processes are presented in figures 15 (pallet) and 16 (parcel). Data for the process charts was gathered during few days spent in the DC by observing the processes, and interviewing warehouse workers during the picking and packing activities.

Picking process for both shipment types begins similarly. After the Voicelink system has told the picker which type of shipment is going to be picked, the picker prints out the picking list, which indicates all the delivery lines (amount of each SKU) to be picked. All picking is done as human picker-to-parts –picking which means that the picker travels in the picking area and picks the goods from their storage locations using a fork lift.

Pallet shipments are picked as single order -picking. That means that picker picks one delivery ready for shipping and only after then begins picking new delivery. After printing the picking list, the picker chooses a correct pallet on which the goods are picked. The choice of pallet depends on the customer and is indicated by the Voicelink system. When the picker has taken the pallet on the forks, the Voicelink gives the storage location of the first goods to be picked. Picker travels to the location and confirms the location by predefined speech commands for the Voicelink system. If the location is correct, Voicelink system gives the quantity that needs to be picked from this location. This can be for example three retail boxes and five individual products (pieces) or any combination of different units.

The picker confirms quantity by speech command. The picker takes the goods and has to double check the quantity because there have been situations, where the information in the Voicelink system doesn't match the reality. In practice this means that the retail box contains more or less pieces than is set in SAP. Reason for this is that the communication between packing designers and DC is not working well enough. When the quantity is correct, the picker has to organize the products on the pallet in most space-efficient way. It is possible to ship more products in one pallet if the products are organized well and there is no empty space between them. Well organized pallet also helps in handling the pallet later. These steps are repeated as many times as needed to pick the shipment ready.

After the pallet is ready it is manually measured to determine the real volume of it. This is quickly done by measuring the height of the stacked products. The width and length of the pallet are always known beforehand according to the pallet which is used. One shipment can include multiple pallets, but in the context of this thesis, the volumes of the shipments that are relevant (in comparing shipping in pallets or parcels) are so small, that assumption can be made that the shipment consists of only one pallet The volume of one full pallet is approximately 1-1,5 m^3 and the range of volume which is relevant in this thesis is 0,1 – 0,6 m^3, which basically means that the shipment of that volume includes one pallet which is not considered full.

When the actual picking task is finished, picker prints out needed shipping documents from the nearest computer station. These are the packing list and address labels which are attached to the pallet. Pallet shipments are wrapped in plastic to keep the boxes and products stable and to protect them. Pallets can also be protected with cardboard and pallet collars in some cases.

When the pallet is ready to be shipped, Voicelink gives the location in the outbound area where the pallet should be transferred for waiting to be shipped. All in all, the whole picking process is guided by the Voicelink automation and leaves a small margin for any errors from the picker. Use of Voicelink makes it also more efficient and time saving to perform picking when the picker doesn’t have to think of routing or calculate the quantities of each SKU picked. The whole process from activating Voicelink to loading the pallet into the truck is presented in figure 15 on the next page.

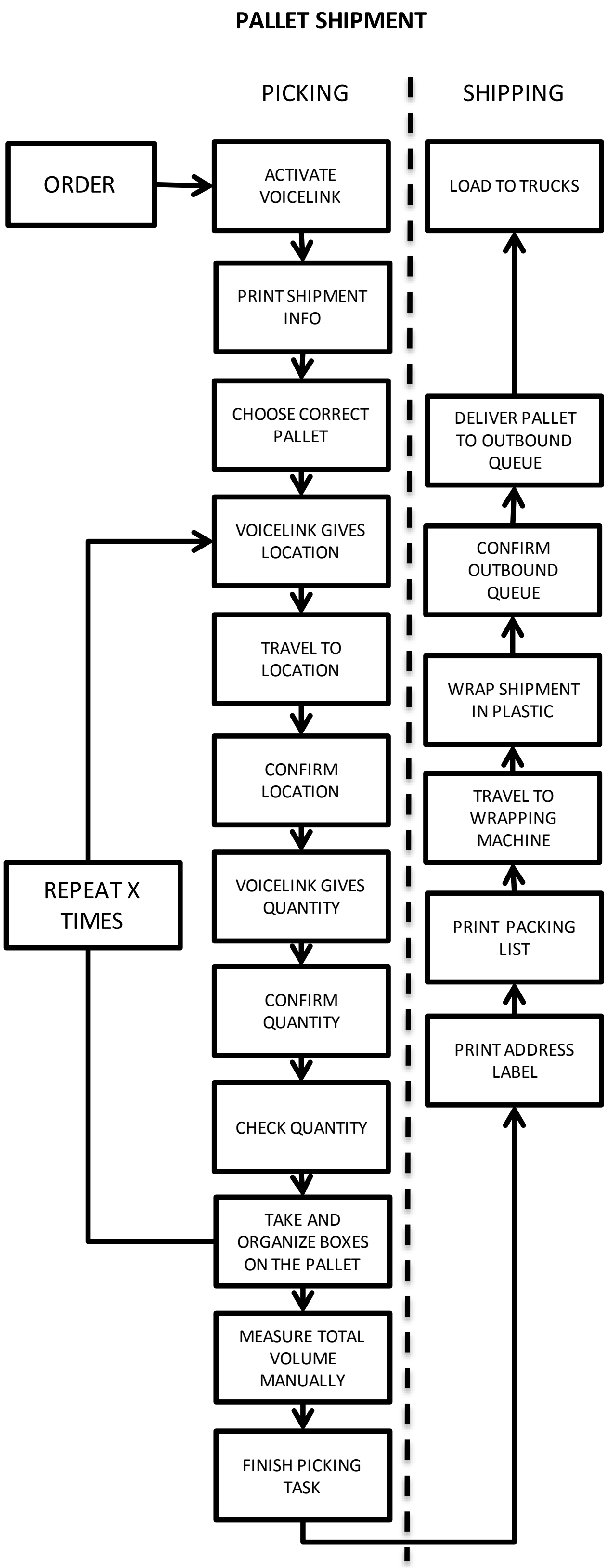

Figure 15. Pallet shipment processes.

Parcel picking has some features that are meant to optimize small quantity – picking. Parcel picking has more steps and it is more complicated. After printing the shipment info, the picker collects a roller cage on which the orders are picked. Small size of shipments makes it possible to pick simultaneously for up to six different shipments. This method of picking has features of batching. Shipments are organized on picking lists according to destination and products in the shipments. This way the travel distance is optimized, when the products for each customer are picked from same storage locations.

Otherwise the picking of the goods is more or less the same than in pallet picking. The picker is guided by the Voicelink system to correct picking locations and he needs to always confirm the location and the quantity which is picked. Additional phase in this is, that every time a SKU is picked, the system gives customer number. Based on this customer number, the picker knows in which shelf (or slot) on the roller cage the goods are supposed to be put. Each customer has their own slot to prevent shipments mixing up. When the picking task is finished, the roller cage is delivered to a queue in packing area.

Packing is additional and very labor intensive work phase that separates the parcel shipments from pallet shipments. The roller cage sits in the queue until the packer starts his packing task and takes the roller cage to the packing station. Based on the volume of the shipment and packing instructions, the packer chooses correct parcel box/carton and scans it to create a handling unit in ERP system (different from SAP and Voicelink). Then the packer scans each product unit and places them into the box and adds protective materials (bubble wrap, paper etc.). One shipment can include multiple cartons so this phase is repeated as many times as needed. For each carton the packer prints address labels and the packing list. Then the cartons are moved by a conveyor belt to assistant worker, who organizes the parcels on mixed pallets based on their destinations. Pallets are used to make handling of the parcels easier. Finally, the parcels are moved to the outbound queue to be shipped. All process phases of parcel picking, packing and shipping are presented in figure 16 on the next page.

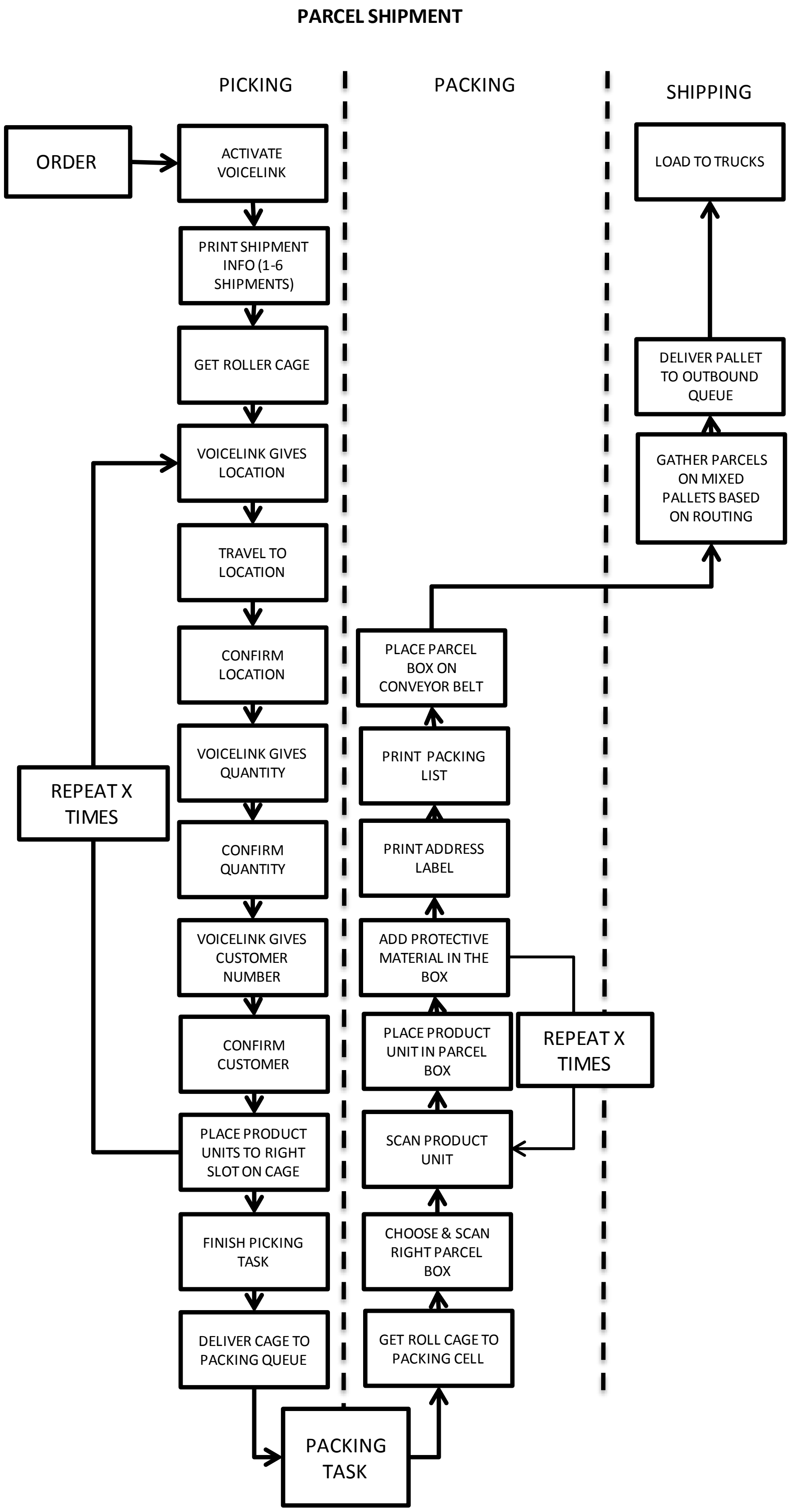

Figure 16. Parcel shipment processes.

