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Logistical efficiency in comparison when outsourcing from Asia versus outsourcing from Europe

A case study on a shoe developing company

A Bachelor Thesis within the program Economics and Manufacturing Technology

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Abstract

Icebug AB's headquarter is located near Gothenburg in a town named Jonsered. The company has 26 employees and the net sales of 2018 were around 157,4 million SEK. Main areas of conducted business are designing, developing and selling outdoor shoes for extreme weather conditions.

The purpose of this case study was to evaluate the difference in logistical efficiency based on outsourcing Icebug AB's production of a specific product from an Estonian vendor versus outsourcing from a Vietnamese vendor. The current state (Vietnamese case) is based on data from 2018. The prospective state (Estonian case) is based on data from 2018 and feedback from the Estonian vendor.

To be able to validate the data in this study, open-ended cross sectional interviews with multiple departments were conducted and multiple documents were overviewed. Furthermore, the processed data was reviewed, compared and followed up with informal interviews. Procedures such as checking transcripts for mistakes and comparing findings from multiple sources were implemented.

The logistical efficiency was limited by variables such as total cost, tied up capital, customer service, delivery flexibility, environmental impact and time to market. The supply chain was delineated with the boat freight from the vendors to the main storage facility in Gothenburg.

To examine the purpose, the current state (Vietnamese case) and prospective state (Estonian case) were compared. The difference in outsourcing the production of product a specific from Estonia versus outsourcing from Vietnam were: The total cost will decrease with 30%, the overall customer service will improve, the overall tied up capital will be minimized, the overall environmental impact will decrease, and the delivery flexibility will increase.

This study concluded, on the basis of the empirical evidence and evaluated factors, that Icebug AB should change the outsourcing of the production of the specific product to Estonia.

Sammanfattning

Icebug AB:s högkvarter är beläget nära Göteborg, i staden Jonsered. Företaget har 26 anställda och 2018 hade de en omsättning på 157,4 miljoner kronor. Verksamheten går ut på att designa, utveckla och sälja skor för extrema väderförhållanden.

Syftet med denna fallstudie var att utreda skillnaden i logistisk effektivitet av att outsourca Icebugs AB:s produktion av en särskild produkt från en estländsk leverantör kontra att outsourca från en vietnamesisk leverantör.

Det nuvarande tillstånd (Vietnamesiska fallet) grundar sig på data från 2018. Det framtida tillståndet (Estländska fallet) grundar sig på data från 2018 och återkoppling från den estländska leverantören.

För att validera den insamlade data utfördes intervjuer på olika avdelningar och flera dokument undersöktes. Utöver detta analyserades data, jämfördes och följdes upp genom olika informella intervjuer. Den insamlade data från olika källor korrekturlästes och jämfördes inbördes.

Den logistiska effektiviteten begränsades till följande effektivitetsvariabler: Total kostnad, kapitalbindning, kundservice, leveransflexibilitet, miljö och tid. Den logistiska kedjan begränsades med båtfrakten från respektive leverantör till huvudlagret i Göteborg.

För att utreda syftet jämfördes det nuvarande tillståndet (Vietnamesiska fallet) och det framtida tillståndet (Estländska fallet). Skillnaden i att outsourca produktionen av en utvald produkt från Estland kontra att outsourca från Vietnam var: Den totala kostnaden kommer att minska med 30%, kundservice förbättras, kapitalbindningen minskas, miljöpåverkan minskas och leveransflexibiliteten kommer att öka.

Fallstudies slutsats var, med grund in den empiriska undersökningen och dem undersökta faktorerna, att Icebug AB bör outsourca produktionen av en utvald produkt till Estland.

Contents

1 INTRODUCTION

This chapter provides an introduction to the study. The chapter gives the reader a brief introduction to the subject and an understanding of the background, purpose and delimitations of the conducted study.

1.1 Background

The business principle outsourcing is defined as the action of partially or entirely transferring production of products or services to an outside company. The company which is obtaining goods or services from another company is called a Buyer while the company which produces goods or services is called a Vendor (Dolgui & Proth, 2013).

Outsourcing became a world wide phenomena in the latter part of the 1980s establishing itself as a legitimate business principle. Although it has become popular during the last 40 years, the principle is centuries old and derive from the concept of specialization. The concept can be defined as the concentration of an activity in those lines of production whereat the business has some advantage (Jenster, 2005). Outsourcing, more specifically outsourced manufacturing was in the beginning seen as a way to minimize or eliminate those activities that were not considered a core competency (Hartman et al., 2017). Due to the rapid growing of the global market and global competitiveness, the main purpose of outsourcing was to be able to focus on the core competencies at a more cost efficient basis (Hartman et al., 2017).

Outsourcing has increased the complexity and demand on the supply chain networks. Thus, it has increased the importance of logistics control for manufacturing and distribution operations. Reasons for outsourcing vary dependent upon the company business model and some of the reasons are business competition, production flexibility and time to market (Sandhu et al., 2018).

This study examined the possibilities of outsourcing in Europe based on a case study on the Swedish company Icebug AB. Icebug AB's headquarter is located near Gothenburg in a town named Jonsered. The company has 26 employees and the net sales of 2018 were around 157,4 million SEK. Main areas of conducted business are designing, developing and selling outdoor shoes for extreme weather conditions (mostly for winter conditions). The current retail market is predominantly located in the Scandinavian countries. There are ongoing projects for expanding the retail market in countries such as Germany and the USA.

The business venture is based on sustainable and durable products where the customer is offered repairs when needed. Repairs are done locally with material supplied by the manufacturer. The company does not own any production facility and is currently in partnership with a vendor. The vendor is located in Ho Chi Minh City, Vietnam.

Time to market varies dependent upon the complexity of the product. The development phase lasts around 11 month which extends from the conceptualization to the launching of the product. Two months after the launching, the vendor receives their first order of production. The time frame for ordering product is about 7 months per year. The assembly of the product is estimated to take about 1,5 months. The vendor is available to deliver the merchandise 4 months after the first order of production. Sea freight, customs, cargo terminal and truck transportation take about 5-6 weeks. In conclusion, the time to market is approximately 1,5 years.

The company has a long partnership with the vendor. The partnership is characterized by good communication, transparency and discounts. Most importantly, there is mutual trust and understanding. However, the distant geographical location requires a long forward planning which leads to a delayed return on invested capital. What's more, it requires a high level of finished goods inventory due to the long freight. The long freight is subjectable to unpredicted risks and the high temperature inside the containers contaminate the goods with mold. Decontamination generate additional cost. The high level of finished goods inventory and the large amount of monthly shipped cargo increase cost and tied up capital.

Due to the seasonal variation in sales, on-time delivery is crucial. Past due orders in combination with long lead times are a liability in relation to the customer service. Notwithstanding the long partnership, problems that occur are often communicated late leaving the buyer with a small time frame to react.

Icebug AB is striving for a more sustainable business model. Therefore, outsourcing to a nearer country appears to be an eligible alternative. However, in this case the economical factor is the deciding factor which needs to be weighted in the comparison.

1.2 Purpose

The purpose of this study was to evaluate the difference in logistical efficiency based on outsourcing the production of a specific product from Estonia versus outsourcing from Vietnam.

1.3 Delimitations

This study was limited to examining a best selling product that is composed of 32 components. There was limited data shared by the vendors regarding the cost drivers that arise in the manufacturing of the product and therefore was not analyzed. In addition to this, there was limited data shared by the vendor in Vietnam regarding the sourcing of all the components and therefore, it was not be included into the evaluation. However, the sourcing cost is estimated to be included in the buyers purchasing price for the studied product.

The supply chain was delineated to the main storage facility in Gothenburg. Hence, the study did not include cost drivers for transportation of the merchandise to the customers.

The logistical efficiency was limited by variables such as total cost, tied up capital, customer service, delivery flexibility, environmental impact and time to market.

1.4 Research questions

The main objective of the study was to provide a decision basis for Icebug AB towards evaluating the possibility of whether or not outsourcing the production of a specific product to Estonia. All available and relevant data on key performance indicators was used to provide the decision basis. In order to be able to provide a concrete decision basis, the questions below need to be examined and answered. The following questions examine the difference in outsourcing the production of a specific product from Estonia versus outsourcing from Vietnam.

1. What is the difference in logistical total cost of a specific product?

The difference in total cost gives an understanding of which logistical activities lead to an increased total cost.

2. How will the environmental impact change?

Environmental sustainability is aligned with the company goal and therefore, needs to be examined. The environmental impact is delineated to carbon dioxide, energy consumption, nitrogen oxides and sulfur dioxides.

3. How will the customer service change?

Stock availability and delivery lead time are crucial for maintaining customer service. Therefore, examining how the vendor impacts customer service contributes to a more relevant decision basis.

4. How will the delivery flexibility change?

Delivery flexibility creates value for the customer and impact indirect variables such as customer service, total cost and tied up capital. Therefore, it is important to examine for a more comprehensive conclusion.

5. What is the variance in tied up capital?

Tied up capital affects cash flow, ability to pay and generates cost. Therefore, it gives an alternative perspective on the logistical activities.

6. Which other factors are relevant to take into consideration?

Factors that are not decisive and not directly associated with logistical activities are presumed to affect the decision basis.

This study concludes, on the basis of the evaluated factors, whether or not Icebug AB should outsource the production of a specific product to Estonia.

2 METHODOLOGY

The methodological approach for solving the research questions is presented in this chapter. This chapter gives the reader an overall explanation of the research method and explain in depth data collection, literature gathering and the chosen strategy. The final subchapter depicts how the questions were answered.

2.1 Research method

To be able to understand and explain a case study, a qualitative method is preferred (Söderbom & Ulvenblad, 2016). A qualitative purpose statement characterizes itself by including words such as *purpose*, intent or objective (Creswell, 2009). Furthermore, the statement focuses on a single circumstance and comprise of action verbs such as describe, examine and *evaluate*. Qualitative research questions generally begin with words like *what* or *how* and the questions are formulated without reference to theory.

Firstly, a qualitative method requires data collection from the environment where the actual question arises. Secondly, a qualitative method requires multiple sourcing of information and data such as interviews, documents and observations. Thirdly, the focus on the research should be aimed towards understanding the actual problem and not what already is explained in the literature (Creswell, 2009).

Examples of qualitative methods are case studies, observations and interviews.
Söderbom & Ulvenblad (2016) explains the methodology case study as a holistic perspective applied on one or several cases dealing with real world phenomena such as a company.

A Case study consists of two essential parts which are its scope and its features, therefore a binary definition is required in order to understand what a case study is. Starting with the scope, a case study is a practical approach, where researchers examine the case and its circumstances. The complexity in differentiation between the case and its circumstances lead us to the second part of the definition, which is the features. A case study confronts the complexity of the case and its circumstances by regarding the case as the only data point. In other words, by being comprehensive. Various source of evidence is required for a case study inquiry. Furthermore, the inquiry utilizes the improvement of previous literature to manage the collection and analysis of the data (Yin, 2014).

2.2 Data collection

The primary task was to collect data to be able to answer the research questions. Data collection in a case study differs from other research methods. Moreover, the procedures in a case study are not chronological and requires non ended cooperation between collected data and theory (Yin, 2014). Reliability procedures such as checking transcripts for mistakes and comparing findings from multiple sources add to a more consistent case study (Creswell, 2009)

Documentation, archival records, interviews and direct observation are all different sources of data. Interviews are considered as a source of evidence. In a case study the interview is

preferred to be open-ended. In other words, the questions are more broadly formulated. Thus, making the interviewee more capable of expanding upon the questions rather than be restricted by questions boundaries. Other more informal definitions of this type of interview methodology are “intensive interview”, or ”in-depth interview” (Yin, 2014).

Open-ended interviews are conversational in style and can be categorized by its length and structure. Prolonged interviews extended over two hours or more. Moreover, the interview can occur in one or more sessions. Shorter interviews might be more concentrated than the previous one and occur during one session (Yin, 2014).

To be able to validate the data in this study, open-ended cross sectional interviews with multiple departments were conducted and multiple documents were overviewed. Furthermore, the processed data was reviewed, compared and followed up with informal interviews. Procedures such as checking transcripts for mistakes and comparing findings from multiple sources were implemented.

2.3 Theory review

A theory review is required to be able to understand and interpret the data. The process of gathering literature was ongoing throughout the whole case study. The literature consisted of scientific articles, printed books and e-books. Most of the literature was acquired through Chalmers library search engine. Recent literature was prioritized to add a more contemporary perspective to the study. Primary keywords for searching literature are shown down below.

Keywords: Outsourcing, total cost, logistical efficiency, supply chain.

2.4 Strategy

Processing the collected data requires a determined analytical approach. Which strategy to implement depends on the type of case at hand and the type of collected data. There are four general strategies that can be implemented in a case study (Yin, 2014).

- Relying on theoretical propositions: The starting point in this strategy is to track theoretical assumptions which intuited the case study. The purpose of the case and objectives was established by those assumptions. This implies a declaration whether or not initial assumptions have been proved.
- Working your data from the “ground up.”: The starting point is collecting and analyzing data. Thereafter, form a theoretical assumption.
- Developing a case description: Existing gaps in current literature or/and self-interest acts as an essential source for formulating the framework. This strategy is useful to evaluate propositions of a certain nature.
- Examining plausible rival explanations: This strategy is appropriate when reviewing literature leads us to an opposing proposition. Those propositions can be investigated and put forward through new evidence. This type of strategy can be combined by previously mentioned strategies.

The framework in this study was determined by the self-interest of the company, which was aligned with the strategy of developing a case description. Hence, the framework was determined by what was prioritized and relevant for the company. Therefore, the framework was expected to change during the research due to the predicted uncovering of additional data. In hindsight, the framework was restricted by the lack of uncovered data and was changed accordingly.

2.5 Approach

The aim of the case was to compare the current logistical efficiency to the prospective logistical efficiency. That is to say, to compare the current state to the prospective state.

Figure 2.1 shows the methodological approach which is explained in further detail below.

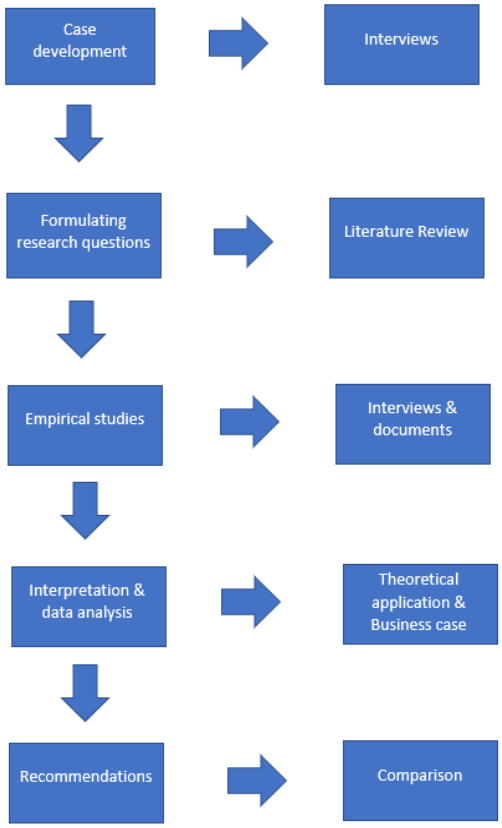

Figure 2.1: Approach methodology

The first step, case development, was to get a further understanding of the problem through open-ended cross sectional interviews with multiple departments.

The second step, formulating research question, dealt with acquiring theory through an informal literature review process.

The third step consisted of empirical studies. Prolonged interviews, informal interviews and documents were used for acquiring data and information about the current state. Interviews were mostly time limited to one hour. Interview questions were emailed in advance, clarified during the interviewee and followed up after the interviews. No formal interview template

was used and the questions framework was determined by what was prioritized and relevant for the company and the conducted study.

The fourth step, interpretation and data analysis, was to interpret and analyze calculations by applying the theoretical framework. To be able to provide a concrete decision basis based on the prospective state, a business case was presented to the vendor in Estonia. The business case was developed by the quality department. The development consisted of choosing what subcontractors the vendor was sourcing from. The aim of the business case was to derive a manufacturing cost of the product which was the predicted purchasing price. Expected pitfalls were communication barriers and a prolonged deadline. However, the deadline for feedback was prolonged to extensively and exceeded the project scope deadline. Therefore, no purchasing price was derived from the business case. See appendix 3 for further details. On the other hand, the Estonian vendors production capacity and the lead time for sourcing the components were derived from the business case which made it possible for lot sizing and MRP planning.

Subsequently, in order to make recommendations the advantages and disadvantages of the current and prospective state was weighed against each other both quantitatively and qualitatively.

3 THERORETICAL FRAMEWORK

This chapter will provide the reader an understanding of the subject and the theoretical background for the conducted study. The argumentation in the analysis chapter is based on what is put forward in this chapter.

3.1 What is logistics?

Jonsson & Mattsson (2016) defines the conceptual word *logistics* as:

"Planning, organizing and controlling all activities in the material flow, starting from the acquisition of raw material to the final consumption and return flow of products and materials, whose purpose is to satisfy the customer and other stakeholders needs and desires".

