



# CHALMERS

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## **A cost comparison between an outsourced and in-house storage solution**

*Master of Science Thesis  
in the Supply Chain Management Program*

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MASTER'S THESIS E 2017:029

# **A cost comparison between an outsourced and in-house storage solution**

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A cost comparison between an outsourced and in-house storage solution  
Studying the case of Focus Nordic identifying costs and possible areas of improvement within  
the central warehouse in a future structure

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Cover:

The cover picture shows the logo of the company studied and gathered from the company.

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## **ABSTRACT**

It has become a survival factor to have a constantly evolving business in order to handle today's changing markets. The distributor role in the supply chain has evolved, leading to more pressure on cutting both costs and lead times. The usage of third party logistics providers has increased during the last decade. Companies outsource parts or entire activities to meet customer demands as well as to be able to focus on the company's own core competence.

Focus Nordic have an established partnership with a third party logistics provider that handles parts of the warehouse operations, in order to cope with current space issues at the central warehouse. Even though Focus Nordic outsource some of the storage to an external partner there are still other issues connected to the lack of space, for instance lack of picking locations, congestions, picking routes etc. Focus Nordic has considered the possibility of expanding the central warehouse to increase the capacity, thus enabling to store all goods at the central warehouse, excluding the external third party logistics provider from the structure. The purpose of this master thesis was to provide the company with a data foundation, comparing the current outsourced cost structure with a future in-house one. In addition to the cost comparison the study aims towards identifying areas of improvement within the current warehousing activities that could be further investigated during a potential expansion.

To be able to investigate and reach the objectives of the study both quantitative and qualitative data have been gathered using a triangulation approach. This further means that multiple sources of information have been used in order to increase the reliability and validity of the study. The theoretical and empirical findings were combined in order to conduct the analysis and provide the company with answers to the main objectives.

The results show that the total cost in a future structure would be decreased with an expansion of the required capacity of 600 m<sup>2</sup>. The main differences in the new structure is that all cost categories related to the partnership would be decreased or cease to exist, except for the storage rent that would increase. An in-house solution would also require some initial material investments during the first period for new pallet locations. The second part of the analysis showed that ergonomics, goods reception, storage assignments and picking routes were all identified as clear areas of improvements that could be combined with an expansion in order to develop the future structure. However, to successfully improve these areas more than 600 m<sup>2</sup> would be needed, that would require further investments.

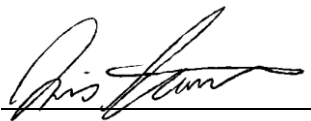


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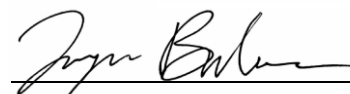
First of all we would like to send our sincerest appreciations to CEO Jonas Wernbo at Focus Nordic for giving us the opportunity to conduct this study. Adding to this, we are very grateful for the trust, belief and curiosity of the entire company. Great support has been shown from both management and other departments, especially the warehouse employees who have been very supportive with their special knowledge and own thoughts. We are very thankful for the participation of everyone within and outside of the company, where every participant has been keen to assist us in pushing the study forward.

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Denis Alickovic



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Jesper Behrman





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# 1. INTRODUCTION

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*This chapter aims towards providing an overview of the area in focus and the underlying reasons behind the main problems, in order to understand the following chapters of the study. The analyzed company is presented as well as a description of their specific problems. Thereafter the purpose of the study is presented, leading to the main objectives of the study. Lastly the limitations, scope and main assumptions are brought up.*

---

## 1.1 BACKGROUND

The distribution network plays a key role when it comes to meeting the customer demands on short lead times and custom-made solutions. Due to the long distances between manufacturers and end customers, new distribution methods have been implemented in order to satisfy the demand. Suppliers of materials or finished goods are forced to collaborate with distributors (Hilletofth et al., 2011). Focus Nordic is a distributor who have followed this trend, handling larger volumes and entering new markets. The usage of a third party logistics provider for extra storage is now questioned, as the need for extra capacity at the central warehouse in order to reduce cost and improve the internal activities is discussed. This requires further investigations regarding both cost structures and areas of improvement.