There are four packing stations which handle the packing of the parcel shipments. According to the original assumption of the results of this thesis, packing volumes would increase. This would mean more packing work and a thing that needs to be considered is that the packing stations are already working on the limit of packing capacity during high demand seasons with current setting. There is space for setting up two additional packing stations if needed. If the results suggest that the amount of parcels should be increased, the solution to deal with the limited packing capacity needs to be discussed. It is also important to note that the packing labor varies according to destination country and LSP used.

Packing personnel also obey the packing instructions differently. The basic guideline is to fit the shipment in the minimum amount of cartons. The biggest available carton size is currently 0,14 m^3 but it is not fully utilized. This package is mainly used for export (excluding Sweden) and in domestic shipments smaller standard cartons are used to make handling easier. Fortunately the amount of cartons doesn't affect the rate in those routes where smaller cartons are used (Finland and Sweden) and shipments include multiple cartons, because the shipment is priced according to size of the total shipment, not individual cartons.

The main differences between parcel shipment and pallet shipment processes are clear: parcel picking is more efficient since there is possibility to pick multiple orders simultaneously. On the other hand parcel shipments have additional work phase that pallet shipments don't have: packing. Packing is surprisingly labor intensive and it affects the labor costs of parcel shipments a lot. These differences between the shipping types need to be included in the activity-based costing calculations by calculating the costs for each activity (picking, packing).

After detailed analysis of the distribution center processes and comparison to the relevant literature models, it can be stated that currently the DC is working well. All the necessary activities are optimized on a reasonable level, keeping in mind the size and role of the DC in case Company's business. Especially the picking procedures which are the most cost intensive processes are designed efficiently (storage locations, parcel picking batching) and modernly (voice guided picking).

Some minor possible modifications are pointed out, such as better communication between packing designers and DC management, but these don’t have a major effect on the costs and potential savings. Packing personnel could start following the packing instructions better to ensure the optimization of packing labor, material and freight cost. All in all the conclusion is that it is justified to perform the activity-based costing calculations based on current, as-is, situation.

8 FREIGHT COST OPTIMIZATION

As a way of achieving cost efficient freight rates the Company wants their tender process to be evaluated. The evaluation is based on comparison to the model presented in the chapter 4. First, the Company's current tender process is presented. Then the main development areas of the process are discussed, keeping in mind the "ideal" process as long it is applicable. An example of savings that are achievable by tendering is also presented to underline the importance of an efficient tender process. Chapter also includes the findings about the different pricing models that are currently in use by LSPs. Important points regarding the choice of implementing LSP are discussed in the end of the chapter.

8.1 Company's Freight Service Tendering Process

The Company has previously held tenders every now and then, whenever there has been some reason for it. Recently the company has started planning the tenders more in long term and more systematically. Usually the tenders are arranged globally for the air and sea shipments and regionally for the road shipments. Tender projects are led centrally from the Helsinki headquarters. For executing efficient tenders, the company has more or less already standardized the process. This process is then modified according to the scale of the tender (global vs. regional). Current process is presented in the figure 17.

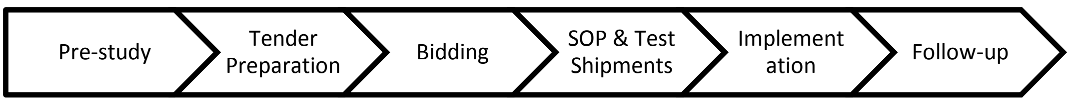

Figure 17. Company's tendering process.

Ppre-study is the first phase of the process. Actions taken during the pre-study are preparation activities which include such things as setting the target and scope for the project (which region, which type of logistics services is tendered), estimating the volumes and economic impact (savings). During the pre-study, the potential LSP candidates are also screened and evaluated, usually with the expertise of company employees according to past experiences and co-operation with LSPs. The regional tenders are supported by the country organizations. As a part of normal project planning and management, the schedule, use of resources and the responsibilities inside the project are decided. Risk evaluation is also a part of the pre-study phase. As a result of pre-study, the project plan is presented and approved.

Next step is the preparation of the tender itself. Tender preparation means preparing the RFx material that will be sent to the LSPs which have been chosen to participate in the tender. Also determining the detailed scope of the tender and the main drivers for selection (price, service, other?) are an essential part of tender preparation. The creation of RFI and RFQ material needs careful thinking of which information is relevant to have from the LSPs but also to think that what information the LSPs need to provide the requested information and rates. Usually the more detailed tender material is, the easier it is for LSPs to answer with accurate information.

External service providers can be used in creating the RFI and RFQ documents, for example by using e-tender solution providers. As a result of the tender preparation the participating LSPs are chosen and the tender documents are sent to them. RFI and RFQ phases can be done separately (in bigger tender projects) to screen the LSPs more or the needed information can be requested simultaneously with the rate quotations. Tender preparation phase can last from weeks to several months.

After sending out the RFIs, RFQs and general instructions and timetables of the tendering process, the suppliers will start bidding for the service tendered. When the deadline is reached, the responsible person from the Company will go through the price rates and other documents required from the suppliers. Based on the evaluation of these documents and previous experiences, the suppliers are compared (not only based on the price rates!). Some of the suppliers are invited to further negotiations related to tender to discuss practical requirements. The last round of price quotation requests is held after the meetings.

Recently the Company has started utilizing e-auctions as a tool for creating real time competition and to achieve better results. Based on the e-auction/last round the winning LSP(s) are awarded with business in the tendered markets. Bidding phase can last up to 1-3 months. Sometimes there are problems in getting the requested information on time from the LSPs, because of complicated RFQ files and using e-tendering solutions is one way of overcoming these difficulties.

Next step is to plan the implementation of chosen LSP. Defining the Standard Operating Procedures (SOPs) and making test shipments are the two major activities done in this phase. SOPs are documents where the co-operation between the Company and the LSP is described in detail including information of the origin and destination locations, cargo pick-up times, final rates, contact persons and terms and contract related things. After SOP has been produced, the IT connection is tested and set up and test shipments are shipped. When everything is working according to requirements, the full implementation can take place.

After closing the implementation project the main tasks are to follow the LSP performance with regular business meeting and keeping score of the Key Performance Indicators (KPIs) such as transit times, delivered shipments etc. Part of the follow-up activities is also updating the prices through negotiations (in case that new tenders are not executed).

The main reason for not executing tenders on a yearly basis is that there are multiple regions and transport modes in use, and the company doesn't have enough resources to execute many tenders yearly and at the same time. The reason for this is that at the moment each tender project is really time consuming and includes a lot of manual work. Especially the tender material preparation and bidding process execution are labor intensive project phases which could be dealt more efficiently.

Table 5 shows two example tenders in which the writer of the thesis has been involved. In both cases savings are significant compared to the project cost and savings exceeded the estimate. The project cost comes almost completely from the use of labor resources but also includes some costs of using e-tendering solutions.

Table 5. Examples of savings achieved by tendering.

Project	**Objective**	**Annual spend before tender (k€)**	**Annual savings achieved (k€)**	**Project cost (k€)**	**Payback time (years)**
Tender 1.	Reduce ROAD freight costs in European country 1	2900	145	35	0,2
Tender 2.	Reduce ROAD freight costs in European country 2	1900	400	35	0,09

Experience has shown that the savings achieved through tendering can be significant and usually there are at least some savings achieved. Therefore executing efficient tender projects should be a no-brainer to have as a tool for procurement. The Company has realized this, but the lack of resources is preventing the yearly tenders. Solutions for making the process easier and more efficient are discussed in the following paragraphs.

The main topics and development areas are:

1. Tender material preparation and making the tender “easy” for LSPs
2. Bidding process execution and use of e-tendering tools (e-RFx/e-auction)
3. Follow up in bidding phase to stay on schedule

The Company should use the external reporting tool they already have in use for creating the tender material more efficiently. This tool offers a possibility to filter shipment data according to multiple criteria such as the routes, transport methods and LSPs used, and export it to Microsoft Excel for processing. By using this tool, the person who is responsible for preparing the tender material could easily build the needed templates with sufficient information on routing, volume and transit time requirements for the LPSs so they have detailed information on what they are bidding for. By using this already existing tool better, the tender material preparation would take significantly less time: for example the writer of the thesis used the tool to create global air and ocean freight tender documents in few days instead of few months, time that the tender volume preparation would take when trying to create the volume information from e.g. invoices manually. Not only this saves time, but the tender also becomes clearer and easier for the LSPs bidding and they can provide more accurate rates. This benefits both the Company and the LSPs.

There have been some problems in the bidding process itself also. The Company needs to keep better track on what information which LSP has provided and if the information is correct. The Company needs to have the correct and up-to-date contact information of the participating LSPs in order to communicate efficiently. All of this can be taken care of by an external service provider, who offers an e-solution to execute the tender. These service providers and solutions are one tool that the company needs to utilize more and better. The Company should meet up with several e-tendering service providers and choose the one that meets the needs of the Company. This means that the solution chosen really suits especially freight service tendering and the e-service provider modifies the solution accordingly. Usually the solutions are concentrating on product tendering and are not the best suited for tendering freight services.