The main purpose of conducting logistics according to Jonsson & Mattsson (2016) is to increase the overall efficiency of the business, and hence enhance the profit. Logistics can be described as an open system that interacts with its environment. The system comprises of different stakeholders that exists both inwards and outwards of the company. Constantly exchanging information and material.

3.2 Logistical efficiency

Logistical efficiency can be described in efficiency variables that are represented in different measurements. In order to have competitive advantages, efficiency variables are used as tools for setting up, measuring and following up goals (Jonsson & Mattsson, 2016). The efficiency variables listed below are not mutually exclusive.

- Customer service
- Total cost
- Tied up capital
- Time
- Environmental impact
- Social aspects

The economical aspect of logistics is described with variables that affects revenue, costs and assets. Variables that indirect impacts the economical aspect are time and flexibility. Logistical efficiency can also be described as sustainable efficiency by combining economical, environmental and social variables. Many of these variables contradict each other and must be prioritized according to the overall company goal (Jonsson & Mattsson, 2016).

Stock et al. (2005) asserts that the marketing concept is dependent upon logistics. The marketing concept state that the purpose of a business is meeting customer need. Customer satisfaction, integrated effort and company profit are three key elements of the concept that are constantly interchanging with each other. The integrated effort is based on having the right product, at the right price, at the right place and combined with the right promotions. At the right place is dependent upon customer service. Customer service is the key for gaining

competitive advantage and by aligning customer service with customer need, it ultimately results in cost reduction. The trade off between logistical activities such as transportation costs, warehousing costs and inventory carrying cost impact customer service. The total cost concept is a useful tool for analyzing the trade off.

Most of the efficiency variables are conflicting, as previously explained. Therefore, all efficiency variables must be considered to increase the overall logistical efficiency. The trade off is visible when prioritizing a certain efficiency variable. A high customer service is achieved with a high finished good inventory which leads to higher tied up capital and higher carrying cost. Flexible and quick transportation often leads to higher environmental impact (Jonsson & Mattsson, 2016).

Different logistical solutions signify different cost which results in alternative environmental impact, customer service and social aspects that are not always possible to estimate in quantitative terms. Therefore, qualitative estimates are used to evaluate how cost affect other efficiency variables (Jonsson & Mattsson, 2016).

3.2.1 Customer service

Customer service is an umbrella term for services provided for the customer with correlation to business agreements. Services and activities revolving around customer service include the buyer, the vendor and the third partner. Activities such as delivery and transactions are connected to the material flow and mutually add value to the product. These activities also include long term partnerships, agreements and business deals. The common denominator of these activities is the potential to impact the revenue (Jonsson & Mattsson, 2016). Increased customer service increases opportunities for customer growth which directly increases income (Oskarsson et al., 2013).

Customer service include activities that arises before the order, from order to delivery, during delivery and after delivery. Activities before the order include preconditions for the customer to place an order (Jonsson & Mattsson, 2016). Activities from order to delivery reference to how easy it is for the customer to place an order and in which capacity the supplier can adjust crucial for a good customer service. Customer service during the delivery, delivery service is about how the to the fluctuation in customer demand. Transparency in communicating past due orders is order is carried out which includes if it is in time, undamaged and correct. After the delivery, delivery service include the customers ability to trace the components of the product, to acquire spare parts and reclaim or repair the product (Jonsson & Mattsson, 2016).

Order to delivery is the most relevant activity to examine from a logistical perspective (Jonsson & Mattsson, 2016). Listed below are the most ordinary elements of delivery service.

- Stock availability
- On-time delivery
- Delivery dependability

- Delivery lead time
- Delivery flexibility

Perfect order achievement measures the overall level of service performance during a specific period. It determines the combined effect of three elements: on time, complete and error free (Stock et al., 2005). Equation (1) calculates the perfect order rate.

$$Perfect\ order\ =\ \%\ on\ time\ *\ \%\ complete\ *\ \%\ error\ free \qquad (1)$$

Stock availability

Stock availability is to what extent a stocked product is available for delivery. It is a measurement on the probability of direct delivery to customers when demand arises. Below are quantitative methods listed for measuring stock availability (Jonsson & Mattsson, 2016).

- Share of completed orders directly delivered from stock
- Share of order lines available for direct delivery from stock
- Share of products available for direct delivery from stock

Stockouts on the shelf impact both the manufacturer and retailer. Over two-thirds of the purchase at the retailer are prompt by seeing product on the shelf. Thus, the stockout forces the customer away from the brand (Christopher, 2016).

On-time delivery

On-time delivery refers to which extent delivery is made according to what is agreed upon with the customer. This element is used for products that are not stock kept and directly delivered to the customer. Past due orders and too early delivered orders in combination with low reserve stock leads to extensive consequences (Jonsson & Mattsson, 2016).

Delivery dependability

Delivery dependability measures the quality of the delivery in terms of the right product delivered in the right quantity. Delivery dependability is measured as the total amount of delivered orders without customer complaint in relationship to the total amount of delivered orders. Customer complaints extends from wrongly delivered quantity of product to wrongly delivered product quality. Product quality defects can arise in the manufacturing process or during the transportation and handling (Jonsson & Mattsson, 2016).

Delivery lead time

Delivery lead time is the time from when the customer order is received to the completed delivery. Delivery lead times are measured in days or weeks. An extensive delivery lead time reduces the delivery flexibility, increases tied up capital and capital cost due to an increased safety stock (Jonsson & Mattsson, 2016). Past due orders take up stock volume which put restraint on the current stock keeping (Oskarsson et al., 2013).

Delivery flexibility

Delivery flexibility is the ability in adjusting to fluctuations in customer demand and ongoing orders. For instance, adjustments to delivery time and order quantity. Fluctuations in customer demand is the capacity in adapting to irregular delivery time and order quantities. Fluctuations in ongoing orders requires high capacity to redirect orders in order to accommodate customer desire. Delivery flexibility creates value for the customer and impact indirect variables such as customer service, total cost and tied up capital (Jonsson & Mattsson, 2016).

Maximum contribution margin

Expenditures for activities such as transportation, warehousing and inventory management can be considered expenditures for customer service. Customer service, more specific stock availability is often increased by stock investment. The increased stock results in increased logistical costs (Stock et al., 2005). If customer service increases by increasing sales it will not directly impact the revenue. Therefore, there is a maximum contribution margin restricting the possibility on increasing the customer service (Jonsson & Mattsson, 2016).

3.2.2 Total cost

Logistical costs arise directly or indirectly by activities included in the logistics process. Focusing on the total cost of logistical activities should be prioritized, rather than focusing singularly on each of the activities. Reducing cost for individual activities can lead to an increased overall total cost (Stock et al., 2005). Figure 3.1 shows a visual representation of the total cost concept.

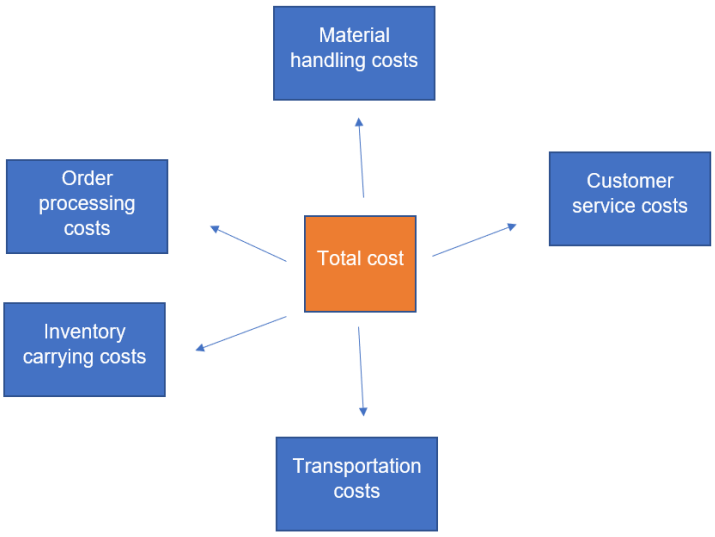

Figure 3.1: The total cost concept, adapted from Stock et al. (2005).

Separate costs are cost that arises or recede as a consequence of a decision. Joint costs are cost that remains unaltered as a consequence of a decision (Jonsson & Mattsson, 2016).

Material handling costs
Material handling cost often include activities such as receiving goods, inventory control and withdrawing inventory (Oskarsson et al., 2013).

Customer service costs
Customer service costs include product return costs, cost of lost sales, costs of spare parts and service support. Product return costs have a decisive impact on how customers view the organizational customer service. Cost of lost sales include the lost contribution of current and potential future sales (Stock et al., 2005). Additional costs can arise if delivery method or rout is changed due to delays or changes in customer demand (Jonsson & Mattsson, 2016).

Transportation costs
Transportation costs arises when administering and transferring products (Oskarsson et al., 2013). Transportation of goods ties up capital and generates capital cost (Jonsson & Mattsson, 2016). Relatively low transportation costs are often obtained on the expense of customer service which can generate additional costs such as costs regarding an increased safety stock.

Ordering processing costs
Order processing costs arises when processing customer orders, demand forecasting and maintaining information systems. Ordering processing costs include administrative costs regarding order entry, order handling, notifying customers of information regarding shipping and product availability (Stock et al., 2005).

Inventory carrying costs
Inventory carrying costs are the most difficult to identify. Therefore, the costs that vary with the amount of inventory are the most relevant to consider for decision making. There are four components attributed to the inventory carrying cost which are capital cost, inventory service cost, storage space cost and inventory risk cost (Stock et al., 2005).

Capital cost on inventory investment is equal to the return that the company could have made if it had not tied up its capital in the current inventory. Companies experiencing capital shortage should use the minimum rate of return on new investments as the capital cost. If not, the cost of capital should be determined as if the value from a diminishing of inventory would be invested otherwise (Stock et al., 2005). The value of the inventory varies dependent upon which type of products that are stored and in turn as the specific value of each and every stored product. The specific value of a stored singular product is often determined based on a standardized price. The standardized price of a purchased product is often equal to the purchasing price of the product (Jonsson & Mattsson, 2016).

Inventory service cost include inventory related taxes (Some states in the United States of America) and insurance cost (Stock et al., 2005). Storage space cost for rented storage spaces are often variable and based on the amount of rented pallets (Jonsson & Mattsson, 2016).

Inventory risk cost should include the cost of damage, obsolescence and movement within the inventory system (Stock et al., 2005).

Carrying charge is proportional to the inventorial volume and based on the established capital cost and the inventory risk cost. The carrying charge is supposed to mitigate the risk of having capital tied up in the inventory (Oskarsson et al., 2013). The equation (2) illustrates how to calculate the carrying charge.

$$Carrying\ charge = (\ Capital\ cost\ (\ Sek/\ year) + Inventory\ risk\ cost\ (\ Sek\ /\ year)) \div Average\ stock \quad (2)$$

Cost associated with carrying inventory are generally among the logistical activities with highest costs. In many organizations inventory carrying costs have never been established and managers usually determine the costs based on textbook percentages or industry averages. However, textbook percentages tend to vary dependent upon which costs the authors chose to include and upon what prime interest rate was relevant when the textbooks were published. Moreover, establishing inventory carrying costs based on industry averages is likewise flawed because of the large variations of business models and business strategies adopted in different industries. Therefore, each and every company should determine its own inventory carrying cost (Stock et al., 2005).

3.2.3 Tied up capital

Asset investments binds capital which impacts cash flow and ability to pay. The flow of goods throughout the logistical chain binds capital in the form of current assets which affect the overall tied up capital. Tied up capital directly impact profitability and indirectly impact profitability through customer service (Jonsson & Mattsson, 2016). When analysing a material flow it is important to estimate the average tied up capital occurring throughout the flow (Oskarsson et al., 2013). The average tied up capital is the total sum of tied up capital in each part of the flow. Storage, transportation and finished goods inventory are activities that bind capital (Jonsson & Mattsson, 2016).

The cost of the product increases downstream towards the customer. Therefore, stock keeping is advantageous at the beginning of the material flow and lead time reduction is advantageous close to the customer (Jonsson & Mattsson, 2016).

Tied up capital is measured in different metrics (Jonsson & Mattsson, 2016). The metrics below represent alternative methods for estimating tied up capital.

- Tied up capital key figures
- Financial key figures

Tied up capital key figures

Work in progress (WIP) is a measurement used for estimating the average stock kept in a specific part of the material flow (Oskarsson et al., 2013). Equation (3) explains how to calculate WIP.

$$WIP = Demand\ (\ amount\ /\ time\ unit\ ) * Lead\ time\ (\ time\ unit\ ) \qquad (3)$$

Average tied up capital is calculated with emphasis on the average stock throughout the material flow. Steady demand equals a linear order rate meanwhile seasonal variation equals a more periodic order rate. A linear oder rate equals in turn a more ideal average stock estimation. Equation (4) explains how to calculate the average tied up capital.

$$Average\ tied\ up\ capital\ =\ Product\ value\ (sek)\ *\ WIP\ (\ amount\ ) \qquad (4)$$

Inventory turnover rate measures how many times in a year the average stock is replaced. It gives information on the total value of the material flow during a specific time period relative to the average tied up capital (Jonsson & Mattsson, 2016). Equation (5) explains how to calculate the inventory turnover rate.

$$Inventory\ turnover\ rate\ = Demand\ (\ amount\ /\ time\ unit)\ \div\ WIP \qquad (5)$$

Run-out time explains how long time deliveries to customers can be covered by the current inventory (Jonsson & Mattsson, 2009). Equation (6) explains how to calculate the inventory turnover rate.

$$Run\ out\ time = 52\ \div Inventory\ turnover\ rate \qquad (6)$$

Financial key figures

Return on investment is usually measured as the profit relative to the invested capital. The tied up capital in stock keeping and transportation directly impact the return on invested capital. Furthermore, higher cost elements such as higher administration cost, handling cost, transportation cost and warehousing cost decreases the return on invested capital (Jonsson & Mattsson, 2016). The DuPont-model measures return on invested capital while showing the interaction between the asset turnover and the profit margin. The profit margin is retrieved from the profit and loss statement while the asset turnover is retrieved from the balance sheet (Oskarsson et al., 2013). Asset turnover and/or the profit margin must increase to be able to increase the return on invested capital. Customer service and cost elements affect the profit margin while tied up capital affect the asset turnover. Improvements can simultaneously impact positively both the profit margin and the asset turnover (Jonsson & Mattsson, 2016). Figure 3.2 shows the DuPont-model.

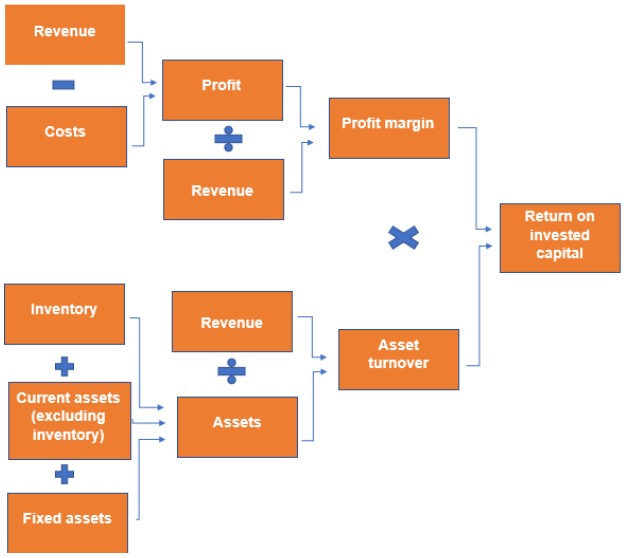

Figure 3.2: DuPont-model, adapted from Jonsson & Mattsson (2016).

Solidity measures how sustainable financially the company is. It is a ratio between the shareholders' equity and the assets (Skärvad & Olsson, 2017). Equation (7) explains how to calculate the equity ratio.

$$Solidity = Shareholders' \ equity \div Assets \qquad (7)$$

Liquidity measures the ability to pay off short term debt (Skärvad & Olsson, 2017). Equation (6) explains how to calculate the liquidity.

$$Liquidity = (Current \ assets - Inventory) \div Short \ term \ debt \qquad (8)$$

The balance sheet is often based on measurements done the 31 of December. Therefore, deliveries before that date could increase the inventory and alter the average stock levels. Likewise, the measured inventory is representative for the whole year (Oskarsson et al., 2013).

Increased customer service leads to an increased sales rate which impacts revenue directly thus, increasing the asset turnover. Moreover, decreased inventory level increases the asset turnover. Decreased costs such as transportation costs, material handlings costs and warehousing cost increases the profit margin. Decreased inventory increases solidity and liquidity (Oskarsson et al., 2013).

3.2.4 Time

Time is an essential logistical variable because it directly impacts the other variables. Short and dependable delivery lead times are an important part of an effective customer service. Delivery lead time is often referred as time to customer (TTC). While the time to market (TTM) is the time from conceptualizing the product to the product launch. However, TTM is dependent upon the delivery lead time. A shorter TTM could improve the whole business

model making the company more reactive to changes in customer demand (Jonsson & Mattsson, 2016). However, only prioritizing the variable time could lead to higher costs and inferior customer service (Oskarsson et al., 2013).