According to Nakagawa et al. (2012) the distributors also work as a connection point between other actors, and are therefore important when it comes to building partnerships and strengthening the collaboration. The authors further state that the distributor role has shifted from a simple warehousing and transporting point to a value adding and important function in the chain. Faber et al. (2013) explain that the warehouse now can be used in different ways depending on the type of product, where some warehouses are used as a last assembly point in the chain. The authors further state that this has led to a focus on increasing the warehouse operations performance but at the same time cutting down the related costs. Petersen (1999) stresses the importance of using the right strategy for the warehouse, optimizing activities connected to route planning, storage, transportation, packaging etc. A problem that can occur is lack of capacity due to the fluctuations in demand, which according to Al-Gwaiz et al. (2016) may lead to a need for capacity investments. There are different solutions to these types of problems and companies need to determine which alternative suits their context the best.

An increasing supply chain complexity has according to Azzi et al. (2010) led to many suppliers or manufacturers outsourcing parts of the distribution to experts within the area, namely third party logistics (hereinafter called 3PL) providers. The authors further state that this is an increasing phenomenon due to the cost focus and demand uncertainty as well, where many companies have realized the importance of improving the logistics performance, often leading to the dilemma of in- or outsourcing. Andersson (1998) argues that some of the major benefits of outsourcing are cutting cost and enabling the buying company to focus on core competences. Van Weele (2014) agrees that there are major benefits connected to outsourcing but points out that there are some risks as well. The author further argues that this depends on what type of solution is used and to what extent

activities are outsourced. Some of the risks mentioned are mostly connected to lack of influence, bad communication, large dependence and bad coordination, influencing the total performance.

It becomes quite clear that the market is directly influenced by costs, which according to Amiri (2006) leads to tradeoffs between costs and performance. Distributors with own warehouses need to consider how to handle capacity expansions while keeping the performance at the same level (Al-Gwaiz et al., 2016). These two combined contribute to a clear need of cost evaluations between different options. This is strengthened by Longo (2011) who states that it is important for the management to consider questions regarding warehouse size and capacity, layout, internal and external transportation, material handling routines, performance, storage strategies and operational strategies performed by employees. It is therefore of utmost importance to consider different options in regards to costs, potential benefits and risks to be able to choose the right type of strategy and structure for the company.

When companies consider the decision of performing certain activities in-house compared to outsourcing the operations to other external companies, it often comes down to costs as a determining factor in the decision making process (Bigelow & Argyres, 2008). These make-or-buy decisions are putting cost in relation to the safety and security of keeping it in-house, where the control is kept within the organization. The external companies that are operating within a certain area of expertise, will most likely perform each activity much cheaper than the focal firm, although a loss of control might follow (Vallespir & Kleinhaus, 2001). Since the activity is the external company's core competence, benefits from economies of scale and focus on improving that isolated process can be achieved. In the end it is important to take all details into consideration when dealing with a make-or-buy decision. Aspects such as environmental impact, social responsibilities, loss of control and focusing on core competence are all determining factors that are weighed against the costs (Andersson, 1998; Gimenez et al., 2012).

## **1.2 ABOUT THE STUDIED COMPANY**

Focus Nordic (hereinafter called FN) is currently the largest distributor within the imaging industry of the Northern European business-to-business market. FN distributes all kinds of finished products that are connected to photography, such as cameras; accessories; frames; binoculars; etc. FN is a general agent of most of the brands they sell, such as Tamron; Pentax; Lowepro; and FN's own brand, "Focus". The own brand's products include frames; albums; binoculars; and other accessories. The production of these products is outsourced to external companies in Asia, which makes FN a non-producing company only importing and selling finished products. FN is currently active in nine countries of northern Europe; Sweden, Norway, Denmark, Finland, Iceland, Estonia, Latvia, Lithuania and Poland. There are sales offices located in each of these countries (Icelandic office is located in Denmark), with the head office located in Gothenburg, Sweden. FN only operates one central warehouse (hereinafter called CW) in

direct connection with the head office, where all customer orders regardless of destination are handled and shipped. In Table 1 annual statistics of FN's volumes are shown.