Instead of sending e-mails/calling all suppliers, during the last bidding rounds, real-time e-auction is efficient when used correctly. E-auctions offer multiple choices of what type of auction is used, what the bidders can see during the auction etc. Nowadays e-auctioning is an everyday activity for the LSPs so they are used to take part in those. This means that the practicalities relating to organizing the auction are easy and the e-auction can be held efficiently. The Company should design the e-auctions and set the markets that are competed so, that the LSPs become active during the auction and there are real competition during the auction. This is achieved by evaluating each market separately and setting the markets attractive to the LSPs. If the business in some market is significantly smaller than on others, some LSPs are not interested in dropping their rates on the smaller markets. Anyway the business value that is being auctioned needs to be big enough to be attractive to the LSPs. When setting up the e-auction the following auction types should be used according to the situation after initial RFQs:

- Reverse English auction when there is clear competition
- Reverse Dutch/Japanese auction when there is one leader

Reverse English auction means that the competing LSPs are lowering their prices according to the leading price. The LSPs possibility of seeing the actual leading bid and other LSPs bids or just the position of the bidder is a thing that needs to be considered by the Company on each auction, based on the value of the business and the dynamics that are desired. In reverse Dutch auction, the price is set low in the beginning. Then the price is increased until one LSP offers the requested price. This offer is automatically the winner. In reverse Japanese version the price is lowered in decrements and LSPs need to confirm that they accept the price at each price level. When the price goes down enough, LSPs start dropping out from the competition and in the end only the winner remains. This way the LSPs don't have information on what is the leading bid and they have to confirm their willingness to match the price level at each level to stay in the auction.

One common problem in the tenders that the Company has run, has been the LPSs who are slipping from the timetable. In order to make the tender process smooth and efficient, the LSPs need to stay on schedule. Ways of engaging the bidders better would be setting some kind of penalties to those who don't obey the time limits. In the worst case this could mean losing the right to participate to auctions and automatically lose the business on some markets.

With these actions the Company can make its tendering process more efficient. It has become clear that by concentrating on tendering, the cost savings can be significant and the key to achieve these savings is developing the activities related to tendering continuously. Because the Company is not the biggest and most interesting customer for LSPs (based on volumes), it needs to pay attention on involving the LSPs to tenders better and seek suitable and interested LSPs to keep the competition active.

8.2 Freight Rates & Choosing the LSP

The negotiated prices are the result of tendering. During this thesis project it became clear that the company doesn't have complete understanding of the freight rates and pricing models that the LSPs are using currently. There are big differences in pricing with different LSPs, especially in pricing of the parcel shipments. The different pricing models according to the destination country are presented in figure 18. These prices are not straightly comparable to each other because Finland's rates include fuel surcharge (FSC) and Sweden's doesn't.

In figure 18, the pallet rates are indicated with red color and the parcel rates with blue color (in Finland also web shop parcels with green). In both countries the curves are different. This clearly indicates that the pricing models vary according to the destination country. This is because each route has different LSP(s) in use. Three LSPs are used in Finnish shipments, one for each shipment type. In Sweden, one and same LSP handles both parcel and pallet shipments.

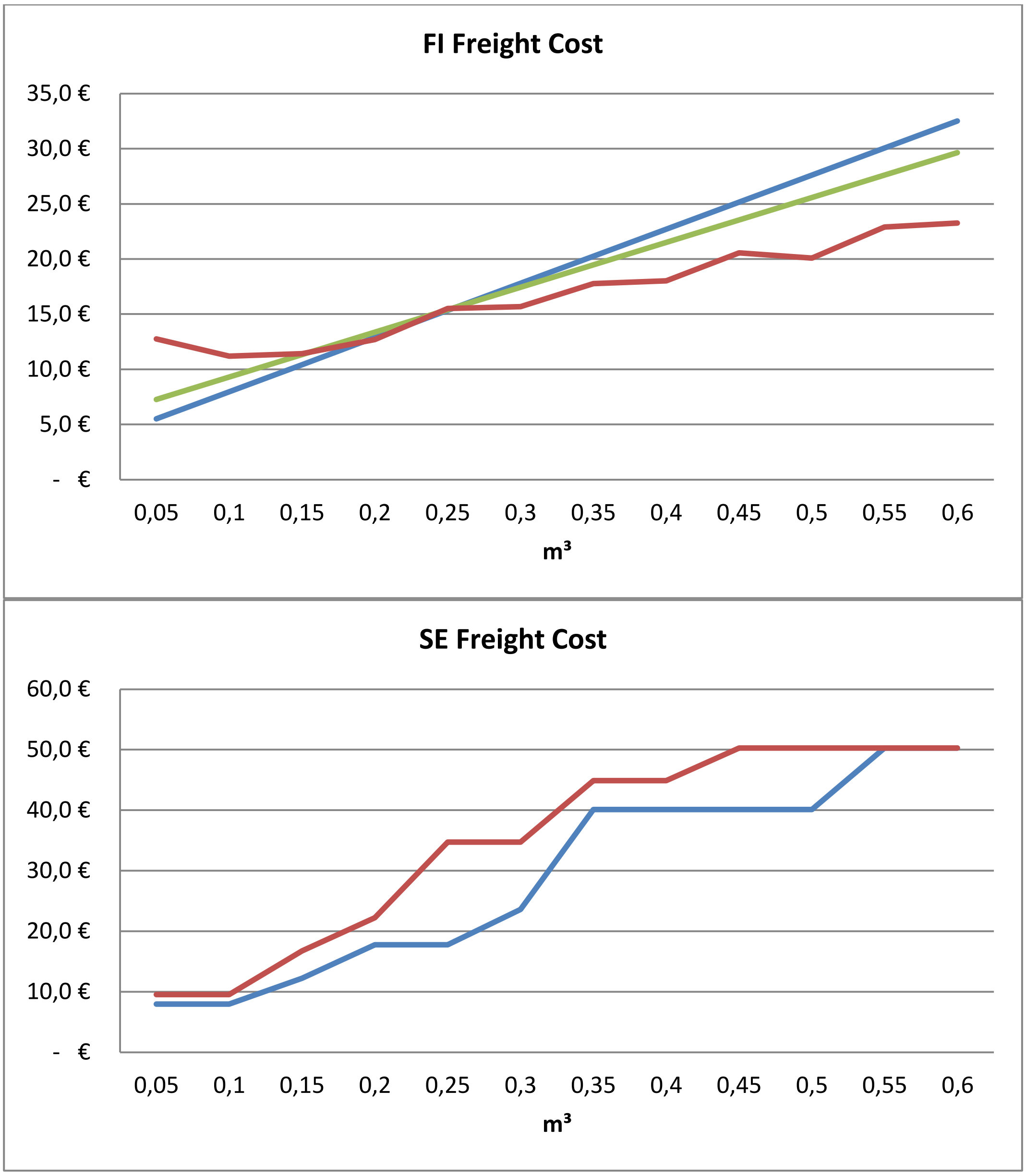

Figure 18. Freight rates for pallet and parcel shipments.

Pallet rates behave similarly in Finland and Sweden: as the volume of the shipment increases, the price per weight band gets relatively smaller. Sweden has a steep rise of prices with smaller shipments. Parcel pricing varies much and it is important to understand what kind of benefits the Company could achieve based on these pricing models or which kind of pricing the Company should request when organizing tenders.

In Finland the parcels are priced with base price of €/shipment and then an additional price is added according to the chargeable weight of the shipment. This pricing model is pretty much the standard in parcel industry and the cost savings are achieved by packing products in cartons with not too much extra space (since the dimensional weight is usually determining the chargeable weight).

In Sweden the parcels are priced in € (SEK) /shipment per weight band. With this type of pricing, the Company should optimize its packing based on keeping within a certain weight band, since the price is same for shipments of all weight in a weight band. This means that if it would be possible to consolidate two small shipments of the lowest weight band together and still be within the same weight band, the Company would save half of the freight costs.

Additional realization was that in many cases when using parcel shipments, there are multiple cartons included in the shipment. This leads to conclusion that generally the Company should request shipment –level pricing (multiple cartons included in the same price) instead of paying for each carton separately. In B2C shipments there is usually only one carton included in the shipment and carton weight based pricing is justified. Opposite example of this is shipping parcels to Denmark where the freight costs the same for three or more cartons. In this case shipping larger shipments (over three cartons) with carton-based pricing is of course cost efficient.

Conclusion can be drawn that clearly the destination country and the characteristics of typical shipments to each country have a big effect on what kind of pricing model would benefit the Company most. The Company should pay attention to this when executing tenders to request freight pricing in suitable pricing format. In all of the mentioned routes the packing efficiency and the amount of “empty space” in cartons straightly affects the freight price, because the dimensional weight usually overcomes the real weight. Therefore it is important that the Company packs parcels efficiently and in smallest possible shipment volume.

It became evident during the thesis project that the Company doesn't have complete understanding of the rates and logic that are used for pricing. There are cases where the LSP has invoiced freight on a different basis that the Company has thought. Naturally this leads to increased costs which could be avoided by having clear understanding of the pricing logic. As a result of this thesis, some of these cases are now being investigated.

The final decision of choosing the LSP is the outcome of evaluating the combination of:

- Final prices & pricing model
- Previous experiences (positive or negative)
- Other costs: set-up, IT etc.
- Reporting abilities → Data quality
- Hidden costs

In addition to the final prices, the Company should put a lot of emphasis especially on the two last points: reporting and hidden costs. It is stated that the Company should concentrate on executing efficient and regular tenders. Reporting and data quality is related to tendering, because the tendering process is made more efficient by improving the tender preparation. Data from LSPs is used for this and therefore the data should be correct, so that the tender volumes in produced tender documents are realistic.

Hidden costs are easily explained through an example. In the tender for Finnish domestic parcel shipments LSP 1 had significantly better offer than LSP 2. The comparison of rates made it clear that using LSP 1 would lead to big savings. The difference in the processes of these LSPs was that LSP 1 handles parcels with sorting machines and the cartons need to be well packed and protected to prevent the products to break during transport. LSP 2 instead handles parcels manually and the cartons can be lightly protected and smaller cartons can be used. The calculation of increased DC costs in the case of using LSP 1 exceeded the price difference and it became clear that the total cost savings were bigger when using LSP 2. This example highlights the goal of this thesis in taking into account all of the logistics costs related to shipping goods.

The strategical point of view has to be considered also when choosing LSPs. The Company is in the process of reducing the number of LSPs and implementing new LSPs should be in line with this strategy. If there are two LSPs competing for the same market, with no significant difference in pricing and service abilities, then the preferred LSP is the one that is already included in the company strategy.