3.2.5 Environmental impact

The environmental impact of the logistical activities can be considered a part of the customer service through customers demand for more eco-friendly products and services. Traditionally, companies have prioritized the economical aspect instead of the environmental aspect. In other words, prioritizing more frequent deliveries with lower fill rates results in lower costs, lower tied up capital and higher customer service while increasing emissions and impacting the environment negatively (Jonsson & Mattsson, 2016).

Shorter delivery lead times can lead to prioritizing faster transportation which increases emissions. Emissions are dependent upon the transportational mean, the fuel type, the velocity of the transportation and the carried weight (Jonsson & Mattsson, 2016). Emissions consists of the elements listed below.

- Carbon dioxide
- Nitrous oxide
- Carbon monoxide
- Hydrocarbons
- Sulphur oxides
- Particles

The emissions listed above impact the environment and cause environmental threats (Jonsson & Mattsson, 2016). The environmental threats are listed below.

- Greenhouse effect
- Acidification
- Ground-level ozone
- Over fertilization
- Exhaustion of the ozone layer

Different transportational means

Road transportation by truck with a diesel engine have a higher emission rate of nitrous oxide and particles while having a lower emission rate of carbon dioxide relative to a petrol engine. The environmental impact of railroad transportation is dependent upon if the engine is powered by diesel or electricity. As shown in figure 3.3 the lowest energy consumption is attributed to railroad transportation. Flight transportation requires the most energy and is the highest contributor to the greenhouse effect. According to figure 3.3 is sea freight a transportational mean with a relatively low energy consumption. However, the emissions are high relative to the energy consumption (Jonsson & Mattsson, 2016).

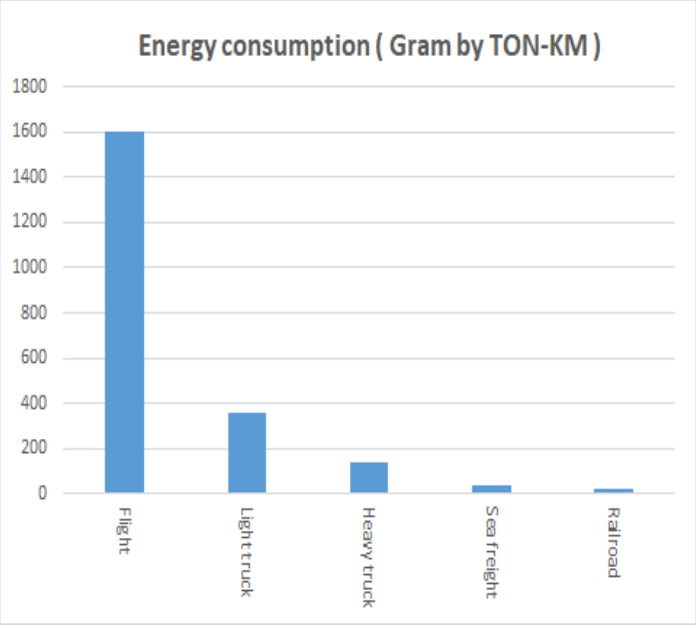

Figure 3.3: Energy consumption, adapted from Jonsson & Mattsson (2016).

Figure 3.4 shows the connection between four transportational means and four relevant factors to take into consideration when choosing transportational means.

	Sea freight	Railroad	Truck	Flight
Shipment size	Big	Big	Low	Lowest
Transportational cost	Low	Low	High	Highest
Tied up capital	High	High	Low	Lowest
Customer service	Low	Low	High	Highest

Figure 3.4: Comparison between four transportational means, adapted from Jonsson & Mattsson (2016).

Sustainable logistics

Climate change and global warming are solid evidences that human activities have potentially effect on the environment. Sustainability is defined as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*" (Christopher, 2016).

The environmental impact of the transportation system can be mitigated to some extent thru prioritizing more eco-friendly transportational means, minimize transportation and choosing alternative fuel sources. Minimizing transportation can be accomplished by a higher fill rate which lowers the amount of transportation. The average fill rate of trucks is approximately 50 %. However, less frequent deliveries and higher delivery quantities can impact customer service negatively, increase the tied up capital and contribute to a higher inventory shrinkage. An alternative for minimizing transportation is to decrease the transportational distance by choosing local suppliers or suppliers from adjacent regions (Jonsson & Mattsson, 2016).

The environmental impact is usually reported as a combination of quantified estimations and qualitative explanations of workarounds. Emissions that derive from transportational means are often quantified. There are calculation models available for estimating emissions for each and every transportational means and conditions (Jonsson & Mattsson, 2016). For example, DHL offers a carbon calculation model (DHL, 2019). In addition to this, EcoTransIT offers a free web-based calculation model for determining the environmental impact of different transportation means (EcoTransIT, 2019).

3.3 Materials planning

The aim of the material planning concept is to decide what quantities to order and when to place an order to either the in-house shopfloor or external supplier. Thus, to initiate a material flow in order to satisfy an existing need (Jonsson & Mattsson, 2016). In other words, material planning is about the answering of the following questions:

- Which items shall be included in the order?
- Which quantity for respective item shall be ordered?
- When shall the order be placed either in-house or to outside suppliers?
- When shall the ordered items be delivered to inventory?

Fundamentally, material planning addresses balancing the need and the resource of materials in the flow. If the resources are less than the need, the material flow must be increased by placing either a purchasing order or a production order (Jonsson & Mattsson, 2016).

The material flow is normally described as either a push or a pull flow. The characteristic of the material flow depends heavily on how the material flow is initiated. The material flow is a pull flow if the production and material movement are merely initiated by the consuming process. The material flow is a push flow if the production and material movement are merely initiated by producing plans or direct orders (Jonsson & Mattsson, 2016).

Inventories can be described as the following different types:

- Cycle stock inventory: This type of inventory arises when deliveries have a different pace and larger quantities compared to consumption.
- Safety stock inventory: This type aims to mitigate the damage which is caused by delayed deliveries or increased demands.
- Work in progress: The products accumulate along the flow between production process which operate at different paces. Thus, they establish disconnecting points between production process in the flow.
- Coordination inventory: This type of inventory is purposefully established to connect two parallel material flows. The outcome of those two parallel flows is then included in the next material flow which is located after the coordination inventory.
- Control stock inventory: This type appears to tackle the effects of delays in deliveries of some items which take part in constructing other complex items.

- Speculation inventory: The purpose of this type is to cover the prospective needs which are predicted to increase rapidly in the future.
- Obsolete inventory: This type function as a place to gather items which are unable to be sold or consumed in the future.
- Seasonal inventory: Seasonal products often requires a high customer service. To be able to satisfy the customer demand, inventory is successively built during a longer period and withdrawn during a shorter time period. A safety stock is often required to mitigate unpredicted seasonal fluctuations (Oskarsson et al., 2013).

The balance between needs and resources can be maintained through placing new orders either to in-house shopfloor or external supplier. Material planning has distinctive methodologies which all have been used in different organizations. The principal cause of their existence is to give a decision basis in order to answer the questions have been mentioned previously. Those methodologies have different properties which differ them in degree of appropriacy in various work environments (Jonsson & Mattsson, 2016).

3.3.1 Time dimension: Material planning methods

The following methods are based on time as a decision variable.

Re-order point system

Is an inventory control system in which a produce or purchase order is automatically placed when the number of items on hand drops to what is called the Re-order point. The Re-order point is calculated by adding safety stock inventory to anticipated demand during the lead time (Jonsson & Mattsson, 2016). Which can be expressed in the following equation:

$$ROP = SI + LT * D \quad (9)$$

Where ROP = Re-order point
SI = Safety stock inventory
D = Demand per period
LT = Lead time in periods

Inventory review is a term which implies to look back over the inventory status. Hence, to figure out if it is time to release an order or not if the inventory has not fallen below the order point. Moreover, inventory review is a factor on which order point system can be described as the original version where inventory review is continuous or periodic where inventory review occurs at predetermined period cycles (Jonsson & Mattsson, 2016).

Finally, the order quantity does not interfere in Re-order point calculations, so the number of units should be ordered has nothing to do with the moment of placing the order. The demand is expected to be continuous, independent, and uniform. However, in many cases the demand is not continuous. Thus, approaches other than the original version of order point system are needed to manage the inventory (Toomey, 2000).

Periodic review system

This method is based on periodic review where inventory review occurs at rigid cycle intervals. It is an inventory control system in which a produce or purchase order is automatically placed when the number of items on hand drops to what is called the Re-order point (Toomey, 2000). The reorder point can be expressed as the following equation:

$$ROP = D * (LT + RP) + SI \quad (10)$$

Where ROP = Re-order point
SI = Safety stock inventory
D = Demand per period
LT = Lead time in periods
RP = Review period

Since ordering is focused on meeting a target level, the order quantity will not always be the same as the original version of order point system. Generally, the target level is decided by the lead time, review period, forecast, and safety stock. The review period is decided by the running plans. However, favorable lot sizes and inventory levels have to be taken into consideration as well. Normally, the risk of variations in forecast will be higher during longer period of time compared to a smaller one. Thus, the safety stock is assumed to be higher here compared to original version of order point system as safety stock will mitigate the risk of stockout during the lead time and review period (Toomey, 2000).

Material requirements planning

MRP is a type of materials planning that aims to keep the inventory level as low as possible to lower unnecessary tied up capital. The time scheduling of deliveries is based on when the net requirements arise which is when the inventory level is depleted. In other words, an order has to be placed so it can be delivered when the number of products in the inventory are going to become negative. Safety stock or safety lead time is applicable when utilizing this method. Safety stock is managed by reducing the forecast or need with the beforehand established safety stock quantity before calculating the net requirements (Jonsson & Mattsson, 2016).

The principle when applying MRP is: Plan an order for delivery according to the first net requirement (Jonsson & Mattsson, 2016).

According to figure 3.5, if an order is not placed in week 3, the inventory level will be negative. Lead time is 3 weeks and 25 units are inbound in the inventory.

Week		1	2	3	4	5	6
Forecast/Need		20	20	10	5	5	15
Inventory	25	5	25	15	10	5	30
Net requirements		0	0	0	0	0	10
Deliveries			40				40
Planned orders				40			

Figure 3.5: Example of MRP planning.

3.3.2 Quantity dimension: Lot sizing

The quantity dimension is crucial as well as the time dimension and both has to be taken into consideration when creating the balance between needs and resources in the material flow. In other words, to decide the amount of units of an item which have to be delivered in order to keep the material flow balanced (Jonsson & Mattsson, 2016).

The economic order quantity

The principal is minimizing costs. If order costs have to be minimized, the lot size have to be maximized. On the contrary, if the carrying costs have to be minimized, the lot size have to be minimized. Those contrasting cases need to be compromised in order to obtain the optimal order quantity (Toomey, 2000). The following equation shows how to calculate the EOQ.

$$EOQ = \sqrt{\frac{2*A*S}{C*I}} \qquad (11)$$

Where EOQ = Economic order quantity
A = Annual quantity
S = Ordering cost
I = Inventory carrying charge
C = Item cost

Ultimately, there are some important points to mention. The inventory carrying charge is not determined based on accurate calculations, it is based on estimation. The Lowest point in the curve, which determines EOQ, is somewhat flat, so it is possible to rounded it up or down to meet any other order needs (Toomey, 2000).

Fixed period quantities

This method is based on already determined rigid period cycle such as a week, as two weeks, or as months. The order quantity is supposed to meet the requirements under the fixed period. Hence, the quantities are not fixed and change according to the anticipated requirements. This will lead to a more flexible operation where it is capable to adapt to any changes in the requirements. The method is especially convenient for retail and distribution environments, where it is advantage to place an order with different items from the same supplier (Toomey, 2000).

Week	1	2	3	4	5	6
Requirements	20	30	20	25	24	30
Order quantity	50		45		54	
Inventory	30	0	25	0	30	0

Figure 3.6: Inventory status when the fixed period quantities method is used.

Lot-for-lot quantities

This method is based on the same way of thinking such as in the fixed period quantities method. However, the planned order quantity of a period will be exactly equal to the requirements in the same period. In other words, the order quantity will be directly associated with the requirements. The potential problem with this method is that the ordering cost has to be minimized in order to set this method in practice. The obtained advantages will primarily be minimized inventory and lead time reduction which will both contribute to a more flexible operation (Toomey, 2000).

Week	1	2	3	4	5	6
Requirements	20	30	48	15	0	100
Order quantity	20	30	48	15	0	100

Figure 3.7: Inventory status when the Lot-for-lot quantities method is used.

3.3.3 Inventory reliability

Service levels and safety stock calculations are discussed in this chapter.

Service Levels

The knowledge of service levels is central in the context of determining the stock level. Thus, to be able to offer a service level which is seen as satisfying by the customer. Generally, the product goes through a set of buyer-purchaser tracks to finally get into the hands of the final customer. In that context each buyer has to take into consideration the requirements of his customer in order to satisfy them. To put it simply, the service level determines the level of stock in the inventory (Toomey, 2000).

The principal cause of using service levels is that there are serious consequences of not using it. The stockout will probably lead to dissatisfied customers which in turn will lead to losing future orders. In manufacturing organizations, the consequences of lack of raw materials or semi-finished components leads to inefficiency in performance (Toomey, 2000).

Safety stock calculations

When the service level is established. Safety stock can be calculated according to equation (12) (Jonsson & Mattsson ,2016):

$$SL = K * \sigma t * \sqrt{LT} \qquad (12)$$

Where SL = Safety stock
K = Safety factor
σt = Standard deviation of demand per period
LT = Average lead time in periods from order to delivery

Figure 3.8 shows a variety of safety factors in normal distribution which are related to the different service level. Thus, it is possible to determine a specific safety factor for a specific service level.

Service Level	K factor
50.00%	0.00
80.00%	0.84
90.00%	1.28
95.00%	1.65
98.00%	2.05
99.00%	2.33
99.99%	4.00

Figure 3.8: Shows different standard service levels and their respective K factors, adapted from Toomey (2000).

3.4 Supplier selection

During the supplier selection process often arises the question of whether sourcing from local or international suppliers. Local suppliers refer to suppliers located in the regional area. However, there are different dimensions to consider when selecting suppliers (Jonsson & Mattsson, 2016). Those dimensions are listed below.

- Spatial dimension
- Time dimension
- Cultural dimension

The spatial dimension refers to the geographical distance. A shorter distance between the buyer and the vendor results in lower transportation costs and enables more frequent deliveries containing lower quantities. In addition to this, it shortens the delivery lead time and improves the delivery flexibility. A shorter distance facilitates the establishment of a partnership and facilitates meetings, development programs as well as quality control procedures (Jonsson & Mattsson, 2016).

The time dimension refers to the time zone difference between the buyer and the vendor. Different time zones equate difference in work hours, lunch breaks and other types of brakes. Due to this difference there can difficulties in scheduling meetings that satisfy both partners restricting communication and flexibility. In addition to this, holidays and vacations can occur during different time periods leaving the communication impractical and sometimes impossible (Jonsson & Mattsson, 2016).

The cultural dimension refers to the difficulty in communication due to language differences. Communication barriers enhance the risk for misunderstandings and enhances the risk for disturbances in the material flow. In addition to this, there can be difference in behavioral manners and in business approach which complicates the establishment of a good partnership (Jonsson & Mattsson, 2016).

A Supplier located in the regional area have the possibility to improve the communication, achieve a higher delivery flexibility and creates possibilities for more frequent deliveries. Moreover, a shorter distance between the supplier and the customers facilitates when operating with more customer oriented business model. A reason for choosing an international supplier, especially suppliers located in Asia and Eastern Europe is the possibility of acquiring products at a lower purchasing price. Other reasons are of specific possibilities that an international supplier offer such as the possibility for an alternative quality, technology or competency (Jonsson & Mattsson, 2016).

Customer order decoupling point

A direct transactional channel is characterized by a transactional channel flowing directly from the customer to the product distributing company. The transactional flow in then transmitted to an intermediary company and the material flow is then transmitted from the intermediary company to the customer. Which means that product distributing company receives orders, manage orders and invoice customers. The delivery of the orders is handled by the intermediary company which sometimes is referred as a “inventory hotel”. This process continuously restocks the intermediary company to be able to deliver according to customer orders (Jonsson & Mattsson, 2016).

Free on Board

Free on board (FOB) are pricing terms offered by vendors to buyers. FOB means that the ownership of the goods is transferred from the vendor to the buyer as soon as they are placed on an agreed upon transportational mean. Thereafter, the buyer is responsible for the goods and accountable if the goods are damaged or destroyed. The terms of sales include matters such as when the goods shall be delivered, where the goods shall be delivered and where the responsibility ends or begins (Stock et al., 2005)

Below are some examples of terms of sale with buyer respective vendor responsibilities (Stock et al., 2005):

Terms of sale FOB-Shipping Point, Freight collected:

- Buyer pays freight charges.
- Buyer bears freight charges.
- Buyer owns goods in transit.
- Buyer files claims.

Terms of sale FOB Destination, Freight collected:

- Buyer pays freight charges.
- Buyer bears freight charges.
- Vendor owns goods in transit.
- Vendor files claims.

4 EMPERICAL STUDIES

The current state is based on collected data from year 2018. The data is gathered from interviews and reviewing multiple documents. Calculations are based and referred to the theoretical framework. Figures are utilized for helping the reader visualize and further understand the empirical data.

The prospective state is based on feedback from the Estonian vendor.

4.1 Company

Icebug AB's headquarter is located near Gothenburg in a town named Jonsered. The company has 26 employees and the net sales of 2018 were around 157,4 million SEK. Main areas of business are designing, developing and selling outdoor shoes for extreme weather conditions (mostly for winter conditions). The current retail market is predominantly located in the Scandinavian countries. There are ongoing projects for expanding the retail market in countries such as Germany and the USA.

The business venture is based on sustainable and durable products where the customer is offered repairs when needed. Repairs are done locally with material supplied by the manufacturer. The company does not own any production facility and is currently in partnership with a vendor. The Vietnamese vendors role is to manufacture the products, more specifically assemble the products with the processing steps of cutting, stitching, lasting and printing. The buyer, in this case Icebug AB, designs the product and estimate a target cost for each and every component. Some components are essential to the design and quality of the product, and thus are required to be sourced from specific subcontractors.

4.2 Products

Most products consist of around 32 components, while there are specific quality requirements for each and every component the vendor is free to select subcontractors for a variable number of components. Thereafter the vendor estimates the price for the finished product. The price is supposed to cover costs such as: the bill of material, freight from subcontractors, value added tax, carrying cost and direct labor cost as well as indirect labor cost.

There is almost no available data on transportation from the subcontractors to the vendor. There are subcontractors located in Argentina, different parts of China and Taiwan. According to an estimate based on known components of a specific product model made by Eklund (2018), the average distance from a subcontractor to the vendor is about 6 300 km by cargo ship and 760 km by truck.

Figure 4.1 shows the specific product. The shoe is designed with an urban look for outdoor use in harsh winter conditions. As previously mentioned, the study was based on this specific product and it will be referred henceforth as product A.

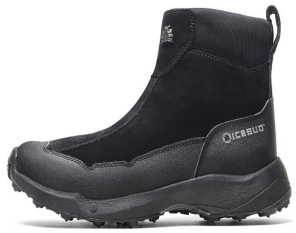

Figure 4.1: Product A.

Figure 4.2 shows another product. The shoe is designed for winter walks that require reliable grip.

Figure 4.2: Product designed for designed for winter walks.

Figure 4.3 shows a product which is designed for orienteering and off-trail running.

Figure 4.3: Product designed for orienteering and off-trail running.

Figure 4.4 shows a product which is designed for trailrunning, orienteering and swimrun.

Figure 4.4: Product is designed for trailrunning, orienteering and swinrun.

4.3 Materials planning

As previously stated, the buyer is currently in partnership with a vendor located in Ho Chi Minh City, Vietnam. The transportation from the vendor to the main storage facility in Gothenburg is handled by the buyer which mainly consists of sea freight to Gothenburg, unloading of goods, customs, cargo terminal and transportation by truck to the storage facility. The current terms of sale between the vendor and the buyer are set according to FOB-Shipping Point, Freight collect, where the buyer owns the goods in transit directly after

they are stored on the freight ship. In 2018 the cargo ships carried approximately 120 TEU (Twenty-foot equivalent unit) containing 220 662 products and travelling 2 169 791 km.

Time to market varies dependent upon the complexity of the product. The development phase lasts around 11 month which extends from the conceptualization to the launching of the product. Two months after the launching, the vendor receives their first order of production. The time frame for ordering product is about 7 months per year (December - June). The assembly of the product is estimated to take about 1,5 months. The vendor is available to deliver the merchandise 4 months after the first order of production. Sea freight, customs, cargo terminal and truck transportation take about 5-6 weeks. In conclusion, the time to market is approximately 1,5 years.

The time difference between Sweden and Vietnam is five hours which entails that meetings are either scheduled early in the morning according to the buyer's location or scheduled late in the afternoon according to the vendors location. Communication is handled in English.

The production orders consist of primary orders and additional orders that are placed according to fluctuations in customer demand. An average of 85 % of the ordered products are pre purchased by retailers and distributors while the rest are speculative. However, due to the restricted time frame for ordering products and due to the long distance between the vendor and the buyer, the first orders (Usually ranging from late December to early February) are predominately speculative. The speculative orders are based on forecasts. Forecasts are based on direct communication with large customers and expected sales. Although the first orders are speculative, most of the products eventually result being purchased by customers before being delivered to the inventory warehouse.

The customer order deadline is Mars the fifteenth and 65 % of the products are expected by the customers to be on shelves by September. Customer orders increase in frequency and in volume in proximity to the order deadline.

Figure 4.5 illustrates the order time frame for orders containing product A and when they were placed. A total of five orders containing product A were placed during the period from January to June 2018.

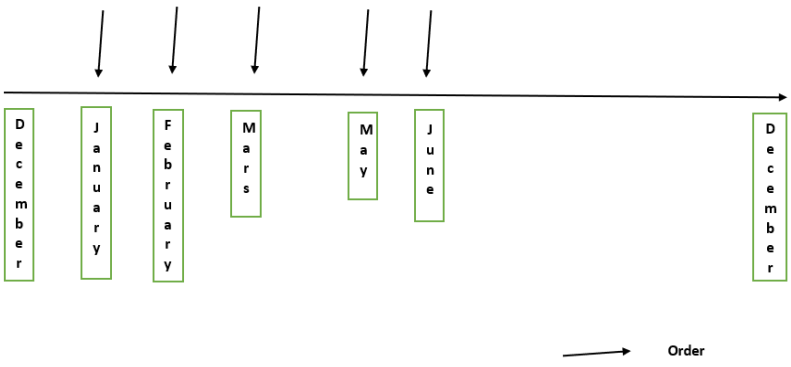

Figure 4.5: Order time frame for orders containing product A.

The customer base consists of retailers and distributors predominantly located in the Scandinavian region. In addition to this, the customer base is expanding in Poland, Germany and in North America. Large retailers and distributors purchase the products directly at the vendors location at a lower price.

Icebug's storage space is outsourced to a storage renting business where fees include storage cost, inventory withdrawal cost and inventory intake cost. A forwarding agent handles deliveries from the inventory warehouse to the customers.

Figure 4.6 shows the order flow and goods flow of product A. Around 74 % of product A is shipped to the warehouse inventory and 26 % is directly sold at the vendors location by Icebug to retailers and distributors. In other words, 26% of the transportation is outsourced. Product A is purchased at a lower price at the vendors location. Product A constitutes of about 5,6 % of the total products shipped to the inventory warehouse and is categorized as a low risk product. Therefore, for speculative reasons larger quantities of product A are ordered.

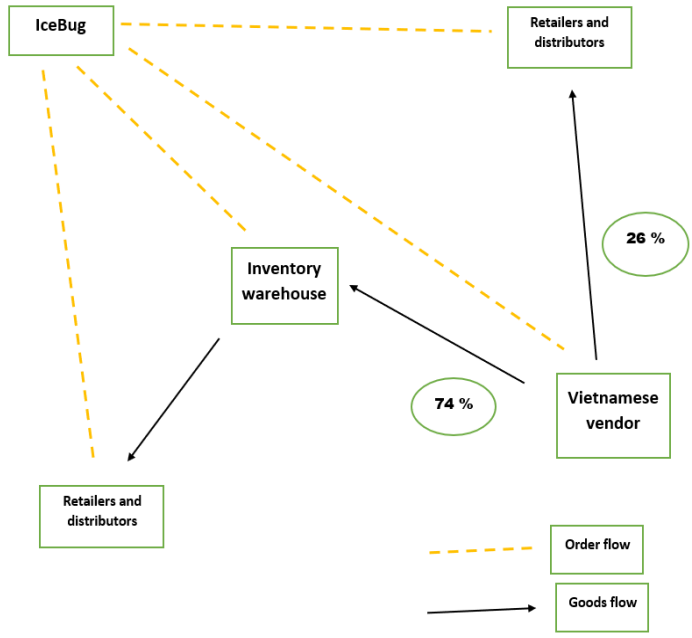

Figure 4.6: The order and goods flow of product A.

Figure 4.7 illustrates the order history of orders containing product A. The average delivery lead time which includes past due orders and too early delivered orders is 5,5 months.

Order week	Agreed upon delivery week	Actual delivery week		Difference	Delivery lead time (weeks)	Delivery lead time (months)
1803	1824	1824			21	5,25
1805	1828	1828			23	5,75
1812	1834	1834			22	5,5
		1835	Partial order	1 Week	23	5,75
1820	1841	1842		1 Week	22	5,5
1822	1845	1843		2 Weeks	21	5,25
		1845	Partial order		23	5,75
Average					22,14	5,54

Figure 4.7: Order history of orders containing product A.

In figure 4.8, the inventory withdrawal frequency is shown for year 2018. The graph shows the withdrawn amount of products on a weekly basis for the whole of 2018. Week 1814-1835 had less than three withdrawn products on a weekly basis. See appendix 1 for graph values.

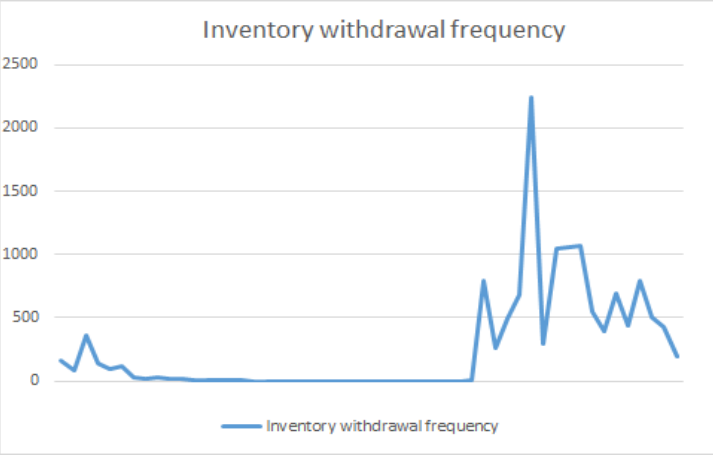

Figure 4.8: Inventory withdrawal frequency.

In figure 4.9, the inventory level and withdrawal frequency are shown for year 2018.

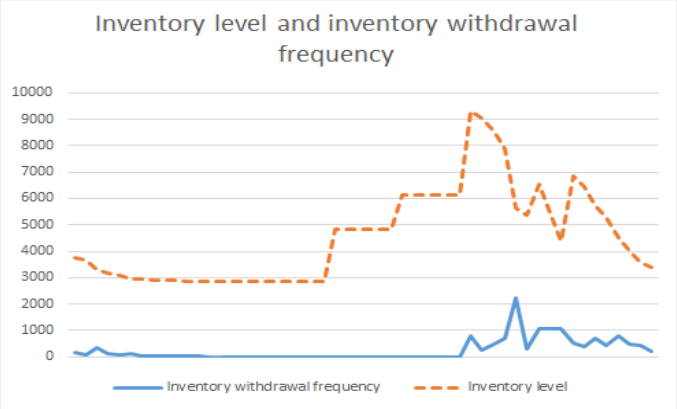

Figure 4.9: Inventory level and inventory withdrawal frequency.

4.4 Total cost

In this section, the total cost for product A is presented. Figure 4.10 shows all the costs included in the total cost calculation.

The transportation cost includes the boat freight from Vietnam to Sweden and the truck transportation from the harbor in Gothenburg to the buyer's inventory warehouse. The yearly worldwide insurance cost is set according to the terms of sale FOB-Shipping Point, Freight collected and covers all the products against loss or damage. The customs cost is set according to GSP (Generalized System of Preferences) and constitutes of about 4,5 % of the purchasing price of product A. The destination agent is responsible for tracking, providing information and offering local assistance, including customs clearance. The cost for the destination agent varies with the number of shipments. The quality control is handled by the Vietnamese vendor and the cost consists of a price per product that is set in agreement with the buyer.

Cost such as transportation, yearly worldwide insurance and destination agent were the total invoiced costs for the whole operation during 2018. Therefore, they had to be allocated to product A according to the percentual amount of shipped product A. Customs and quality control were directly calculated. The inventory intake cost is a variable cost that varies with the total number of intaked product. The storage cost is a weekly based fee that varies with the total amount of stored products. Therefore, it was calculated according to the weekly inventory level for each and every week of 2018 and compiled as a total sum for the whole of 2018. The inventory withdrawal cost comprises of emballage, fixed cost and a variable cost. The fixed cost is an order based fee while the variable cost varies with the amount of handled products. Therefore, a cost average was estimated by combining a wide range of withdrawn order costs and distributing them on the total amount of withdrawn products contained in those orders. Thus, estimating the price for withdrawing an article.

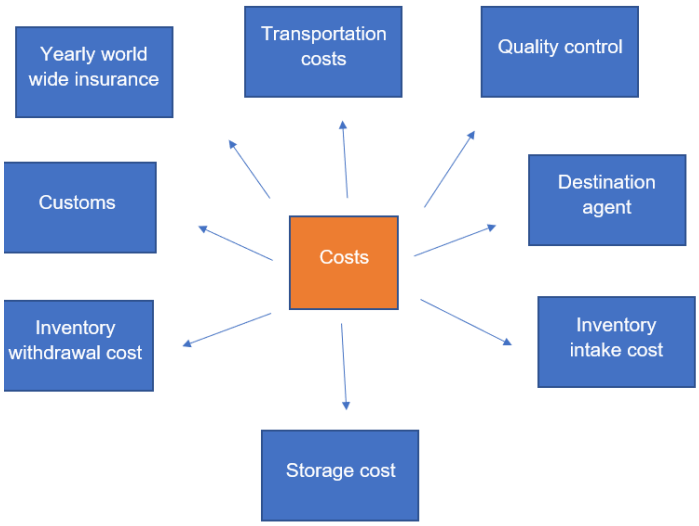

Figure 4.10: Visual illustration of costs for product A included in the total cost calculation.

Figure 4.11 shows the costs and their respective amount in SEK per year.

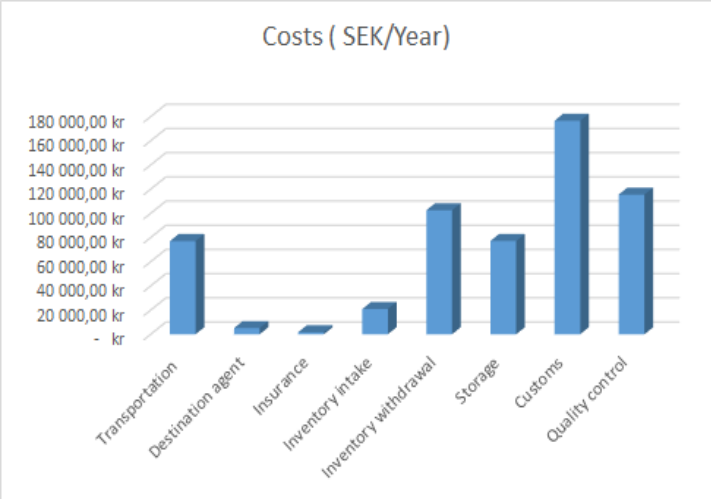

Figure 4.11: Total cost of product A.

4.5 Tied up capital

In this section, the tied up capital for product A is presented. Due to the FOB agreement, the logistical activities start when the goods are stored on the freight ship. After the freight, goods are stored for an average of two days in the goods terminal. Subsequently, goods are transported with trucks to the inventory warehouse which takes about 30-45 minutes. Therefore, the truck transportation is not visually represented in the figures below, except for figure 4.8. However, the truck transportation adds product value and thus is incorporated in the sea freight activity. See figure 4.12 for visual representation of the logistical activities with additional information about lead times and WIP.

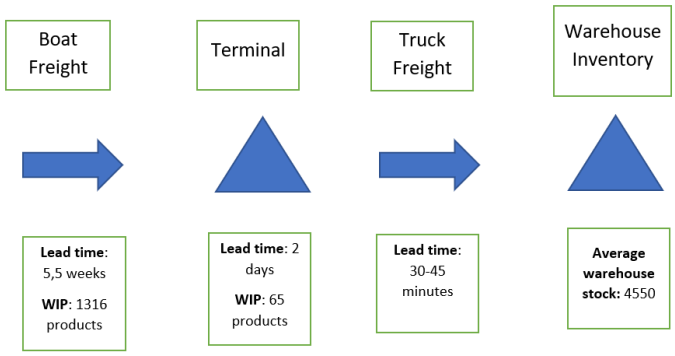

Figure 4.12: Logistical activities that arises with the Vietnamese case.

Tied up capital key figures

The product value of each and every activity was calculated accordingly as shown in the equations below. The total invoiced freight for 2018 is allocated to the total amount of shipped products. GSP (Generalized System of Preferences) is applicable to product A and is constitutes of about 4,5 % of the purchasing price.

$$Product\ value\ freight = Purchasing\ price + quality\ control + (invoiced\ freight \div 2) \quad (13)$$

$$Product\ value\ terminal = Purchasing\ price + quality\ control + invoiced\ freight \quad (14)$$

$$Product\ value\ warehouse = Purchasing\ price + quality\ control + invoiced\ freight + customs \quad (15)$$

The work in progress for the freight, goods terminal was calculated with equation (3) in chapter 3. Average warehouse stock was estimated from the inventory level by utilizing the Excel function AVERAGE, see figure 4.13. The demand for the boat freight and goods terminal is set to the total amount of shipped product A. The demand for the inventory warehouse is set to the total amount of withdrawn product A.