9 ACTIVITY-BASED COSTING ANALYSIS

An activity-based costing analysis is used for calculating the cost of shipping goods. To determine the optimal split volume, the calculations for parcel and pallet shipments are compared to each other. In this chapter, the costs included in the calculations are presented and justified, and the calculation method is explained. The outcome of the chapter is the summary of calculation results.

9.1 Calculation Method & Costs Included

The calculations are done for two cost objects: pallet shipment and parcel shipment. After making the calculations, these two objects are compared to determine which way of shipping is cheaper. Calculations are made for each cost object for different volumes. Shipment volumes are classified in “volume classes” from less than 0,05 m³ to 0,55-0,6 m³. Each class has a range of 0,05 m³, so the volume classes are: <0,05 m³, 0,05 m³- 0,1 m³, etc. The values for different resources have been calculated as averages for each volume class. Cubic meter volumes are used instead of weight because of the warehouse data in SAP is in cubic meters and therefore the split volume is in cubic meters. For transforming the volume into corresponding weight when needed (when calculating freight cost), the conversion factors are used: 333 kg/ m³ for pallets and 250 kg/ m³ for parcels.

One of the research questions set in the beginning of the project was:

RQ5: *Which costs should be included in the analysis?*

After initial review of possible cost components to be included, it was determined that it is not necessary to include all of the costs, but only those in which the two cost object differ from each other. Reason for this is to make the calculations and analysis as simple as possible, so that the possibility of calculation errors is minimal and the results can be easily presented to Company employees who are not necessary familiar with the topic. This simplification also underlines the objective to recognize the differences in shipping goods with pallets or parcels. This decision leads to calculation, where e.g. IT costs, energy cost and other indirect costs that can be allocated equally to both cost objects, have not been included.

The activities behind the cost objects were defined as DC processes and freight transport. DC processes were divided into picking- and packing-activities from which the packing –activity is only existing for parcel shipments. These activities are using four recognized cost resources from which three are in common with both cost objects. Cost resources are DC labor, freight services, package materials and packing facilities. Facility resource is only used by parcel shipments to track cost of having packing stations in the DC. Behind these resources are the cost drivers which affect the total cost of the cost object through resources and activities. Simplified allocation of costs to cost objects is presented in figure 19.

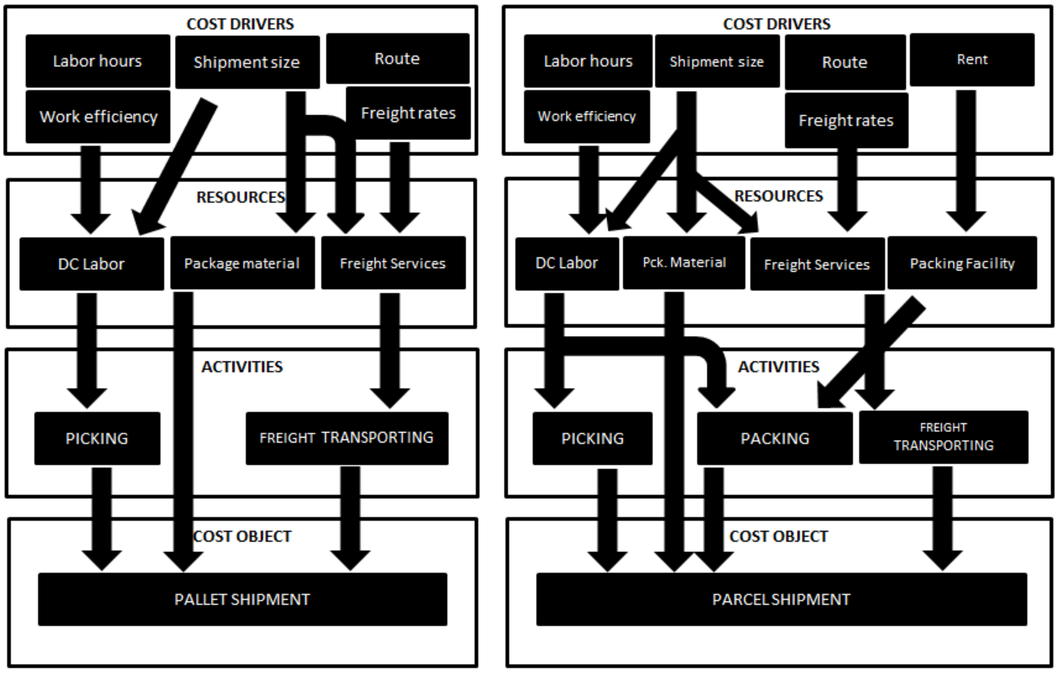

Figure 19. Activity-based costing objects: pallet & parcel shipment.

Calculation logic and equations used for each cost resource are presented in following subchapters. Calculations are presented on a resource level as a request from the Company. This enables closer examination and gives better understanding of the real costs and their share from the total cost. In each chapter one cost resource is divided into smaller parts based on the cost drivers and in the end its effect on the activity cost is calculated. In the final chapter all cost resources are added together (per volume class) to create a total cost for both cost objects. The numerical data is presented only in the chapter 9.5. These total cost/shipment/volume class are presented in a graph to demonstrate the cost difference of the shipment types and also to visually determine the optimal split volume. Calculations are done for main routes/destinations: Finland and Sweden. Together these countries cover over 50 % of the total road freight spend related to the main DC.

In this thesis project the ABC calculations have been done as one-time calculations, but in the future the calculations has to be made every time there is major change in freight rates or DC processes. The data sources used and “data-to-cost keys” transforming them to concrete cost elements are presented in figure 20.

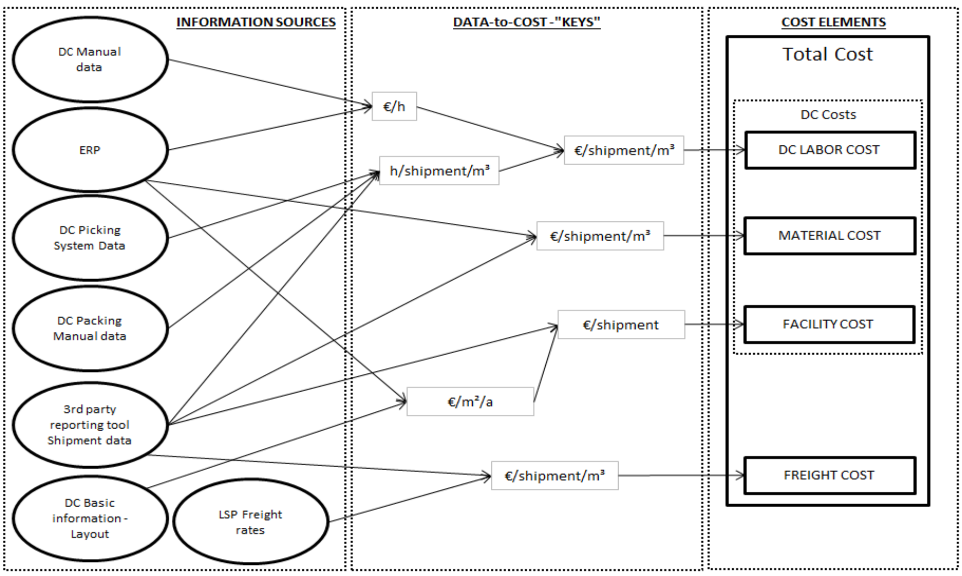

Figure 20. Data for ABC.

Multiple data sources were used and many of them were for different time period, which makes calculations and comparison challenging. The validation of data and creation of the ABC model was he most time consuming part of the thesis project. The calculations have been validated by the Company's personnel and have been confirmed accurate and realistic.

9.2 DC Outbound Labor Cost

The main cost component in the DC is labor cost. Data needed for calculating the labor cost (€/shipment for each volume class) is gathered from multiple sources: The bases for the calculations are actual budgeted DC labor costs in the year 2014 and DC's manual records of working hours and efficiency in picking and packing. Data from picking guidance system Voicelink is used for calculating picking times. The following calculations were done separately for both destination countries which are in the project scope. Separation is done because even though the basic picking work is more or less the same for each route, the packing work varies based on the destination country.

In addition to the warehouse labor (own employees and rental workers), the management labor costs are included in the labor cost. This decision was made to assign indirect management overhead to direct labor costs. Labor costs are calculated only for the outbound labor because the scope of the thesis is only on outbound processes.

First it is determined that all labor in the outbound processes ($\mathrm{lc_{ob}}$) has the same cost/hour regardless of the process phase (equation 1). This means that one hour of packing ($\mathrm{lc_{pack}}$) and picking ($\mathrm{lc_{pick}}$) are valued the same.

$$\mathrm{lc_{ob}} = \mathrm{lc_{pack}} = \mathrm{lc_{pick}} \quad (1)$$

Outbound labor hours' ($\mathrm{T_{ob}}$) share of all DC labor hours ($\mathrm{T_{dc}}$) is calculated as a percentage:

$$\%_{\mathrm{ob}} = \frac{\mathrm{T_{ob}}}{\mathrm{T_{dc}}} \qquad (2)$$

As a result of equation 2 the share of outbound hours ($\%_{\mathrm{ob}}$) from all DC labor hours is 72 %. This percentage is used in the next phase of calculating the labor cost/hour ($\mathrm{lc_{ob}}$). In equation 3 the multiplier of 72% is used to determine the share of labor cost of all DC labor costs / month ($\mathrm{lc_{dc}}$). This is divided by the outbound labor hours/month ($\mathrm{t_{ob}}$) to get the result in €/hour.

$$lc_{ob} = \frac{\%_{\mathrm{ob}} \times \mathrm{lc_{dc}}}{\mathrm{t_{ob}}} \qquad (3)$$

As a result of these calculation the cost of outbound labor is 27 €/h. When taken into account equation 1, it is determined that cost per hour is same for picking and packing, 27 €/h. This cost/hour is used as a base for later calculation of cost/shipment.

When calculating the labor cost for parcel shipments, it is necessary to calculate the cost €/carton (parcel box). The data produced by packing workers is used for calculating the packing efficiency. The labor cost/carton ($\mathrm{lc_{parcel}}$) is calculated from equation 4.

$$\mathrm{lc_{parcel}} = \frac{\mathrm{lc_{ob}}}{\mathrm{P}} \qquad (4)$$

The previously calculated outbound labor cost ($\mathrm{lc_{ob}}$) is divided by the packing efficiency (P), which is measured in cartons/hour. This efficiency indicator differs according to the parcel shipment type (web shop, courier, B2B etc.). The reason for this is that cartons with certain shipping destination and LSP need more protection in the box which takes more time and decreases packing efficiency.