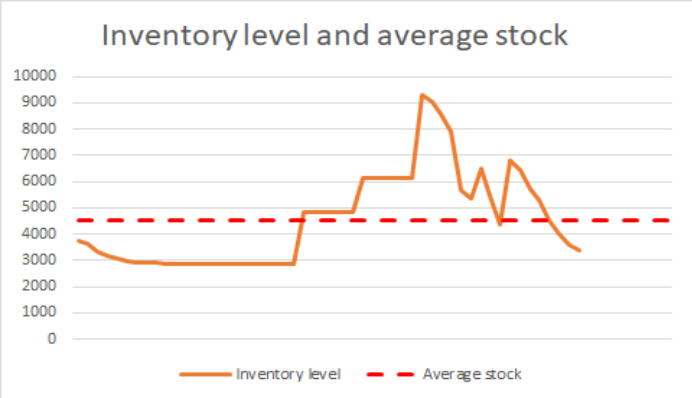

Figure 4.13: Average warehouse stock for product A.

Average tied up capital is calculated with equation (4) in chapter 3. Figure 4.14 illustrates the logistical activities and the amount of tied up capital in each of the activities.

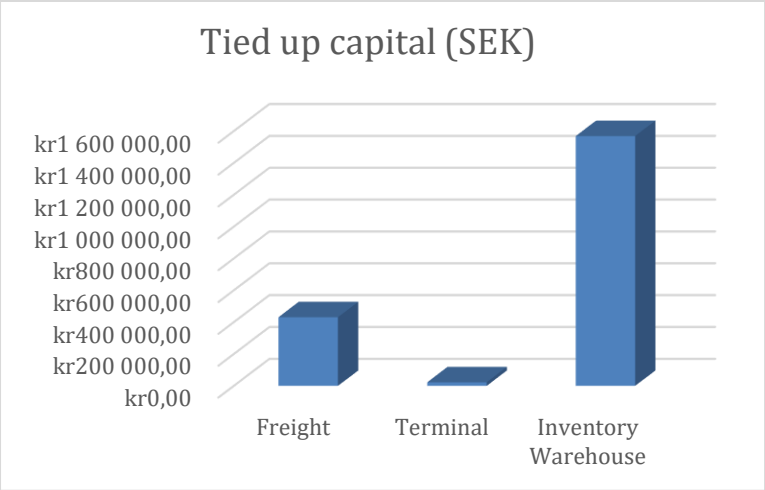

Figure 4.14: Average tied up capital for product A.

Figure 4.15 illustrates the logistical activities and the amount of product A in each of the activities. As previously stated, the average warehouse stock was estimated from the inventory level by utilizing the Excel function AVERAGE. The work in progress for the freight, goods terminal was calculated with equation (3) in chapter 3.

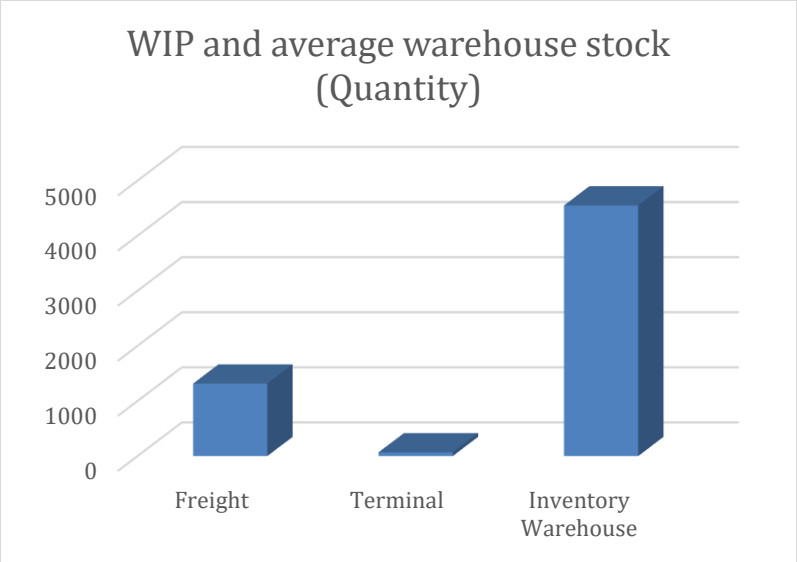

Figure 4.15: Amount of product A.

The inventory turnover rate is calculated with equation (5) in chapter 3. Figure 4.16 illustrates the inventory turnover rate. Cargo terminal is not shown due to the high inventory turnover rate which derives from the short lead time.

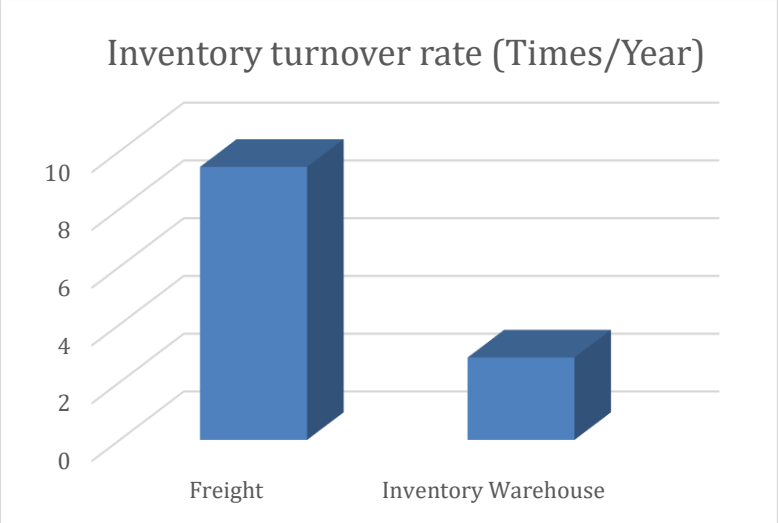

Figure 4.16: Inventory turnover rate for product A

The run-out time is calculated with equation (6) in chapter 3. Figure 4.17 illustrates the inventory turnover rate. Cargo terminal is not shown due to the low run-out time which derives from the short lead time.

Figure 4.17: Run out time for product A

Financial key figures

All the data included in the financial key figures is taken from the company's financial statement compiled 2018. The inventory value from the financial statement consists of the products stored in the inventory warehouse. Product value is set according to the purchasing price for each one of the products, plus quality control, plus the total invoiced freight allocated to the total amount of shipped products.

Figure 4.18 illustrated the empirical DuPont-model.

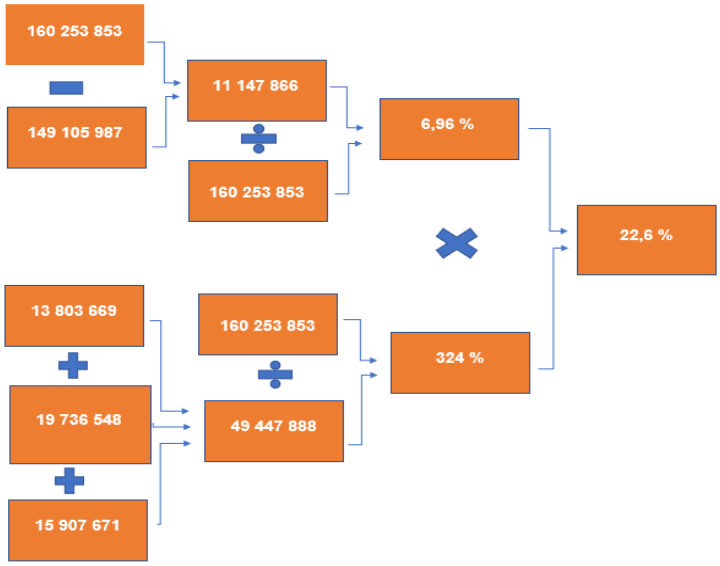

Figure 4.18: Empirical DuPont-model.

Equity ratio was calculated according to equation (7) in chapter 3.

$$Equity\ ratio = 21\,887\,868 \div 49\,447\,888 = 0{,}44 = 44\,\%$$

Liquidity was calculated according to equation (8) in chapter 3.

$$Liquidity = 33\,540\,217 - 13\,803\,669 \div 16\,620\,949 = 1{,}19$$

4.6 Environmental impact

The environmental impact was calculated with EcoTransit World and was for practical reason dilated to the sea freight and the transportation of 1 TEU which contains approximately 2000 products (100 % fill rate). See appendix 2 for input.

Figure 4.19 illustrates the traveled distance and environmental impact for the boat freight from Ho Chi Minh City to Gothenburg.

Measurement	Unit	Amount
Distance	Km	17 404
Energy consumption	Megajoule	16 088
CO2	Tonnes	1,226
Nitrogen oxides	Kilograms	28,466
Sulfur dioxides	Kilograms	17,189

Figure 4.19: Traveled distance and environmental impact.

4.7 Prospective state

The Estonian vendor is located near Tallinn (Estonia) and has been in business with multiple Swedish and Finnish companies. The Estonian vendor offers the availability of renting production and ordering product all year around. Their production capacity extends to 3 000 product per month and are able to deliver 750-1500 two or three times every month. The time difference between Gothenburg and Tallinn is one hour. Components will be sourced from Europe if possible. However, some of the components must be sourced from suppliers located in East Asia due to specific quality requirements. See appendix 3 for questions to the Estonian Vendor and respective answers.

Figure 4.20 shows the average estimated delivery lead time when ordering quantities of 2000 products.

	Sourcing of components	**Production**	**Boat freight**	**Terminal**	**Total**
Average lead time (weeks)	9	3	0,28571	0,28571	12,57
Average lead time (months)	2,25	0,75	0,07143	0,07143	3,14

Figure 4.20: Average delivery lead time.

In chapter 5, further data will be presented regarding the prospective state.

5 ANALYSIS

The analysis of the prospective state (Estonian case) is based on empirical data from 2018 and feedback from the Estonian vendor. The data for the prospective was compared with the data from the current state (Vietnamese case) which is presented in chapter 4. Thereafter, the theoretical framework was applied to the empirical evidence and discussed accordingly.

5.1 Materials planning

In order to determine the material flow, two factors have to be identified. Firstly, how many products have to be ordered. Secondly, when an order has to be placed.

Order quantity may be determined by using several methods. Economic order quantity is one of the most useful methods due to its properties in optimizing the lot size with a minimized total cost of a product (Toomey, 2000). However, applying EOQ is prevented due to the missing purchasing price for product A that was supposed to be provided by the Estonian vendor. In addition to this, applying EOQ requires both ordering cost and inventory carrying cost, which were both unable to be estimated due to restricted information from the buyer. Therefore, the order quantity had to be estimated regarding to the average demand taking into consideration that 85% of demand is pre purchased. Thus, the estimated order quantity was proceeded from the weekly average demand which was about 250 products.

The material requirement planning was applied according to the ability to place an order all year around offered by the Estonian vendor and the buyer's high pre-order rate of 85%. The MRP, according to Jonsson & Mattsson (2016), implies that an order has to be placed when inventory’s level become negative. Thus, the MRP helps the buyer to determine when he has to place an order. But, the MRP method does not determine the ordered quantity.

The Estonian vendor is able to deliver a volume up to 3000 products/month. In order to choose the optimal order quantity in this case, different order quantities were evaluated. Several factors were weighted against each other such as the economical factor, the environmental factor and customer service. Larger order quantities reduce the order cost by product. Larger lot sizes have a positive effects on customer service and minimize the impact of stockout costs. However, a larger lot size is considered to be a cause of inflexibility in operations and increase the delivery lead time (Toomey, 2000). A high customer service is achieved with a high finished good inventory which leads to higher tied up capital and higher carrying cost. Flexible and quick transportation often leads to higher environmental impact (Jonsson & Mattsson, 2016). The environmental impact of the transportation system can be mitigated to some extent thru prioritizing more eco-friendly transportational means and minimize transportation. Minimizing transportation can be accomplished by a higher fill rate which lowers the amount of transportation (Jonsson & Mattsson, 2016). A lower number of orders results in a lower environmental impact as well as reduced ordering costs. A higher average inventory level leads to increased storage cost, inventory carrying cost and a higher tied up capital. Thus, a lot size has to be determined according to the three deciding factors. Boat freight was chosen as the transportational mean for the shipment of product A. The geographic proximity, low energy consumption, low transportational cost were the deciding

factors behind the choice. Jonsson & Mattsson (2016) asserts that the emissions from boat freight are high relative to the energy consumption. However, due to the geographic proximity of Tallinn to Gothenburg, the delivery lead time is two days which equates to a shorter period were emission can arise.

Figure 5.1 shows how the different lot sizes impact the average inventory. The horizontal axis shows lot size and the vertical axis shows average inventory. See appendix 4 for the different MRP for each and every lot size that equated to the respective average inventories. The MRP was applied by taking into consideration the vendor's production capacity and without including a safety stock.

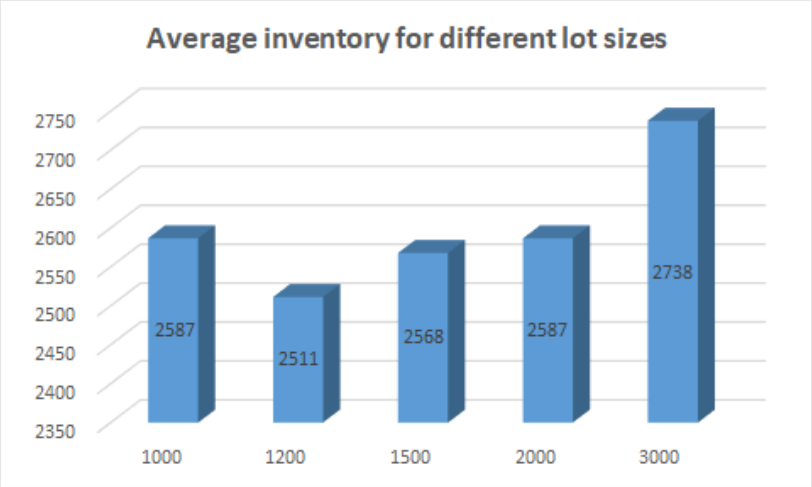

Figure 5.1: Average inventory for different lot sizes.

Figure 5.2 shows the amount of orders required for the respective lot sizes. The horizontal axis indicates lot size and the vertical axis shows the number of orders. See appendix 4 for the different MRP for each and every lot size that equated to the respective number of orders. The MRP was applied by taking into consideration the vendor's production capacity and without including a safety stock.

Figure 5.2: Different number of orders for different lot sizes

The theoretical model off the trade off explained by Jonsson & Mattsson (2016) was applied when evaluating lot sizes. From a customer service perspective more frequent deliveries with larger quantities are preferred. In contrast to customer service, from an economical perspective a lot size which offers the lowest amount of orders and the lowest average inventory is to be preferred. However, the buyer's business model revolves around sustainability which in this case means higher fill rate and less orders.

A lot size of 2000 equates to a 100 % fill rate in a TEU container and has according to figure 5.2 the second lowest amount of orders. By analyzing figure 5.1 and 5.2, there are difficulties when choosing a lot size which gives the least of both number of orders and average inventory. Examining the maximum and minimum values of lot size shows that there is an apparent discrepancy between them, the maximum lot size offers the least number of orders. However, it leads to the largest average inventory. On the other hand, the minimum lot size offers the largest number of orders, but it offers the lowest average inventory. Consequently, the maximum and minimum values of lot sizes were excluded. Although a lot size of 1200 decreases the average inventory compared with other values of lot sizes, it leads to a relatively high number of orders. As a result, the choice was between either 1500 or 2000. The both values have somewhat similar average inventory, but 2000 leads to lesser number of orders and achieves a 100% fill rate.

Taking into account the buyers sustainability business model, the chosen amount of lot size was 2000 due to the possibility of a 100 % fill rate. Therefore, the economical perspective and the customer service perspective were weighed against each other while the environmental perspective was used as the deciding factor. However, the chosen lot size equates to the least amount of trade off between the three perspectives.

As mentioned previously, MRP implies that an order has to be delivered when the inventory level becomes negative. Figure 5.3 shows the inventory level when ordering a lot size of 2000 products while applying the MRP system. The forecast was based on the inventory

withdrawal frequency of 2018. The deliveries were planned as shown in figure 5.3 and the inventory level changed accordingly to the MRP. No planned orders are shown in figure 5.3 due to the restricted figure.

Weeks	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852
Forecast/Need	2245,00	291,00	1042,00	1056,00	1066,00	548,00	397,00	695,00	443,00	788,00	502,00	426,00	197,00
Inventory	377,00	86,00	1044,00	1988,00	922,00	374,00	1977,00	1282,00	839,00	51,00	1549,00	1123,00	926,00
Deliveries	2000	0	2000	2000	0	0	2000	0	0	0	2000	0	0
Planned orders	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.3: Applying MRP without taking into consideration the vendor's production capacity and without including a safety stock.

Figure 5.4 shows the inventory level when ordering a lot size of 2000 products while applying the MRP system while taking in consideration the vendors production capacity. The vendors production capacity creates a gap between the demand and the possible deliveries. In order to solve this problem, the orders were placed in a wider range. See appendix 4 for the whole MRP schedule. According to figure 5.4, the order planned in week 1837 is delivered on week 1849.

Weeks	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852
Forecast/Need	258,00	494,00	684,00	2245,00	291,00	1042,00	1056,00	1066,00	548,00	397,00	695,00	443,00	788,00	502,00	426,00	197,00
Inventory	3800,00	3306,00	2622,00	2377,00	2086,00	1044,00	1988,00	922,00	374,00	1977,00	1282,00	839,00	2051,00	1549,00	1123,00	926,00
Deliveries	2000	0	0	2000	0	0	2000	0	0	2000	0	0	2000	0	0	0
Planned orders	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.4: Applying MRP by taking into consideration the vendor's production capacity and without including a safety stock.

Generally, service level expresses how often the products are in stock (Toomey, 2000). Hence, the estimation of service levels requires access to data that traces how delayed delivers impact the inventory level and impact the customer service. However, the inventory withdrawal frequency which is the study's primary data does not register late deliveries. In other words, the inventory withdrawal frequency does merely show when withdrawal occurs regardless to the fact if the products have been withdrawn on time or not. In order to determine which service level is appropriate for product A, several service levels were compared by how they directly impact the amount of safety stock and of yearly cost.

Figure 5.5 shoes how different service levels the standard deviation, the amount of safety stock and the yearly cost of safety stock.

Service level	K factor	Standard deviation (σt)	Adjusted standard deviation ($\sigma t * \sqrt{LT}$)	Amount of safety stock	Yearly cost (SEK)
75 %	0,67	421,4	1494,2	1001,09	16 970,45
80 %	0,84	421,4	1494,2	1255,10	21 276,39
90 %	1,28	421,4	1494,2	1912,53	32 421,17
95 %	1,65	421,4	1494,2	2465,37	41 792,91
98 %	2,05	421,4	1494,2	3063,03	51 924,53
99,99 %	4	421,4	1494,2	5976,65	101 316,15

Figure 5.5: Service levels and the respective k factors, amount of safety stock and yearly cost for the safety stock.

The excel function STDEV was used for estimating the standard deviation of the withdrawn inventory. Thereafter, it was adjusted according to the delivery lead time for ordering a product from the Estonian vendor. The amount of safety stock in figure 5.5 was calculated according to equation (12) in chapter 3. The yearly cost for the safety stock was established according to the storage cost that equates for stock keeping the respective amount of safety stock for a whole year. According to Oskarsson et al. (2013) seasonal products often requires a high customer service. To be able to satisfy the customer demand, inventory is successively built during a longer period and withdrawn during a shorter time period. A safety stock is often required to mitigate unpredicted seasonal fluctuations. Therefore, product A needs a safety stock to mitigate unpredicted seasonal fluctuations. A service level should be established according to what is seen as satisfying by the customer (Toomey, 2000). However, there is no available data on what service level product A is categorized as. Therefore, the yearly cost of the safety stock according to the service levels was put in perspective. First and foremost, according to the inventory withdrawal frequency is product A strictly seasonal and most of it takes place from week 36 till week 12. Secondly, around 85 % of product A is pre purchased. Therefore, a safety stock is implemented for the prospective state due to speculative reasons and for mitigating possible delivery delays. The amount of safety stock for a service level of 95 % exceeds the order quantity and the yearly storage cost is 41,2 % less than for the yearly storage cost of a service level of 99,99%. In addition to this, the largest withdrawn inventory amount were 2110 products which the safety stock exceeds. For example a service level of 90 % equivalent an amount of safety stock that is both lower than the ordered quantity and lower than the largest withdrawn amount of products. However, there is no need for a safety stock during the period from week 13-34 because of the low demand. Consequently, the service level was set to 95 % even though

there is a 5 % chance for the customers not getting their merchandise in time.

The delivery lead time for ordering products from the Estonian vendor is 12,57 weeks which is 56,8 % shorter than the delivery lead time for ordering products from the Vietnamese vendor. Which means that both TTM and TTC was reduced. TTM is dependent upon the delivery lead time. A shorter TTM could improve the whole business model making the buyer more reactive to changes in customer demand (Jonsson & Mattsson, 2016). Therefore, the shorter delivery lead time improves the buyer's business model. The customer order deadline is March the fifteenth and 65 % of the products are expected by the customers to be on shelves by September. This entails that with a shorter delivery lead time, orders are possible to be placed closer to the established customer order deadline. Therefore, the production orders will be predominately based on pre purchased products which facilitates forward planning and decreases the risk of invested capital.

As previously mentioned, the lot size was chosen to be 2000 products and the service level was established to 95 %. In this case, the MRP has to take into consideration the Estonian vendor's production capacity and the buyer's safety stock. Planning with a safety stock according to the MRP system means that the inventory level is not supposed to decrease further than the established amount of safety stock at any time of the established period. In this case, the inventory level is not supposed to go below the amount of 2465 products. To be able to uphold the safety stock, one additional order is required to be delivered. See appendix 5 for the MRP. Figure 5.6 shows the prospective state (Estonian case) when applying the MRP system. the average warehouse stock was estimated from the inventory level by utilizing the Excel function AVERAGE.

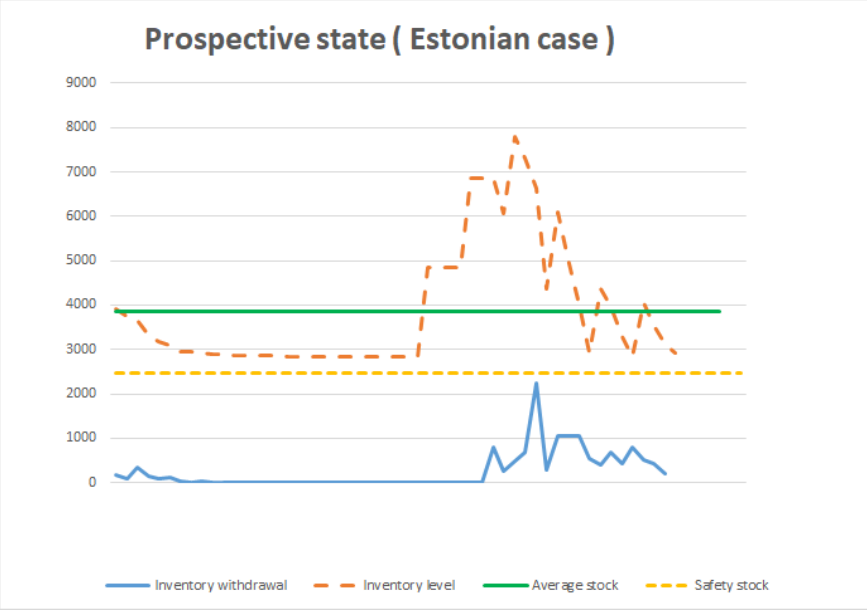

Figure 5.6: Prospective state (Estonian case) when applying the MRP system.

5.2 Total cost in comparison

Figure 5.7 shows the total cost of product A for the Estonian case. Figure 5.7 can be compared with figure 4.10 that shows the visual illustration of costs included in the total cost calculation for the Vietnamese case.

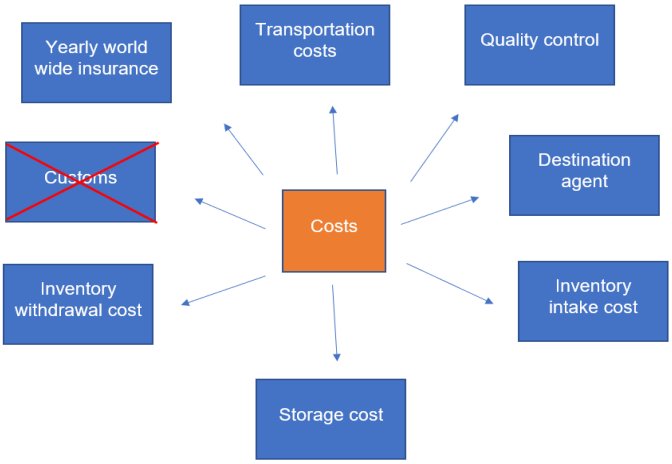

Figure 5.7: Total cost of product A for the Estonian case

Figure 5.8 shows all the costs included in the total cost calculation for the Estonian case. Figure 5.8 can be compared with figure 4.11 that shows the costs and their respective amount in SEK per year for the Vietnamese case.

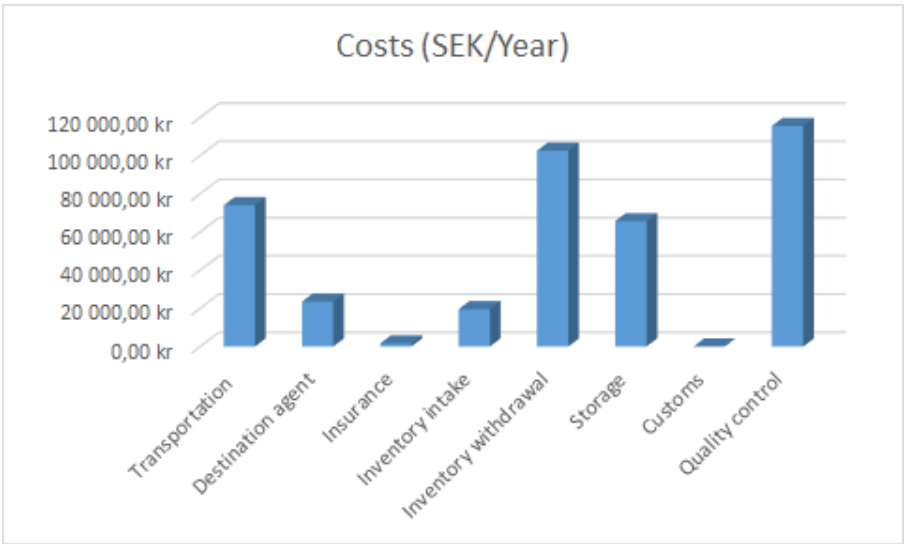

Figure 5.8: Visual illustration of costs included in the total cost calculations for the Estonian case.

Figure 5.9 shows the comparison between costs when outsourcing from the Vietnamese vendor versus when outsourcing from the Estonian vendor.

Costs	Vietnamese case	Estonian case	Difference
Transportation	77 089 SEK	73 986 SEK	-4 %
Destination agent	5 124 SEK	23 472 SEK	+358 %
Insurance	1 636 SEK	1 636 SEK	0 %
Inventory intake	20 943 SEK	19 560 SEK	-7 %
Inventory withdrawal	102 556 SEK	102 556 SEK	0 %
Storage	77 131 SEK	65 587 SEK	-15 %
Customs	176 596 SEK	0 SEK	-100 %
Quality control	155 457 SEK	155 457 SEK	0 %
			0 %
Total	576 534 SEK	402 255 SEK	- 30 %

Figure 5.9: Comparison between costs when outsourcing from the Vietnamese vendor versus when outsourcing from the Estonian vendor.

The cost of quality control is estimated by the buyer to be unaltered, however, it can both decrease or increase depending on the manufacturing quality delivered by Estonian vendor. According to figure 5.8 quality control is among the highest costs. In addition to this, initial quality control costs are expected to arise regardless of the delivered quality if the production is outsourced to Estonia. Therefore, unexpected start up costs such as quality control has to be taken into account. According to Stock et al. (2005) order processing costs arises when processing customer orders, demand forecasting and maintaining information systems. The time spent by employees for activities such as demand forecasting and ordering products may increase during the startup phase due to initial communication barriers. According to Jonsson & Mattsson (2016) a shorter distance facilitates the establishment of a partnership and facilitates meetings, development programs as well as quality control procedures. The distance between the buyer and the vendor decreases with 92,44 % when purchasing products from the Estonian vendor instead of purchasing products from the Vietnamese vendor. Therefore, with a long term perspective the shorter distance will facilitate cooperation and lead to additional decreased costs.

Estonia is part of the European customs union and therefore, the buyer is not required to pay customs which is the highest cost driver. The inventory intake cost is a variable cost that varies dependent upon the total number of intaked product and decreases for the Estonian case according to figure 5.9. The storage cost was calculated according to the weekly inventory level for the Estonian case, see appendix 5 for the storage cost, and is decreased according to figure 5.9. The inventory intake cost and the storage cost are decreased due to the application of the MRP system. The transportation costs were offered by DHL and decrease according to figure 5.9 due to the decreased distance between the buyer and the Estonian vendor. However, according to DHL ship freight costs varies depend on the scheduled delivery week and the current international ship traffic. The only cost that increases is for the destination agent which is contingent upon the amount of orders. Moreover, destination agent costs are lower for the Vietnamese case as a result of

consolidated deliveries of different products models which in turn results in a lower cost per shipped product.

Cost of lost sales include the lost contribution of current and potential future sales (Stock et al., 2005). Potential cost of lost sales is mitigated with the application of the MRP system with a service level of 95 % to mitigate unpredicted seasonal fluctuations.

Cost associated with carrying inventory are generally among the logistical activities with highest costs. Textbook percentages tend to vary dependent upon which costs the authors chose to include and upon what prime interest rate was relevant when the textbooks were published. Moreover, establishing inventory carrying costs based on industry averages is likewise flawed because of the large variations of business models and business strategies adopted in different industries. Therefore, each and every company should determine its own inventory carrying cost (Stock et al., 2005). In this case, the buyer had not established a capital cost which is used according to equation (2) in chapter 3 for calculating the carrying charge. Thus, in accordance to Stock et al. (2005) the carrying charge was neither included in the calculations for the Vietnamese case and for the Estonian case. Therefore, how the carrying charge would alter the comparison is uncertain. With this in mind, the buyer should determine its own inventory carrying cost for a more comprehensive comparison. Furthermore, the inventory carrying cost is needed for estimating EOQ which in turn optimizes the order quantity and minimizes cost.

Separate costs are cost that arises or recede as a consequence of a decision. Joint cost are cost that remains unaltered as a consequence of a decision (Jonsson & Mattsson, 2016). In this case, separate costs are transportation costs, destination agent cost, inventory intake, weekly storage cost and customs. Joint costs are quality control and yearly worldwide insurance. Generally, when considering outsourcing from Asia to Europe, customs can be considered a separate cost.

According to figure 5.9, the total cost decreases with 30% when outsourcing the production of product A from Estonia versus outsourcing from Vietnam. In this case, the total cost model according to Stock et al. (2005) is applicable to a certain extent. Costs included in customer service, order processing and inventory carrying were not included in the total cost calculations. The main reason for not including those costs were that they were not previously categorically registered and cost registration was not the projects scope. However, these costs still arise in conjunction with the logistical activities and as previously discussed have the possibility to impact the comparison. Thus, altering the conclusion. Cost registration is estimated to be resource and time consuming for a business of 26 employees. Nonetheless, cost registration has shown in this project to be essential for a establishing a comprehensive total cost.

5.3 Tied up capital in comparison

Tied up capital key figures and financial key is compared in this subchapter.

Tied up capital key figures

Due to the missing purchasing price from the Estonian vendor, average tied up capital in absolute figures (SEK) were not compared.

Figure 5.10 shows the logistical activities with additional information about lead times and WIP for the Estonian case. The work in progress for the freight, goods terminal was calculated with equation (3) in chapter 3. Figure 5.10 can be compared with figure 4.12 that shows the logistical activities that arise with the Vietnamese case.

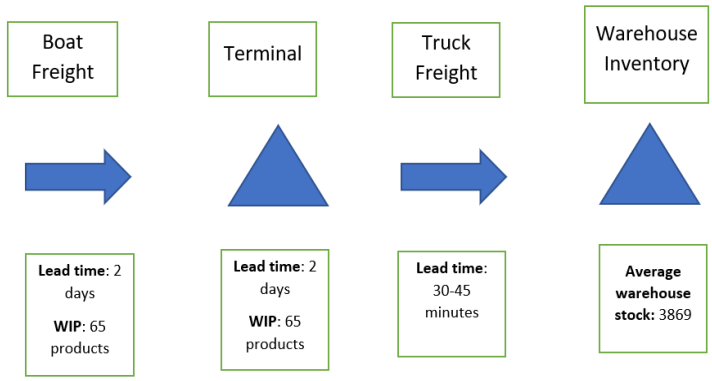

Figure 5.10: Logistical activities that arises with the Estonian case.

Figure 5.11 shows the logistical activities and the amount of product A in each of the activities. The average warehouse stock was estimated from the inventory level by utilizing the Excel function AVERAGE. The work in progress for the freight, goods terminal was calculated with equation (3) in chapter 3. Figure 5.11 can be compared with figure 4.16 that shows the logistical activities and the amount of product A in each of the activities for the Vietnamese case.