For pallet shipments the total labor cost (LC_{pallet}) is only based on the outbound labor cost(lc_{ob}) and picking time (t_s). This is the picking labor cost/shipment (LC_A). Picking time for each volume class is calculated from the Voicelink data, which indicates the real picking time per shipment per volume class.

$$LC_A = lc_{ob} \times t_s \tag{5}$$

Because parcel picking is done simultaneously for multiple shipments, the real picking time per shipment calculated by Voicelink is not correct. In Voicelink data, the picking time for all shipments in certain picking task is the same; the total picking time of the whole picking task. For parcel shipments the real picking time was calculated by allocating the Voicelink picking time according to delivery lines in each shipment compared to the whole picking task. This way each parcel shipment got its real picking time that can be used for calculating picking labor cost.

The total labor cost for pallet and parcel shipments differs in picking time but parcels also have the additional cost of packing($\mathrm{LC_B}$). The cost of packing is calculated by first dividing the total volume of the shipment ($\mathrm{V_{ship}}$) (which is 1,5 times the SAP volume on average) by the volume of the biggest carton used ($\mathrm{V_{parcel}}$) regularly and rounding it up to the nearest full carton**.** This gives the average number of cartons in the shipment. Number of cartons is multiplied with the labor cost/carton ($\mathrm{lc_{parcel}}$). This gives the cost of packing in €/shipment (equation 6).

$$\mathrm{LC_B} = \frac{\mathrm{V_{ship}}}{\mathrm{V_{parcel}}} \times \mathrm{lc_{parcel}} \tag{6}$$

An assumption is made: even if the Company would start shipping larger shipments in parcels, the maximum size of cartons that are used would be the same. This leads to calculations being more comparable and easier to execute, because the average amount of cartons per shipment in each volume class for larger volumes is possible to estimate based on available information. Other option for the company would be to start using bigger cartons to reduce the number of cartons per shipment, but for this option accurate calculations can’t be made, because packing efficiency is indicated only according to the current packing instructions. It can be estimated that even if the Company would start using bigger cartons and there would be fewer cartons in one shipment, one carton would take more time to pack and the packing labor cost/shipment would remain more or less the same.

The total labor cost for pallet shipment (LC_{pallet}) and parcel shipment (LC_{parcel}) are then (€/shipment):

$$LC_{pallet} = LC_A \tag{7}$$

$$LC_{parcel} = LC_A + LC_B \tag{8}$$

Equations 7 and 8 illustrate perfectly the basic difference between the labor cost in pallet and parcel shipments. The cost caused because of increased amount of packing work wasn’t taken into account in the original assumption of achieving savings by sending more shipments in parcels. The numerical results of labor cost calculations are presented along with other cost resources in the chapter 9.5.

9.3 Freight Transportation Cost

Freight transportation cost calculations were the most time consuming and trickiest to get accurate and comparable. Calculations are based on currently (September 2015) used price rates in each route. In some pricing files that were used, the rates include the fuel surcharge (FSC) and in some don’t, but always within the same destination country both pallet and parcel prices are calculated according to the same logic: if FSC is not available for other shipment type, then it is not included in the other type either. This way the prices are comparable.

Because the volume classes are set according to the SAP calculated volume, the volume needs to be corrected for freight. There is always some empty space in shipments and generally the chargeable weight is based on dimensional weight instead of real weight. Because of this empty space, factor of 1,5 is used to make the freight cost comparable. In practice this means that if shipments SAP volume is 0,1 m^3, the freight cost is calculated for 0,15 m^3. The factor of 1,5 comes from analysis of how much empty space there are in shipments on average. It is used in practice when the DC workers book shipments from LSPs. For pallet shipments the addition of the pallet itself and difficulties in organizing the retail boxes and products causes this extra volume. For parcels this is basically result from empty space inside the cartons, because of different shapes of products and the use protective materials and the fact that there are only standard sizes of cartons available instead of unique cartons for each product.

In many cases the pricing is indicated per weight, so dimensional weight factors are used for converting the price to each volume class. Dimensional weight factor is 250 kg/m^3 for parcels (200 kg kg/m^3 in Sweden) and 333 kg/m^3 for pallets. These are official factors that are used by LSPs in contracts between the Company and LSP. Because the rates and pricing models are different for each destination country, all calculations are done separately for both destinations according to following.

In Finland's figures, the FSC is included in both parcel and pallet rates. As mentioned, in domestic shipments three separate LSPs are used. One LSP is used for B2C parcel shipping, another for B2B parcels and yet another for pallet freight. For B2C parcels the pricing is based on €/carton + €/kg according to the real weight of shipment. The freight cost for each volume class is calculated by first transferring the volume to corresponding dimensional weight by using the factor of 250 kg/ m^3. Then the price for each volume class' chargeable weight is calculated by setting the base price for carton and adding the chargeable weight multiplied by €/kg. This results in a price (€/shipment/volume class), that represents the real cost quite accurately. For B2B parcels the calculation logic is the same, but the price of €/shipment and €/kg is different because of another LSP is used.

For pallet shipments the freight cost was easier to determine. During the domestic tender, the LSPs participating had to fill a simulation file with their prices. This simulation file included all yearly pallet shipments of all volumes (real volumes) to all destinations, so the cost/shipment was calculated by dividing all the tender file shipments in volume classes and determining the average price for each volume class. This average is then already destination weighted average.

Sweden's calculations don't include the FSC. All the freight to Sweden is handled by one LSP. This LSP prices the parcels by €/weight band. Same rates are valid to all destinations in Sweden. Volume classes were transformed to weight bands by using the dimensional weight factor of 200 kg/m³. Then the price for each weight band can be easily read from the pricing file. In pallet prices the pricing is also based on weight band but also on destination. Again the volume was transferred into chargeable weight by using the dimensional weight factor of 333 kg/m³. Then the rates for each weight band are calculated as destination weighted average based on shipments to each post code.

The visual presentations of freight costs per each country were presented in the chapter 8 when the different pricing policies where discussed. The numerical results of freight cost calculations are presented along with other cost resources in the chapter 9.5.

9.4 Material & Facility Cost

Minor cost resources are package material and packing facility costs. Share of these costs from the total logistics cost is small, but they are included to make the comparison of parcels and pallet as accurate as possible. Package material and packing facilities costs don't depend on the destination country and route, so these calculations can be used for all countries. Packing materials are handled as direct expense and therefore they are related to the cost object directly, without any activity.

For calculating the material cost, the results of DC manager's previous calculations were used. For 1 m^3 shipment, the package material costs for pallet shipments is 5 € on average. This includes the pallet (3 €) and protective wrappings and possible cardboards used. For same size parcel shipment the package material costs are approximately twice the amount of pallet shipments, 10 € because of multiple cartons and lots of protective materials used. This is scalable to smaller shipments also, because when the shipment gets smaller, the amount of cartons decreases.

For pallet shipments the package material costs lower down to 3 € (which is the minimum cost one pallet) when the size of shipment decreases. This is because even if the shipment is really small, there is still always the pallet included. The package material cost/shipment per volume class is presented in the chapter 9.5.

The cost of having packing facilities is allocated to parcel shipments by the share of packing area from the whole DC area. The area information is based on the layout blueprint of the DC and the annual rent for the DC is from the actual budget for the year 2014. These figures are used to measure the price of floor area in euros. In equation 9, the packing area cost fc (€/m^2) is calculated for the packing stations by dividing the rent for whole DC (R) with the total DC floor area (A_{dc}). Then the combined area of the packing stations ($A_{packing}$) is divided by the rent/square meter to get the packing stations' share of the rent.

$$\mathrm{fc} = \frac{A_{packing}}{\frac{\mathrm{R}}{\mathrm{A_{dc}}}} \qquad (9)$$

To allocate the packing facility cost for shipments (FC), rent/packing area needs to be divided by the number of parcel shipments per year (s). In this case the volume doesn't matter because the packing station cost is the same for each shipment, regardless of shipment size. Equation 10 gives the packing facility cost in €/shipment.

$$\text{FC} = \frac{fc}{s} \tag{10}$$

The numerical results of packing facility cost calculations are presented along with other cost resources in the chapter 9.5.

9.5 Total Cost

The results of ABC –calculations are presented in the following tables and figures. The calculation results of each cost resource by volume class are presented for each destination country individually. Then the total cost comparison is presented as a graph where the total cost for parcel is in blue color and for pallet in red. As the main result of the whole thesis project, the graphs visually point out the optimal split volume which is the crossing point of parcel and pallet total cost curves. Detailed explanation and analysis of the results are discussed in the "Results" –chapter (chapter 10). Cost of Goods Sold –figures (COGS) are also included in the tables but explained more in detail in the results discussion.

Table 6 presents the total cost figures for shipments in Finland. Web shop figures are included also even though in practice web shop shipments are always shipped in parcels. It can be seen that the freight cost and the DC labor cost are the most significant cost resources. For parcel shipments the labor cost increases rapidly as the volume grows, because of additional cartons that need to be packed. This increases the labor cost significantly. For pallet shipments freight is more dominant cost resource, whereas the labor cost increases much more slowly than for parcel shipments. Total cost comparison for Finland is visualized in figure 21. According to the calculations, parcel shipping (normal parcels) is cheaper when the volume of the shipment is under 0,15 m^3. This means that he current split volume of 0,2 m^3 is not optimal and should be lowered to 0,15 m^3.

Table 6. Finland, total cost.