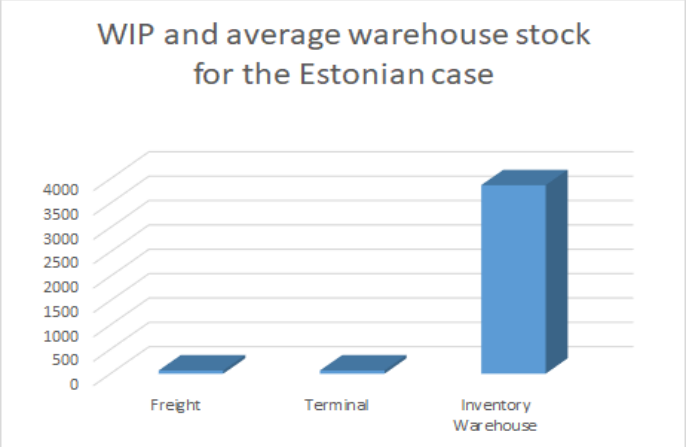

Figure 5.11: Amount of product A when ordering from the Estonian vendor.

The inventory turnover rate is calculated with equation (5) in chapter 3. Figure 5.12 illustrates the comparison of the inventory turnover rate when outsourcing from the Vietnamese vendor versus when outsourcing from the Estonian vendor. The freights inventory turnover rate increases with 1902% due to the decreased lead time when outsourcing from the Estonian vendor. The inventory warehouse turnover rate increases with 9 % due to the decreased average inventory as a result of the MRP when outsourcing from the Estonian vendor. Therefore, the average stock is replaced at a higher rate when outsourcing from the Estonian vendor.

Logistical activities	Vietnamese case	Estonian case	Difference
Freight	9,5	189,5	+1902 %
Terminal	182,5	189,5	+3,6 %
Inventory warehouse	2,9	3,1	+9 %

Figure 5.12: Comparison of the inventory turnover rate.

The run-out time is calculated with equation (6) in chapter 3. Figure 5.13 illustrates the comparison of the run-out time when outsourcing from the Vietnamese vendor versus when outsourcing from the Estonian vendor. The freights inventory turnover rate decreases with 95% due to the decreased lead time when outsourcing from the Estonian vendor. The inventory warehouse turnover rate decreases with 8 % due to the decreased average inventory as a result of the MRP when outsourcing from the Estonian vendor. Therefore, deliveries to customers can be covered for a longer time period when outsourcing from the Estonian vendor.

Logistical activities	Vietnamese case	Estonian case	Difference
Freight	5,5	0,27	-95 %
Terminal	0,28	0,27	-3,6 %
Inventory warehouse	18,2	16,8	-8 %

Figure 5.13: Comparison of the run-out time.

Financial key figures

Due to the missing purchasing price, it was not possible to quantify the impact of outsourcing from the Estonian vendor.

According to Oskarsson et al. (2013), decreased inventory level increases the asset turnover. Decreased costs such as transportation costs, material handlings costs and warehousing cost increases the profit margin. Decreased inventory increases solidity and liquidity (Oskarsson et al., 2013). In this case the inventory level decreases when outsourcing from the Estonian vendor. However, an eventual higher purchasing price for product A leads to an increased

product value which results in a decreased asset turnover. In addition to this, a higher purchasing price results in increased costs which impacts the profit margin. Therefore, how outsourcing from the Estonian vendor impacts the return on invested capital, solidity and liquidity cannot be determined. Therefore, no comparison of the financial key figures was possible.

5.4 Customer service in comparison

Customer service is not always possible to estimate in quantitative terms. Therefore, qualitative estimates are used to evaluate how customer service affect other efficiency variables (Jonsson & Mattsson, 2016). In accordance to Jonsson & Mattsson (2016) qualitative estimates were made.

Long term partnerships, agreements and business deals are activities that have potential to impact the revenue (Jonsson & Mattsson, 2016). The buyer and the Vietnamese vendor have a long partnerships, different agreements and business deals. Notwithstanding the long partnership, problems that occur are often communicated late leaving the buyer with a small time frame to react. As previously discussed, establishing a partnership with the Estonian vendor can lead to additional start up costs. The cultural dimension refers to the difficulty in communication due to language differences (Jonsson & Mattsson, 2016). However, the cultural dimension and how the Vietnamese culture interacts with the Swedish culture and how the Estonian culture interacts with the Swedish culture were not examined.

The time dimension refers to the time zone difference between the buyer and the vendor. In addition to this, holidays and vacations can occur during different time periods leaving the communication impractical and sometimes impossible (Jonsson & Mattsson, 2016). Figure 5.14 shows how the holidays for the respective nations. The green calendar dates show the common holidays. The Estonian holidays occur simultaneously as the Swedish holidays which facilitates communication. Most of the Vietnamese holidays do not occur simultaneously as the Swedish holidays impeding communication during those holidays.

Holidays			
	Vietnam	Estonia	Sweden
	2019-01-01	2019-01-01	2019-01-01
	2019-02-04	2019-02-24	2019-01-06
	2019-02-05	2019-04-19	2019-04-19
	2019-02-06	2019-04-21	2019-04-21
	2019-02-07	2019-05-01	2019-04-22
	2019-02-08	2019-06-09	2019-05-01
	2019-04-15	2019-06-23	2019-05-30
	2019-04-29	2019-06-24	2019-06-06
	2019-04-30	2019-08-20	2019-06-09
	2019-05-01	2019-10-19	2019-06-21
	2019-09-02	2019-12-24	2019-06-22
		2019-12-25	2019-11-02
		2019-12-26	2019-12-24
			2019-12-25
			2019-12-26
			2019-12-31

Figure 5.14: Holidays.

Different time zones equate difference in work hours, lunch breaks and other types of breaks. Due to this difference there can difficulties in scheduling meetings that satisfy both partners restricting communication and flexibility (Jonsson & Mattsson, 2016). The time difference between Gothenburg and Tallinn is one hour. The time difference between Gothenburg and Ho Chi Minh City is five hours. The time difference between Gothenburg and Tallinn is more favorable and allow better communication and flexibility.

Stock availability is to what extent a stocked product is available for delivery. It is a measurement on the probability of direct delivery to customers when demand arises (Jonsson & Mattsson, 2016). As previously discussed, the business model is based on pre-orders. If there is not enough amount of products in stock relative to the amount of customer orders, different customers are prioritized and others result in costs of lost sales. In addition to this, if the demand arises during the season additional products have to be ordered. Ordering products from the Vietnamese vendor means a restricted time frame and a delivery lead time of 5,5 month. Therefore, unpredicted seasonal fluctuations are hard to tackle. The ability of ordering from the Estonian vendor without a restricted time frame and the reduced delivery lead time of 56,8% is expected to increase the stock availability. Therefore, the Estonian vendor is a more eligible alternative for a more favorable stock availability.

On-time delivery refers to which extent delivery is made according to what is agreed upon with the customer. This element encompasses products that are not stock kept and directly delivered to the customer (Jonsson & Mattsson, 2016). In this case, around 74 % of product A is shipped to the warehouse inventory and 26 % is directly sold at the vendors location. The market for product A is predominantly located in the Scandinavian countries. Most of the customers are therefore located closer to the Estonian vendor. Thus, reducing transportation costs and emissions for the customers. Which in turn could result in the possibility for the buyer to further outsource the logistical activities and directly sell a bigger share of products at the vendors location. Therefore, the Estonian vendor is a more eligible alternative for a more favorable on-time delivery.

Delivery dependability is measured in the total amount of delivered orders without customer complaint in relationship to the total amount of delivered orders. Customer complaints extends from wrongly delivered quantity of product to wrongly delivered product quality. Product quality defects can arise in the manufacturing process or during the transportation and handling (Jonsson & Mattsson, 2016). The long freight from Vietnam to Sweden is subjectable to unpredicted risks, harsh weather conditions and the high temperature inside the containers contaminate the goods with mold which generate additional cost. In addition to this, quality defects or misinterpreted instructions are hard to communicate and are often communicated late. According to Jonsson & Mattsson (2016), a shorter distance facilitates the establishment of a partnership and facilitates meetings, development programs as well as quality control procedures. The distance is reduced with 92,44 % when selecting the Estonian vendor which facilitates meetings, development programs and quality control procedures. Thus, increasing the possibility of mitigating customers complaints. In addition to this, the shorter distance between the buyer and the Estonian vendor mitigates unpredicted

risks during the boat freight. Therefore, the Estonian vendor is a more eligible alternative for a more favorable delivery dependability.

Delivery lead time comprise of when the customer order is received to the completed delivery. Delivery lead times are measured in days or weeks. An extensive delivery lead time reduces the delivery flexibility, increases tied up capital and capital cost due to an increased safety stock (Jonsson & Mattsson, 2016). The delivery lead time is 56,8 % shorter when ordering products from the Estonian vendor. Therefore, the Estonian vendor is a more eligible alternative for a more favorable delivery lead time.

Delivery flexibility is the ability in adjusting to fluctuations in customer demand and ongoing orders. For instance adjustments to delivery time and order quantity. A supplier located in the regional area have the possibility to achieve a higher delivery flexibility. In addition to this, it shortens the delivery lead time and improves the delivery flexibility (Jonsson & Mattsson, 2016). The 92,44 % reduced distance when ordering from the Estonian vendor in combination with the 56,8 % shorten delivery lead time achieves a higher delivery flexibility. The increased capability of communication between the buyer and the Estonian vendor facilitates changes in ongoing orders and deliveries. Therefore, the Estonian vendor is a more eligible alternative for a more favorable delivery flexibility.

Increased customer service increases opportunities for customer growth which directly increases income (Oskarsson et al., 2013). In this case, choosing the Estonian vendor improves the customer service in every examined aspect, improves communication and facilitates the establishment of partnership, facilitates meetings, development programs as well as quality control procedures. Thus, increasing opportunities for customer growth which directly increases income.

5.5 Environmental impact in comparison

The environmental impact for the Estonian case was calculated with EcoTransit World and was for practical reason dilated to the sea freight and the transportation of 1 TEU which contains approximately 2000 products (100 % fill rate). See appendix 6 for input.
Figure 5.15 illustrates the traveled distance and environmental impact for the boat freight from Tallinn to Gothenburg. Figure 5.15 can be compared with figure 4.19 that illustrates the traveled distance and environmental impact for the boat freight from Ho Chi Minh City to Gothenburg.

Measurement	Unit	Amount
Distance	Km	1315
Energy consumption	Megajoule	2936
CO2	Tonnes	0,2141
Nitrogen oxides	Kilograms	2,154
Sulfur dioxides	Kilograms	0,1695

Figure 5.15: Traveled distance and environmental impact for the Estonian case.

Figure 5.16 illustrates the comparison of the distance and environmental impact when outsourcing from the Vietnamese vendor versus when outsourcing from the Estonian vendor.

Measurement	Unit	Vietnamese case	Estonian case	Difference
Distance	Km	17 404	1315	-92,44%
Energy consumption	Megajoule	16 088	2936	-81,75%
CO2	Tonnes	1,226	0,2141	-82,54%
Nitrogen oxides	Kilograms	28,466	2,154	-92,43%
Sulfur dioxides	Kilograms	17,189	0,1695	-99,01%

Figure 5.16: Comparison of the distance and environmental impact when outsourcing from the Vietnamese vendor versus when outsourcing from the Estonian vendor.

Clearly, as shown in figure 5.16, the environmental impact decreases drastically when outsourcing from the Estonian vendor. Thus, making the Estonian vendor the eco-friendlier alternative.

6 DISCUSSION & CONCLUSION

In this chapter, the analysis is discussed and commented. A discussion is presented followed by the answering of the research question and a reflection of the methodological approach. In the last subchapter the conclusion to the study is presented.

6.1 Discussion

The empirical data of the study was collected by interviewing employees at Icebug and feedback from the Estonian vendor. The small operation of 26 employees is a factor for the restricted cost registration. Thus, inventory carrying costs, order processing costs and customer services costs were not included. The absence of the inventory carrying costs and the order processing made it not possible for utilizing lot sizing methods such as the EOQ. The time restriction and purpose of this study made it not possible to calculate or estimate these costs. Therefore, we recommend the company to estimate those costs and incorporate them when making logistical decisions. In order to establish a lot size for ordering products from the Estonian vendor, the tradeoff between the efficiency variables was considered and analyzed according to the studied case. The economical factor was weighed against the customer service while the environmental factor was used as the deciding factor. The environmental factor was used as the deciding factor because it aligns itself with the company's sustainability profile.

As previously mentioned, the purchasing price for product A for the Estonian case was not communicated in time. A strong factor when making outsourcing decisions is the possibility of acquiring products at a lower purchasing price. Therefore, the purchasing prices offered by the vendors should be compared for a comprehensive conclusion. In addition to this, we argue that the purchasing price for the product when considering outsourcing decisions should be included in the logistical total cost model. Thus, it should be considered a factor when evaluating logistical efficiency. However, in this case it was not considered due to the missing purchasing price from the Estonian vendor.

The shorten delivery lead time of 56,8% and the reduced distance of 92,44 % when outsourcing to the Estonian vendor improves the overall customer service and delivery flexibility. However, the delivery lead time is possible to reduce even further if components for the product are sourced in proximity to the location of the Estonian vendor.

As previously mentioned, 26% of the transportation of product A is outsourced in the current state. The market for product A is predominantly located in the Scandinavian region which makes the customers and the Estonian vendor near to each other. Therefore, if there is possibility to outsource the transportation even further it would benefit the business by reducing transportation costs, lowering the average tied up capital and reducing storage costs.

The most advantageous factor when outsourcing the production to Estonia is that with a shorter delivery lead time, orders are possible to be placed closer to the established customer order deadline. Therefore, the production orders will be predominately based on pre

purchased products which facilitates forward planning and decreases the risk of invested capital.

6.2 Answering the research questions

The following questions examined the difference in outsourcing the production of product A from Estonia versus outsourcing from Vietnam.

1. What is the difference in logistical total cost of product A?

- The total cost will decrease with 30%.

2. How will the environmental impact change?

- The energy consumption will decrease.
- CO2 emissions will decrease.
- Nitrogen oxide emissions will decrease.
- Sulfur dioxide emissions will decrease.

The overall environmental impact will decrease.

3. How will the customer service change?

- Stock availability will increase.
- On-time delivery will increase.
- Delivery dependability will increase.
- Delivery lead time will decrease., which is favorable.

The overall customer service will improve.

4. How will the delivery flexibility change?

- Delivery flexibility will increase.

5. What is the variance in tied up capital?

- The inventory turnover rate will increase.
- The run-out time will decrease.

The overall tied up capital will be minimized.

6. Which other factors are relevant to take into consideration?

The ability to rent production space all year around in combination with the decreased delivery cycle time improves customer service and is more favorable for improving the tied

up capital. However, the vendors production capacity has to be taken into consideration when lot sizing and planning with the MRP system.

Estonia is part of the European customs union and therefore, the buyer is not required to pay customs which was the highest cost driver for the Vietnamese case.

An establishment of a new partnership is expected to increase costs due to initial communication barriers. However, with a long term perspective the shorter distance will facilitate cooperation and lead to additional decreased costs.

Categorical cost registration is essential and has to be in place in order to make a comprehensive total cost analysis.

Subsequently, time zone difference between the buyer and the vendor has to be taken into consideration. In addition to this, holidays and vacations have to be taken into consideration.

6.3 Reliability

As previously mentioned no purchasing price was derived from the business case due to the prolonged deadline for feedback that exceeded the project scope deadline. In this case, the first contact with the Estonian vendor was established when the projects scope was determined. Afterwards, there was not much to be done to expedite the feedback process. The project's scope extended approximately for a four month time period. Therefore, similar projects require time scopes that extend beyond a four month time period.

Figure 6.1 shows the corrected methodological approach which is explained in further detail below.

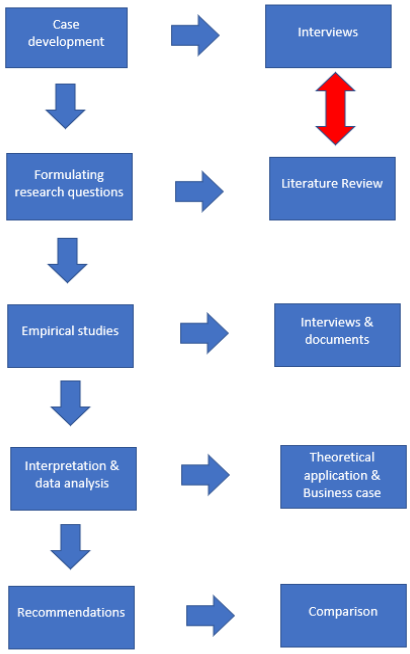

Figure 6.1: Corrected methodological approach.

According to figure 2.1 in the methodological chapter. The first step, case development, was to get a further understanding of the problem through open-ended cross sectional interviews with multiple departments. The second step, formulating research question, dealt with acquiring theory through an informal literature review process. According to Creswell (2009) qualitative research questions are formulated without reference to theory. The case was already developed and the research questions already formulated before the methodological chapter was compiled. In hindsight, the correct methodological approach would have been in accordance with Creswell (2009) which is what is suggested in figure 6.1. The first step, case development, should have been done by acquiring theory through an informal literature review process to get an understanding of what type of data was required for the case. The second step, formulating research questions, should have been done through open-ended cross sectional interviews with multiple departments. A methodical approach according to what was suggested would have resulted in a project with a scope that would have been practical, with the understanding of the required data and aligned with the available data. Therefore, our suggestion is to follow the corrected methodological approach when conducting a case study.