FINLAND	VOLUME CLASS											
Parcel Normal	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6
Nr of shipments/a	19668	2901	1629	1098	0	0	0	0	0	0	0	0
DC Outbound Labor Cost	2,8 €	5,7 €	9,9 €	12,6 €	16,3 €	19,6 €	22,8 €	26,1 €	29,3 €	32,6 €	35,9 €	39,1 €
Freight Cost	5,5 €	8,0 €	10,4 €	12,9 €	15,3 €	17,8 €	20,2 €	22,7 €	25,2 €	27,6 €	30,1 €	32,5 €
Package Material Cost	0,5 €	1,0 €	1,5 €	2,0 €	2,5 €	3,0 €	3,5 €	4,0 €	4,5 €	5,0 €	5,5 €	6,0 €
Facility Cost	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €
Total Cost	9,4 €	15,3 €	22,5 €	28,1 €	34,8 €	41,0 €	47,2 €	53,4 €	59,6 €	65,9 €	72,1 €	78,3 €
COGS Average	33,5 €	178,6 €	288,5 €	405,6 €	489,1 €	606,3 €	729,2 €	889,7 €	885,5 €	1 143,5 €	884,9 €	1 421,2 €
Cost/COGS %	28%	9%	8%	7%	7%	7%	6%	6%	7%	6%	8%	6%
Parcel Webshop	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6
Nr of shipments/a	28632	288	60	9	0	0	0	0	0	0	0	0
DC Outbound Labor Cost	3,5 €	6,8 €	10,1 €	15,4 €	19,2 €	23,6 €	27,5 €	31,5 €	35,4 €	39,3 €	43,3 €	47,2 €
Freight Cost	7,3 €	9,3 €	11,3 €	13,4 €	15,4 €	17,4 €	19,5 €	21,5 €	23,5 €	25,6 €	27,6 €	29,6 €
Package Material Cost	0,5 €	1,0 €	1,5 €	2,0 €	2,5 €	3,0 €	3,5 €	4,0 €	4,5 €	5,0 €	5,5 €	6,0 €
Facility Cost	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €
Total Cost	11,9 €	17,7 €	23,5 €	31,4 €	37,7 €	44,7 €	51,1 €	57,6 €	64,1 €	70,5 €	77,0 €	83,5 €
COGS Average	33,5 €	178,6 €	288,5 €	405,6 €	489,1 €	606,3 €	729,2 €	889,7 €	885,5 €	1 143,5 €	884,9 €	1 421,2 €
Cost/COGS %	35%	10%	8%	8%	8%	7%	7%	6%	7%	6%	9%	6%
Pallet	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6
Nr of shipments/a	0	0	0	0	1452	1116	684	675	489	390	396	324
DC Outbound Labor Cost	4,3 €	5,0 €	5,8 €	6,5 €	7,3 €	8,0 €	8,7 €	10,0 €	11,2 €	12,3 €	13,1 €	13,4 €
Freight Cost	12,8 €	11,2 €	11,4 €	12,7 €	15,5 €	15,7 €	17,8 €	18,0 €	20,6 €	20,1 €	22,9 €	23,3 €
Package Material Cost	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €
Facility Cost	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €
Total Cost	20,1 €	19,2 €	20,2 €	22,2 €	25,8 €	26,7 €	29,5 €	31,1 €	34,8 €	35,4 €	39,0 €	39,6 €
COGS Average	33,5 €	178,6 €	288,5 €	405,6 €	489,1 €	606,3 €	729,2 €	889,7 €	885,5 €	1 143,5 €	884,9 €	1 421,2 €
Cost/COGS %	60%	11%	7%	5%	5%	4%	4%	3%	4%	3%	4%	3%

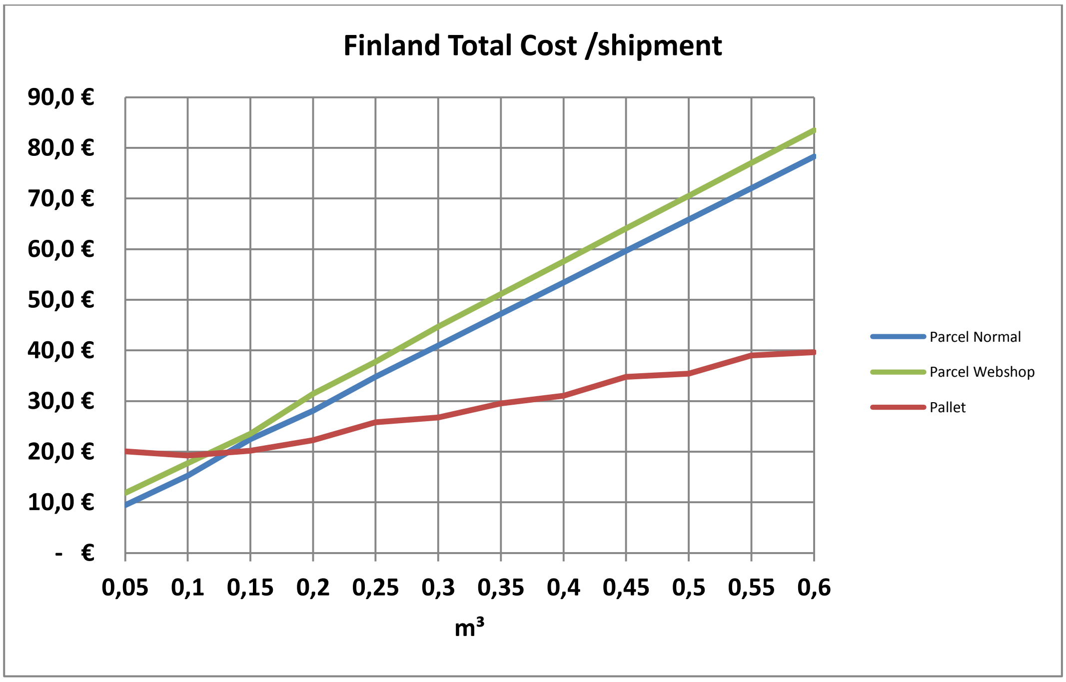

Figure 21. Finland, total cost comparison.

Total cost and split volume results for Sweden are presented in table 7 and figure 22. Results are similar compared to Finland. The main difference is that parcel freight is clearly cheaper than pallet freight and therefore the optimal split volume should be 0,3 m³ instead of current 0,2 m³. Above 0,3 m³, parcel packing labor cost rises high and pallets become cheaper shipping solution.

Table 7. Sweden, total cost.

SWEDEN	VOLUME CLASS											
Parcel	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6
Nr of shipments/a	6858	1980	1110	813	0	0	0	0	0	0	0	0
DC Outbound Labor Cost	2,8 €	5,8 €	9,7 €	12,6 €	17,1 €	20,0 €	22,9 €	27,4 €	30,3 €	33,2 €	37,7 €	40,6 €
Freight Cost	8,0 €	8,0 €	12,2 €	17,8 €	17,8 €	23,6 €	40,1 €	40,1 €	40,1 €	40,1 €	50,3 €	50,3 €
Package Material Cost	0,5 €	1,0 €	1,5 €	2,0 €	2,5 €	3,0 €	3,5 €	4,0 €	4,5 €	5,0 €	5,5 €	6,0 €
Facility Cost	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €	0,6 €
Total Cost	11,9 €	15,4 €	24,1 €	33,0 €	38,0 €	47,2 €	67,1 €	72,1 €	75,5 €	78,9 €	94,1 €	97,5 €
COGS Average	36,3 €	157,9 €	257,9 €	354,2 €	461,6 €	543,4 €	601,8 €	720,6 €	759,3 €	952,8 €	850,1 €	1 125,6 €
Cost/COGS %	33%	10%	9%	9%	8%	9%	11%	10%	10%	8%	11%	9%
Pallet	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6
Nr of shipments/a	0	0	0	0	531	474	300	351	288	222	219	150
DC Outbound Labor Cost	7,1 €	7,8 €	8,5 €	9,3 €	10,0 €	10,8 €	11,5 €	12,6 €	13,5 €	14,3 €	16,0 €	18,8 €
Freight Cost	9,5 €	9,5 €	16,7 €	22,2 €	34,7 €	34,7 €	44,9 €	44,9 €	50,3 €	50,3 €	50,3 €	50,3 €
Package Material Cost	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €	3,0 €
Facility Cost	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €
Total Cost	19,6 €	20,3 €	28,3 €	34,5 €	47,7 €	48,5 €	59,4 €	60,5 €	66,8 €	67,6 €	69,3 €	72,1 €
COGS Average	36,3 €	157,9 €	257,9 €	354,2 €	461,6 €	543,4 €	601,8 €	720,6 €	759,3 €	952,8 €	850,1 €	1 125,6 €
Cost/COGS %	54%	13%	11%	10%	10%	9%	10%	8%	9%	7%	8%	6%

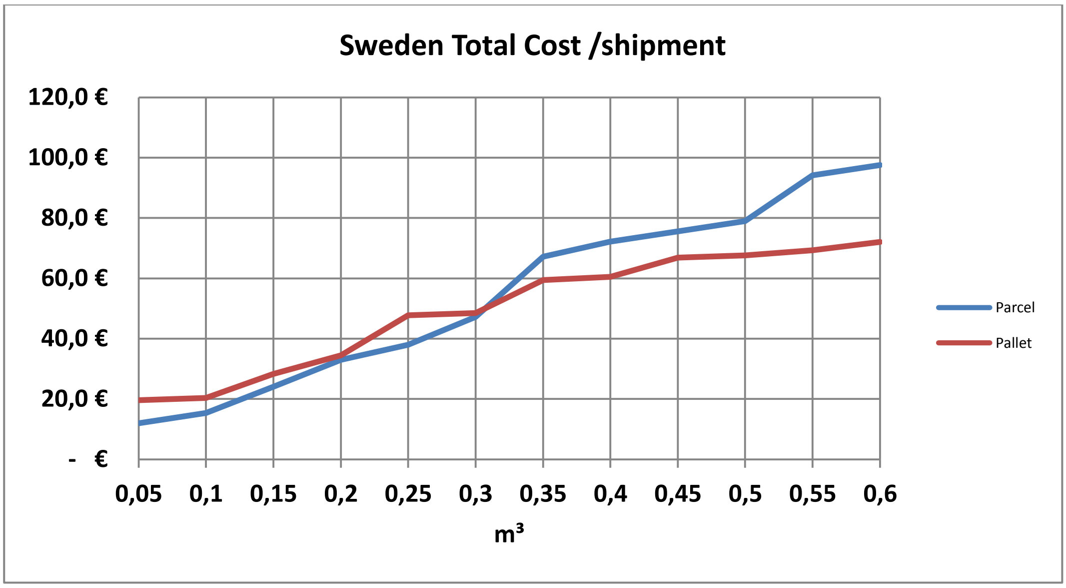

Figure 22. Sweden, total cost comparison.

10 RESULTS

This chapter presents the findings and results of the thesis project and answers the research questions set in the beginning of the thesis project. The most important and interesting results to the Company are presented first. These are cost saving related practical results that are likely to cause further actions. Then the other findings are presented to give the Company some ideas on developing their operating model and processes. The final section discusses some topics for future research and presents possible development projects.

10.1 Main Results

The Company had an assumption that it should increase the split volume and shipping bigger parcels would decrease costs considerably. Based on this assumption and the need of evaluating all the things affecting the decision of the split volume, two main research questions were set:

RQ1: *What is a cost efficient and practical way of delivering road freight shipments and what are the realistic cost savings with it?*

RQ2: *What should be the split volume limit in the distribution center?*

From the results of ABC calculations a major conclusion can be drawn: using a “universal” split volume for all routes is not justified. Also setting this volume automatically higher is not self-evident. The optimal split volume varies quite much depending on the destination country. This is mainly due to the differences in freight rates and the number of parcel boxes in an average shipment. The cost efficient and practical way of shipping goods is to make the decision of using parcels or pallets according to new calculated optimal split volumes for each route individually (table 8)**.**

Estimated savings are calculated as follows for both scenarios: the amount of shipments per each volume class is gotten from the Voicelink –data. Then the number of shipments, which are changed from parcels to pallet shipments or vice versa according to new optimal split volume, is multiplied by the difference in total cost per shipment for parcels and pallets.

With optimal split volumes the annual savings are around 13 000 € which is equal to 0,4 % of the total DC and freight logistics spend in the scope of this study. Savings are not as significant as the Company hoped for, but analysis of the logic and reasons for smaller savings than anticipated is valuable for the Company. It is also important to keep in mind that these savings are achieved by optimizing 50 % of shipments. Possible savings from other routes can be bigger or smaller, further conclusions based on these calculations are not possible, because one finding of this thesis was that split volume settings vary a lot according to the route. The summary of optimal split volumes and savings for each route are presented in table 8.

Table 8. Split volumes and savings by route.

Route	**Current split**	**New Split**	**Savings/a**	**DC Cost Effect**	**Freight Cost Effect**
FI-FI	0,2 m^3	**0,15 m^3**	**7 000 €**	- 6 500 €	- 500 €
FI-SE	0,2 m^3	**0,3 m^3**	**6 000 €**	+ 8 500 €	**-** 14 500 €
Total			**13 000 €**	+2 000 €	-15 000 €

It is good to keep in mind that these calculations are estimates, since averages and grouping of volume classes have been used. Nevertheless they give accurate enough result on desired level with reasonable amount of calculation work. Biggest causes for possible errors are the real number of cartons per parcel shipment, which heavily affects the DC labor cost and the correct use of freight rates when transforming volumes to chargeable weight. Calculations were tested multiple times by using slightly different values for these two variants and in the end the total cost savings/a settled between 12 000 € and 17 000 €. Final result of 13 000 €/a, is the outcome of the calculations which were seen as realistic as possible.

It is important to understand the reasons, why the results vary so much between different routes. In table 8, “DC cost effect” indicates the change in DC labor, packing material and packing facility costs if the shipment type is changed. Similarly, “Freight cost effect” indicates the change in freight costs when split volume is set optimally. Based on these calculations and findings, conclusion can be made, that it is not possible to determine a general ratio between the DC cost effect and Freight cost effect. This means that you can’t calculate how much of costs of added DC work “eats” from freight cost savings as a percentage. This varies very much again based on the route’s pricing and number of cartons in parcel shipments. Examples of different effects are discussed in more detail in following paragraphs.

In Finland the assumption was to send bigger parcels and achieve savings through decreased freight costs. But rather than setting the split volume higher, it should be lowered as the calculations show. New split volume should be set at 0,15 m^3, which means that smaller shipments should be shipped on pallets. Shipping under 0,15 m^3 shipments on pallets is not practical anymore, so this can be thought as the absolute minimum split volume.

There are two main reasons why the split volume should not be increased at all. First, the amount of extra packing work caused by shipping larger shipment in parcels reduces big part of the savings that can be achieved by using parcels. Actually the main savings in shipments to Finland comes from decreasing DC costs when more shipments are shipped on pallets. Other factor was that the prices for pallet shipments decreased significantly as the result of latest domestic road freight tender. The prices dropped almost 50 % compared to previous rates. This led to parcel shipping losing its price advantage, but also to the change of LSP.

In Sweden the calculations support the initial assumption. Optimal split volume is 0,3 m³. This is because of competitive parcel prices and because parcels that are shipped to Sweden are relatively lightly protected and therefore quickly packed. This reduces the cost effect of additional DC work. Additional packing still has a big effect on total savings but the decreased freight cost is dominant in this case. This is an indication for concentrating on more efficient packing to decrease the packing cost and benefit from competitive parcel rates.

Packing capacity is already on its limits during peak seasons. This means that the DC can't handle much more parcels than currently. In case of Sweden's increased amount of parcels the capacity needed is relieved from Finland's parcel shipments that in the future are shipped on pallets. Parcel packing will still increase but in the scope of this thesis, adding new packing stations is not needed. When these calculations are made for the remaining routes, parcel share can grow significantly and discussion of setting up new packing stations becomes relevant.

Technical solution for setting the split volumes by route means designing transportation matrix logic in SAP, where the shipment type is decided based on not only the volume but also the route (destination). Setting this functionality in SAP is possible, but there would be some additional costs related to it. The matrix should be designed so that it is possible to change the split volume easily (manually by DC workers), according to future ABC-calculations. Practical solution for achieving savings but also dealing with the limitations of packing capacity is to set the SAP logic regarding the split volume flexible. This means that during higher demand the delivery manager or DC worker can adjust the split volume according to the work list on packing stations: if packing stations can't handle more parcels at the moment the split volume can be lowered to original 0,2 m³ (or 0,3 m³) temporarily.

10.2 Other Findings

Besides the main research questions, also help research questions were set in the beginning of the thesis project. These questions focused more on evaluating the current state of processes and on how to develop them. The questions were set as follows:

RQ3: *What are the problems in current way of doing things?*

RQ4: *How could the Company affect logistics costs (freight rates and DC costs)?*

Answers for these questions are presented in following paragraphs. These other findings and suggestions based on them are also very important and useful for the Company in their goal of optimizing their shipping and achieving cost efficiency. Other findings in this thesis project can be divided in five topics based on the area they are related to (much like the main empirical chapters of the thesis): High cost of shipping small shipments, DC processes, execution of tenders, better understanding of pricing and rates, and data related problems caused by incompatibility of multiple IT systems.

1. *High cost of shipping small shipments*

Additional important finding was made as a result of calculations. The logistics costs compared to the COGS (cost of goods sold) – value is up to 33% on smaller parcel shipments (web shop shipments). In practice this means that one third of revenue gained from selling these products goes in covering logistics costs. It is important to keep in mind that these costs are not even including all of the logistics cost, since the costs calculated are only the ones where parcel and pallet shipment differ from each other. All the overhead costs related to customer service, rents, machinery etc. are left out from these figures. This along with fact stated in the introduction chapter, that the logistics costs are usually around 10-15 % of all spend in a company, means that it is not reasonable to ship these small shipments with the current operating model. For the Company, this finding can be considered as important as the setting of the optimal split volumes. This needs further investigation and a project for finding solutions for already started in the Company. In practice a solution could be for example setting a minimum limit for products that have to be bought at the same time to increase the value of the shipment, or setting the price of shipping higher for customers to cover the costs better.

2. *DC Processes*

Conclusion is that the DC functions and processes are designed well when taken into account the size and type of the DC and there are no major cost savings achievable through development actions. Smaller adjustments can be made, but they don't have significant effect on the DC labor, material and facility costs. DC packing work is cost intensive and making this process more efficient (even though it is well designed for current DC set up) could lead to reducing DC labor costs in the future. If there are major changes done in the processes in the future, for example added packing stations, the ABC –calculations need to be updated to see the changes in optimal split volumes.

3. *Tendering*

The major freight cost savings come from negotiating better freight rates which are achieved by regular tendering. Tenders should be executed yearly to achieve rates which are valid for the next year. The development suggestions to the tender process are presented in this thesis to support efficient and easier tendering**.** These include better tender material preparation by using the existing reporting tool for gathering the tender data easily and making sure that the data quality is good. By preparing the tender material well, the Company saves time and resources, but also the tender process is easier for the LSPs and they can provide more accurate rates which in practice means better results for the Company.

Also the follow-up of the bidding phase by securing the correct contact information and engaging the LSPs fully to the RFQ phase are topics in which the Company needs to be more alert. Utilization of e-tendering solutions such as e-RFx and e-Auctions should become standard part of tenders when it is reasonable to use them. The ABC calculations should also be done after each tender since the outcome of the tender (the price rates) affect significantly the setting of the optimum split volume.

4. *Pricing & rates*

As the Company has many routes domestically and internationally it is using many different LSPs for shipping goods. The company should carefully evaluate which LSP to use based on the pricing model and rates but also service level and earlier experiences with the LSPs. Parcel shipment rates and choosing the LSP(s) for parcel shipments is an area in which optimizing and further study has to be made.

During the thesis project, it became evident that the Company doesn’t have clear picture of the freight rates that are in use. It would be important to solve these kinds of issues and be aware of current rates and pricing. Also some kind of better invoice checking should be in place to avoid unpleasant surprises.

Currently the Company should request prices on shipment level since there are multiple cartons in one parcel shipment when the volume increases. If in the future bigger cartons are used and the amount of cartons per shipment decreases, it would be cost efficient to request rates on carton level. Current pricing model for Denmark is a working example of this: carton-based pricing is exploited by sending shipments in larger and fewer cartons and this way the cost/shipment is really cheap compared to pallet pricing.

5. Data & IT systems

During the thesis project it became clear that collecting and combining data for making different analyses and calculations was really difficult. The main reason for this is that there are multiple IT solutions in use and the link between them is in many cases missing. Best example is that the data regarding deliveries in the Company's own ERP and the shipment level data provided by LSPs through third-party solution were almost impossible to combine. The link between these two is essential when calculating and evaluating the connection between the real freight costs and DC costs of shipments.

This could be solved by setting a standardized logic on which reference to be used in both systems. Now the other one uses delivery numbers as a reference when the other gives LSPs freedom to include any reference they want. In some cases the reference is the delivery number and the data can be linked but in many cases not. Not only would this make the data analysis easier, but also the supply chain visibility would become better and LSP management decisions would be based on comprehensive reports. The link of data quality to more efficient tender preparation is also good to keep in mind.

10.3 Future Research

This thesis project has already led to further projects inside the Company. Based on the findings from this project there are several topics that need to be examined in the future. The main conclusion, that the split volume should not be set same for all routes, leads to the need of evaluating and calculating the split volume for the remaining routes that were not included in this thesis' calculations. These represent 50 % of total spend and potential savings can be achieved. Possible savings depend heavily on freight pricing on each route. Current freight pricing should also be investigated more in detail to find possible errors in invoicing.