6.3 Conclusion

This study concludes, on the basis of the empirical evidence and evaluated factors, that Icebug AB should change the outsourcing of the production of product A to Estonia. However, the purchasing price for product A has to be included in the total cost model in order to be able to make this study's conclusion an executive decision.

We recommend utilizing the MRP system and applying a service level of 95% for product A when outsourcing from the Estonian vendor.

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Appendix

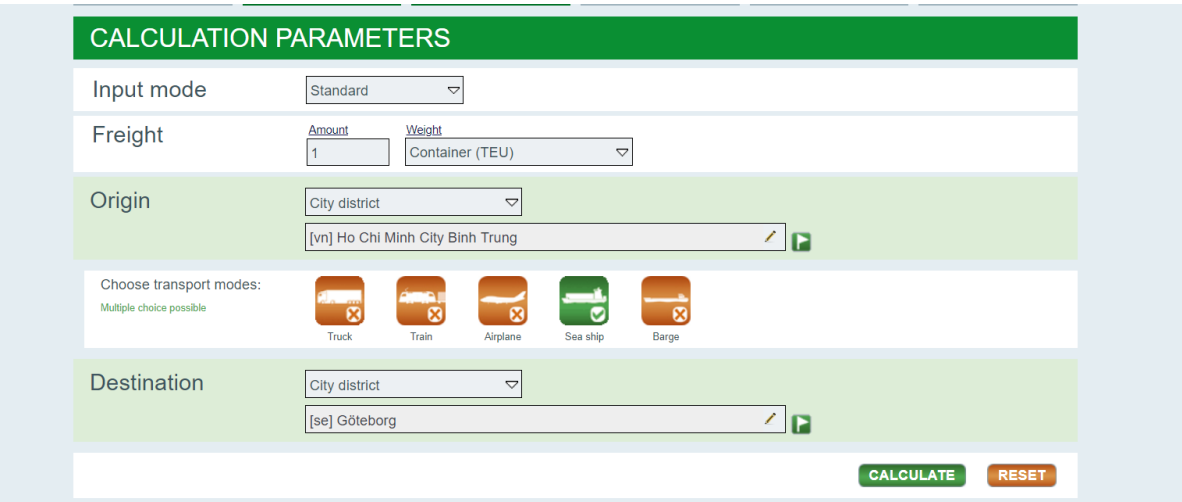
Appendix 1

Withdrawn inventory on a weekly basis for the current state.

1801	163
1802	82
1803	357
1804	136
1805	92
1806	115
1807	24
1808	16
1809	23
1810	17
1811	15
1812	11
1813	4
1814	1
1815	1
1816	2
1817	0
1818	0
1819	0
1820	0
1821	0
1822	0
1823	0
1824	0
1825	0
1826	0
1827	0
1828	0
1829	0
1830	0
1831	0
1832	0
1833	0
1834	0
1835	1
1836	791
1837	258
1838	494
1839	684
1840	2245
1841	291
1842	1042
1843	1056
1844	1066
1845	548
1846	397
1847	695
1848	443
1849	788
1850	502
1851	426
1852	197

Appendix 2

Input for the emission calculation of the current state.



Appendix 3

Questions asked to and received feedback from the Estonian vendor.

Questions	Answers		
		YES	NO
What is the purchasing price of the product?			
What is the manufacturing time for the specific product?			
What is the estimated lead time for the components?			
What is your production capacity ?			
How often can an order be placed ?			
What is the minimum and maximum amount of products that can be ordered?			

Appendix 4

Material Requirements Planning for the respective lot sizes. See average inventory and number of orders. The MRP was applied by taking into consideration the vendor's production capacity and without including a safety stock.

MRP planning with a lot size of 1000 products

Weeks	Forecast/Need	Inventory	Deliveries	Planned orders
		3909		
1801	163,00	3746,00		0
1802	82,00	3664,00		0
1803	357,00	3307,00		0
1804	136,00	3171,00		0
1805	92,00	3079,00		0
1806	115,00	2964,00		0
1807	24,00	2940,00		0
1808	16,00	2924,00		0
1809	23,00	2901,00		0
1810	17,00	2884,00		0
1811	15,00	2869,00		0
1812	11,00	2858,00		0
1813	4,00	2854,00		0
1814	1,00	2853,00		0
1815	1,00	2852,00		0
1816	2,00	2850,00		0
1817	0,00	2850,00		0
1818	0,00	2850,00		0
1819	0,00	2850,00		0
1820	0,00	2850,00		0
1821	0,00	2850,00		0
1822	0,00	2850,00		0
1823	0,00	2850,00		0
1824	0,00	2850,00		0
1825	0,00	2850,00		1000
1826	0,00	2850,00		0
1827	0,00	2850,00		1000
1828	0,00	2850,00		0
1829	0,00	2850,00		1000
1830	0,00	2850,00		0
1831	0,00	2850,00		1000
1832	0,00	2850,00		0
1833	0,00	2850,00	0	1000
1834	0,00	3850,00	1000	0
1835	1,00	3849,00	0	1000
1836	791,00	4058,00	1000	0
1837	258,00	3800,00	0	1000
1838	494,00	4306,00	1000	0
1839	684,00	3622,00	0	1000
1840	2245,00	2377,00	1000	0
1841	291,00	2086,00	0	1000
1842	1042,00	2044,00	1000	0
1843	1056,00	988,00	0	1000
1844	1066,00	922,00	1000	10
1845	548,00	374,00	0	0
1846	397,00	977,00	1000	0
1847	695,00	282,00	0	0
1848	443,00	839,00	1000	0
1849	788,00	51,00	0	0
1850	502,00	549,00	1000	0
1851	426,00	123,00		0
1852	197,00	926,00	1000	0
	Average inventory	2586,75	Number of orders	10

MRP planning with a lot size of 1200 products

Weeks	Forecast/Need	Inventory	Deliveries	Planned orders
		3909		
1801	163,00	3746,00		0
1802	82,00	3664,00		0
1803	357,00	3307,00		0
1804	136,00	3171,00		0
1805	92,00	3079,00		0
1806	115,00	2964,00		0
1807	24,00	2940,00		0
1808	16,00	2924,00		0
1809	23,00	2901,00		0
1810	17,00	2884,00		0
1811	15,00	2869,00		0
1812	11,00	2858,00		0
1813	4,00	2854,00		0
1814	1,00	2853,00		0
1815	1,00	2852,00		0
1816	2,00	2850,00		0
1817	0,00	2850,00		0
1818	0,00	2850,00		0
1819	0,00	2850,00		0
1820	0,00	2850,00		0
1821	0,00	2850,00		0
1822	0,00	2850,00		0
1823	0,00	2850,00		0
1824	0,00	2850,00		0
1825	0,00	2850,00		0
1826	0,00	2850,00		0
1827	0,00	2850,00		1200
1828	0,00	2850,00		0
1829	0,00	2850,00		1200
1830	0,00	2850,00		0
1831	0,00	2850,00		1200
1832	0,00	2850,00		0
1833	0,00	2850,00		1200
1834	0,00	2850,00		0
[illegible]	[illegible]	[illegible]		[illegible]
1835	1,00	2849,00		1200
1836	791,00	3258,00	1200	0
1837	258,00	3000,00	0	1200
1838	494,00	3706,00	1200	0
1839	684,00	3022,00	0	1200
1840	2245,00	1977,00	1200	0
1841	291,00	1686,00	0	1200
1842	1042,00	1844,00	1200	0
1843	1056,00	788,00	0	0
1844	1066,00	922,00	1200	8
1845	548,00	374,00		0
1846	397,00	1177,00	1200	0
1847	695,00	482,00	0	0
1848	443,00	1239,00	1200	0
1849	788,00	451,00	0	0
1850	502,00	1149,00	1200	0
1851	426,00	723,00		0
1852	197,00	526,00	0	0
	Average inventory	2511,28	Number of orders	8

MRP planning with a lot size of 1500 products

Weeks	Forecast/Need	Inventory	Deliveries	Planned orders
		3909		
1801	163,00	3746,00		0
1802	82,00	3664,00		0
1803	357,00	3307,00		0
1804	136,00	3171,00		0
1805	92,00	3079,00		0
1806	115,00	2964,00		0
1807	24,00	2940,00		0
1808	16,00	2924,00		0
1809	23,00	2901,00		0
1810	17,00	2884,00		0
1811	15,00	2869,00		0
1812	11,00	2858,00		0
1813	4,00	2854,00		0
1814	1,00	2853,00		0
1815	1,00	2852,00		0
1816	2,00	2850,00		0
1817	0,00	2850,00		0
1818	0,00	2850,00		0
1819	0,00	2850,00		0
1820	0,00	2850,00		0
1821	0,00	2850,00		0
1822	0,00	2850,00		0
1823	0,00	2850,00		0
1824	0,00	2850,00		0
1825	0,00	2850,00		0
1826	0,00	2850,00		1500
1827	0,00	2850,00		0
1828	0,00	2850,00		0
1829	0,00	2850,00		1500
1830	0,00	2850,00		0
1831	0,00	2850,00		0
1832	0,00	2850,00		1500
1833	0,00	2850,00		0
1834	0,00	2850,00	0	0
1835	1,00	4349,00	1500	1500
1836	791,00	3558,00	0	0
1837	258,00	3300,00		1500
1838	494,00	4306,00	1500	0
1839	684,00	3622,00	0	0
1840	2245,00	1377,00	0	1500
1841	291,00	2586,00	1500	0
1842	1042,00	1544,00	0	0
1843	1056,00	488,00	0	1500
1844	1066,00	922,00	1500	7
1845	548,00	374,00	0	0
1846	397,00	1477,00	1500	0
1847	695,00	782,00	0	0
1848	443,00	339,00		0
1849	788,00	1051,00	1500	0
1850	502,00	549,00	0	0
1851	426,00	123,00		0
1852	197,00	1426,00	1500	0
	Average inventory	2567,89	Numberof orders	7

MRP planning with a lot size of 2000 products

Weeks	Forecast/Need	Inventory	Deliveries	Planned orders
		3909		
1801	163,00	3746,00		0
1802	82,00	3664,00		0
1803	357,00	3307,00		0
1804	136,00	3171,00		0
1805	92,00	3079,00		0
1806	115,00	2964,00		0
1807	24,00	2940,00		0
1808	16,00	2924,00		0
1809	23,00	2901,00		0
1810	17,00	2884,00		0
1811	15,00	2869,00		0
1812	11,00	2858,00		0
1813	4,00	2854,00		0
1814	1,00	2853,00		0
1815	1,00	2852,00		0
1816	2,00	2850,00		0
1817	0,00	2850,00		0
1818	0,00	2850,00		0
1819	0,00	2850,00		0
1820	0,00	2850,00		0
1821	0,00	2850,00		0
1822	0,00	2850,00		0
1823	0,00	2850,00		0
1824	0,00	2850,00		0
1825	0,00	2850,00		2000
1826	0,00	2850,00		0
1827	0,00	2850,00		0
1828	0,00	2850,00		2000
1829	0,00	2850,00		0
1830	0,00	2850,00		0
1831	0,00	2850,00		2000
1832	0,00	2850,00		0
1833	0,00	2850,00		0
1834	0,00	2850,00	0	2000
1835	1,00	2849,00		0
1836	791,00	2058,00	0	0
1837	258,00	3800,00	2000	2000
1838	494,00	3306,00	0	0
1839	684,00	2622,00	0	0
1840	2245,00	2377,00	2000	0
1841	291,00	2086,00	0	5
1842	1042,00	1044,00	0	0
1843	1056,00	1988,00	2000	0
1844	1066,00	922,00	0	0
1845	548,00	374,00	0	0
1846	397,00	1977,00	2000	0
1847	695,00	1282,00	0	0
1848	443,00	839,00	0	0
1849	788,00	2051,00	2000	0
1850	502,00	1549,00	0	0
1851	426,00	1123,00		0
1852	197,00	926,00	0	0
	Average inventory	2586,75	Number of orders	5

MRP planning with a lot size of 3000 products

Weeks	Forecast/Need	Inventory	Deliveries	Planned orders
		3909		
1801	163,00	3746,00		0
1802	82,00	3664,00		0
1803	357,00	3307,00		0
1804	136,00	3171,00		0
1805	92,00	3079,00		0
1806	115,00	2964,00	0	0
1807	24,00	2940,00		0
1808	16,00	2924,00		0
1809	23,00	2901,00		0
1810	17,00	2884,00		0
1811	15,00	2869,00		0
1812	11,00	2858,00		0
1813	4,00	2854,00		0
1814	1,00	2853,00		0
1815	1,00	2852,00		0
1816	2,00	2850,00		0
1817	0,00	2850,00		0
1818	0,00	2850,00		0
1819	0,00	2850,00		0
1820	0,00	2850,00		0
1821	0,00	2850,00		0
1822	0,00	2850,00		0
1823	0,00	2850,00		0
1824	0,00	2850,00		0
1825	0,00	2850,00		0
1826	0,00	2850,00		0
1827	0,00	2850,00		0
1828	0,00	2850,00		0
1829	0,00	2850,00		3000
1830	0,00	2850,00		0
1831	0,00	2850,00		0
1832	0,00	2850,00		0
1833	0,00	2850,00		0
1834	0,00	2850,00		3000
1835	1,00	2849,00		0
1836	791,00	2058,00		0
1837	258,00	1800,00	0	0
1838	494,00	4306,00	3000	3000
1839	684,00	3622,00	0	0
1840	2245,00	1377,00	0	0
1841	291,00	1086,00	0	4
1842	1042,00	3044,00	3000	0
1843	1056,00	1988,00	0	0
1844	1066,00	922,00	0	0
1845	548,00	374,00	0	0
1846	397,00	2977,00	3000	0
1847	695,00	2282,00	0	0
1848	443,00	1839,00	0	0
1849	788,00	1051,00	0	0
1850	502,00	3549,00	3000	0
1851	426,00	3123,00		0
1852	197,00	2926,00	0	0
	Average inventory	2737,70	Number of orders	4

Appendix 5

MRP planning for the prospective state (Estonian case)

Week	Inventory withdrawal	Inventory level	Inventory intake	Planned orders	Weekly storage cost
1801	163	3909	0	0	1221,20 kr
1802	82	3746	0	0	1194,46 kr
1803	357	3664	0	0	1078,08 kr
1804	136	3307	0	0	1033,75 kr
1805	92	3171	0	0	1003,75 kr
1806	115	3079	0	0	966,26 kr
1807	24	2964	0	0	958,44 kr
1808	16	2940	0	0	953,22 kr
1809	23	2924	0	0	945,73 kr
1810	17	2901	0	0	940,18 kr
1811	15	2884	0	0	935,29 kr
1812	11	2869	0	0	931,71 kr
1813	4	2858	0	0	930,40 kr
1814	1	2854	0	0	930,08 kr
1815	1	2853	0	0	929,75 kr
1816	2	2852	0	0	929,10 kr
1817	0	2850	0	0	929,10 kr
1818	0	2850	0	2000	929,10 kr
1819	0	2850	0	0	929,10 kr
1820	0	2850	0	0	929,10 kr
1821	0	2850	0	0	929,10 kr
1822	0	2850	0	2000	929,10 kr
1823	0	2850	0	0	929,10 kr
1824	0	2850	0	0	929,10 kr
1825	0	2850	0	0	929,10 kr
1826	0	2850	0	2000	929,10 kr
1827	0	2850	0	0	929,10 kr
1828	0	2850	0	0	929,10 kr
1829	0	2850	0	0	1581,10 kr
1830	0	4850	2000	2000	1581,10 kr
1831	0	4850	0	0	1581,10 kr
1832	0	4850	0	0	1581,10 kr
1833	0	4850	0	0	2 233,10 kr
1834	0	6850	2000	2000	2 233,10 kr
1835	1	6850	0	0	2 232,77 kr
1836	791	6849	0	0	1974,91 kr
1837	258	6058	0	0	2 542,80 kr
1838	494	7800	2000	2000	2 381,76 kr
1839	684	7306	0	0	2 158,77 kr
1840	2245	6622	0	0	1426,90 kr
1841	291	4377	0	0	1984,04 kr
1842	1042	6086	2000	0	1644,34 kr
1843	1056	5044	0	0	1300,09 kr
1844	1066	3988	0	0	952,57 kr
1845	548	2922	0	0	1425,92 kr
1846	397	4374	2000	0	1296,50 kr
1847	695	3977	0	0	1069,93 kr
1848	443	3282	0	0	925,51 kr
1849	788	2839	0	0	1320,63 kr
1850	502	4051	2000	0	1156,97 kr
1851	426	3549	0	0	1018,10 kr
1852	197	3123	0	0	953,88 kr

Appendix 6

Input for the emission calculation of the prospective state.