When it comes to the ABC calculations done during the project, it is necessary to develop a model or tool for executing these calculations efficiently rather in hours' than in weeks' time (the time it took during the thesis project). Also the utilization of the calculations in other DCs should be discussed.

Development of the transportation matrix in ERP has started and the goal is to implement volume, weight and route-based warehouse management logic for determining the shipping mode in every major European distribution centers. The aim is to develop a tool that can be used and modified easily by the DC workers.

Another major finding was that in small shipments logistics costs are relatively really big compared to the value of the goods. Further projects should focus on developing a practical but also cost efficient model on dealing with small shipments which are mainly web shop related. Already mentioned solutions could be setting a minimum price limit on web shop purchases so that the shipments become larger or setting the price of shipping higher to cover the real costs.

Products have already more optimized tendering processes but useful procedures and e-tender solutions can be used in other sourcing also. When the tender process is standardized, material preparation and bidding process execution are efficient and the benefits of e-tendering tools are utilized, it could be possible to exploit the findings of this thesis in sourcing of finished goods and raw materials also.

11 SUMMARY

In the beginning of this thesis project, the Company had an assumption that they could achieve significant savings in freight costs by sending larger shipments in parcels. However, their evaluations don't take into account the effects of sending large parcels in distribution center (DC) costs. Therefore more detailed calculations needed to be made to determine the real savings that could be achievable in total logistics cost. For determining these savings, the major components of logistics costs; transportation and warehousing (DC) costs were included in the calculations.

Based on these calculations, a volume which divides the shipments in parcels and pallet shipments is set. This is the so-called split volume. Shipments under the split volume should be sent in parcels and shipments over the split volume should be sent on pallets. The Company also wanted to know if their processes related to DC work and freight tendering were optimized or if there were development topics to be discussed in these areas. The scope of the thesis project covers outbound processes in Finland DC and shipping to destinations Finland and Sweden, which cover 50 % of freight spend.

Activity-based costing was used as a model for calculating the total cost of shipping and optimal split volumes. Split volumes were calculated by comparing the total cost of parcel shipping and pallet shipping by volume class. As a part of the thesis project the DC processes were compared to the models found in related literature. The tendering process of the Company was studied by participating in real freight service tenders. Then development suggestions were made based on the findings in tenders and relevant theory was used to justify these actions.

Results indicate that the original assumption of setting the split volume higher was not completely correct. Actually the split volume should be set a little lower compared to current level in Finland's shipments. In practice this means sending smaller shipments on pallets instead of parcels. This is due to competitive pallet prices and expensive packing work. After this realization the activity-based costing -calculations were run for Sweden also. It became evident that the split volume should be determined individually for each destination country. The reason for this is mainly the different pricing models that are used by different LSPs in each country. Annual savings for the routes, that were in scope of the thesis, would be around 13 000 € (0,4 % of DC and freight cost), if split volumes are set optimally. This is significantly less than what the Company expected.

Other findings show that the DC is running more or less optimally, and potential savings could be achieved by developing the freight service tendering process. Company should come up with a better and more cost efficient way of shipping small shipments. Company should also pay more attention on what kind of pricing models the LSPs are using and optimize its packing accordingly. Data systems should be developed to create access to all data more easily.

Next step would be running these calculations to the remaining routes in Finland DC and then act accordingly (e.g. setting up new packing stations). Then the calculations presented in this thesis should also be done for Company's each major DC to determine the total Company level cost savings. As a result of this thesis' findings, these projects have already been initiated.

REFERENCES

Bartholdi, J.J. & Hackman, S.T. 2011. Warehouse & Distribution Science. Atlanta, The Supply Chain and Logistics Institute, School of Industrial and Systems Engineering, Georgia Institute of Technology. 299 p.

Becker, H. & Glad, E. 1995. Activity-Based Costing and Management. Cape Town, Juta & Co. Ltd. 231 p.

Boyd, J.D. & Page, P. 2006. Changing the Shape of Pricing. *Traffic World.* issue: October 2006, pp. 10-12.

Coburn, C. & Mhay, S. 2008. Request for...Procurement Processes (RFT, RFQ, RFP, RFI). [www-document]. [used as a reference 28.7.2015]. Available: http://www.negotiations.com/articles/procurement-terms/

Crainic, T.G. 2000. Service Network Design In Freight Transportation. *European Journal of Operational Research*. Vol. 122, issue 1, pp. 272-288.

De Koster, R. 2004. How to assess a warehouse operation in a single tour, Report, RSM Erasmus University, the Netherlands.

De Koster, R., Le-Duc, T. & Roodbergen, K. 2007. Design and control of warehouse order picking: A literature review. *European Journal of Operational Research.* Vol. 182, issue 2, pp. 481–501.

DHL Express. 2015. Volyymipaino. [www-document]. [used as a reference 20.10.2015]. Available: http://www.dhl.fi/fi/tyokalut/volyymipaino_express.html

Fabbe-Costes, N., Jahre, M. & Roussat, C. 2009. Supply chain integration: the role of logistics service providers. *International Journal of Productivity and Performance Management*. Vol. 58, issue 1, pp. 71 – 91.

Frazelle, E. 2002. World-class warehousing and material handling. New York, McGraw-Hill. 241 p.

Goetschalckx, M. & Ashayeri, J. 1989. Classification and design of order picking. *Logistics World.* Vol. 2, issue 2, pp. 99-106.

Gu, J., Goetschalckx, M. & McGinnis, L. 2007. Research on warehouse operation: A comprehensive review. *European Journal of Operational Research.* Vol. 177, issue 1, pp. 1-21.

Gu, J., Goetschalckx, M. &, McGinnis, L. 2010. Research on warehouse design and performance evaluation: A comprehensive review. *European Journal of Operational Research*. Vol. 203, issue 1, pp. 539-549.

Haapanen, M. & Oksanen, R. Kuljetustalous. 1986. Mikkeli, Ekondata Oy. 319 p.

Huang, K. & Chi, W. 2006. A Lagrangian relaxation based heuristic for the consolidation problem of airfreight forwarders. *Transportation Research Part C: Emerging Technologies*. Vol. 15, issue 4, pp. 209-278.

Iloranta, K. & Pajunen-Muhonen, H. 2012. Hankintojen johtaminen. Helsinki, Tietosanoma Oy. 431 p.

Innes, J. & Mitchell, F. 1998. A Practical Guide to Activity-Based Costing. London, Kogan Page Ltd. 159 p.

Karrus, K. E. 2005. Logistiikka. Helsinki, WSOY. 419 p.

Lambert, D.M., Grant, D.B., Stock, J.R. & Ellram, L.M. 2006. Fundamentals of Logistics Management. Singapore, McGraw-Hill. 436 p.

Mäkelä, T., Mäntynen, J. & Vanhatalo, J. 2005. Logistiikka ja kuljetusjärjestelmät. Tampere, Tampereen teknillinen yliopisto, Liikenne- ja kuljetustekniikan laitos. 165 p.

Mäkinen, I., Saarialho, A. & Timmerbacka, E. 1992. Kuljetusjärjestelmät. Mikkeli, MH -Konsultit. 434 p.

Ng, L., Dickson, K.W.C & Hung, P.C.K. 2007. Tendering Process Model (TPM) Implementation for B2B Integration in a Web Services Environment. *Proceedings of the 40th Hawaii International Conference on System Sciences*.

Noventia Oy. 2015. Sähköinen kilpailutus. [www-document]. [used as a reference 29.9.2015]. Available: http://www.noventia.fi/index.php?id=33

Posti Oy. 2015a. Kotimaan rahti – Tuote-ehdot (Julkinen). [www-document]. [used as a reference 20.10.2015]. Available: http://www.posti.fi/liitteet-yrityksille/ehdot/rahti-tuote-ja-toimitusehdot.pdf

Posti Oy. 2015b. Kansainvälisten tavarankuljetuspalveluiden tuote-ehdot sopimusasiakkaille (Julkinen). [www-document]. [used as a reference 20.10.2015]. Available: https://www.posti.fi/liitteet-yrityksille/ehdot/kv-kuljetuspalvelujen-tuote-ehdot.pdf

Roodbergen, K.J. 2001. Layout and routing methods for warehouses. PhD thesis, RSM Erasmus University. Netherlands.

Salanne, I., Päätalo, M. & Musto, M. 2005. Tienpidon vaikutukset kuljetusten täsmällisyyteen. Tiehallinnon selvityksiä. 3/2005. 71 p.

Solakivi, T., Ojala, L., Laari, S., Lorentz, H., Töyli, J., Malmsten, J. & Viherlehto, N. 2014. Logistiikkaselvitys 2014. Turun kauppakorkeakoulun julkaisuja. 1/2014. 193 p.

Swenseth, S.R. & Godfrey, M.R. 2002. Incorporating transportation costs into inventory replenishment decisions. *International Journal of Production Economics.* Vol. 77, pp. 113-130.

Teich, J.E., Wallenius, H., Wallenius, J. & Koppius, O.R. 2003. Emerging Multiple Issue e-Auctions. *European Journal of Operational Research.* Vol. 159, issue 1, pp. 1-16.

Tompkins, J.A., Bozer, Y.A., Tanchoco, J.M.A. & White, J.A. 2003. Facilities Planning. Hoboken, John Wiley & Sons Inc. 750 p.

Töttö, P. 2000. Pirullisen positivismin paluu – Laadullisen ja määrällisen tarkastelua. Tampere, Osuuskunta Vastapaino. 224 p.

UPS. 2015. Tilavuuspaino. [www-document]. [used as a reference 20.10.2015]. Available:http://www.ups.com/content/fi/fi/resources/ship/packaging/dim_weight.html

Weiskott, M.N. 1999. Hub and Spoke. *Plants, Sites and Parks.* Vol. 26, issue 4, pp. 23-25.

Zeng, A.Z. & Rossetti, C. 2003. Developing a framework for evaluating the logistics costs in global sourcing processes: An implementation and insights. *International Journal of Physical Distribution & Logistics Management.* Vol. 33, issue 9, pp. 785-803.

Özkaya, E., Joseph, V.R., Keskinocak, P. & Weight, R. 2010. Estimating and benchmarking Less-than-Truckload market rates. *Transportation Research, Part E: Logistics and Transportation Review*. Vol. 46, issue 5, pp. 667-682.