*Table 1 – Summary of characteristics of Focus Nordic.*

|                                    |           |
|------------------------------------|-----------|
| Annual revenue                     | ~500 MSEK |
| Number of brands in assortment     | ~75       |
| Number of active products          | ~7 450    |
| Number of active customers         | ~2 150    |
| Number of customer orders per year | ~35 000   |
| Number of order lines per year     | ~280 000  |
| Number of packages sent per year   | ~76 000   |
| Number of pallets sent per year    | ~3 800    |

FN was founded in 2010 through a merger of three actors operating within the imaging industry. These actors were Focus Trading AB in Sweden, Aronsen A/S in Norway and Westheimer A/S in Denmark. Under Focus Trading there was an existing branch called Focus Image Nordic OY in Finland, and these four countries merged together and became Focus Nordic AB. Before the merger there were three warehouses, one in Partille (outside of Gothenburg, Sweden), and one in Copenhagen, Denmark as well as one in Oslo, Norway. The decision was made to only keep one CW and the location was set to Sweden. After the merger FN had to start working hard and thoroughly with the assortment. The original companies did not have the same assortment so in the beginning the company had a much larger product range than optimal for a successful business. Some brands were phased out early in the process and sold out in full. Other brands had to be kept until further notice due to that FN was not allowed to sell these brands in each country for the time being. The company worked hard to become general agents for the largest brands currently handled in the Swedish market, in order to keep the same assortment in all markets. Today, largely same product range is available in all countries.

Since the merger FN has expanded their business by entering the Baltic market in 2013 and the Polish market in 2016. As the company is growing the need to adapt to changing trends in the market has increased, especially as the imaging industry has had a change in focus during the last decade. As smart phones have developed over the years with disruptive technology and highly developed cameras there has been a declining demand for regular compact digital cameras. This has forced FN to change focus and are today selling more accessories and professional gear than previously. By growing in size the need of capacity in the current warehouse has become an arising issue over time.

### **1.3 PROBLEM DESCRIPTION**

FN's HQ is located in Gothenburg, Sweden, with both office and CW. This is the only warehouse that is operated by in-house personnel and is also where all customer orders are handled and shipped out. After the merger in 2010 there was an instant need of space, and the former CW and head office, located in Partille outside of Gothenburg, was

immediately considered too small for the now larger organization. FN was therefore forced to look for additional space to store the products, where a 3PL provider was hired.

The main purpose of the partnership with the 3PL company was to rent pallet locations, working as a buffer to replenish the CW. Initially a certain amount of pallets was sent to the 3PL provider, in order to reduce the fill rate in the CW. The merger also led to a larger product range, since the three previous companies had some differences in the assortments. However, it was not only the range of products that became an issue, but also the fact that larger volumes were purchased, in order to meet the demands in the new and larger markets. This led to issues with receiving the increased volumes at the CW. To solve these issues the partnership with the 3PL company was extended, where goods reception was included and the 3PL company soon started to receive all the larger deliveries at the external warehouse (hereinafter called EW) instead of FN directing such deliveries to the CW. There were mainly brands of low value and high volumes in the forms of twenty (20') and forty-foot (40') containers. All other deliveries of high value products and low volumes were still received at the CW.

As FN grew and got more organized in the product assortment, the need of pallet locations increased at the EW and the annual cost started to increase. Already at the beginning of the merger, the management started to look for new and larger facilities, since there was no possibility to rebuild or extend the warehouse. After a short period of time a facility was found that fitted the purpose well, it was acquired and turned into the new CW for the company. The new, and current, CW did not have the space to fill up all of the pallets located at the EW however, and the 3PL provider therefore had to be kept. Nonetheless, FN quickly started to reduce the number of pallets at the EW and lowered the annual cost. The new CW has better possibilities to receive larger volumes compared to the previous one, thus more and larger shipments are sent directly there instead of through the EW. Even though the new building is not large enough to fit all the pallets in the EW, FN now has the possibility to increase the size of the warehouse. The building is owned by an external landlord, where FN is charged rent per square meter for both the warehouse and office. In the EW, which is also located in Gothenburg, pallets are stored solely as a buffer. Depending on the time of year, usually between 500 and 1000 pallets are stored in the EW, compared to a capacity of around 2400 pallets in the CW.

The space limitation issue is not only related to storing the goods. Problems also arise from a limited number of picking locations, as FN currently have more unique products in the assortment than available picking locations. There are also issues with narrow space both within the in- and outbound areas. In the inbound area it can be very crowded from time to time, where the peak season in October through December leads to disruptions in both storage and daily operations, due to the lack of space. This in turn, leads to disorder where it takes more time than otherwise would be needed to put away products into storage. During peak season, there are both a lot of incoming and outgoing goods at the same time, putting employees in a tight situation, affecting the productivity throughout the whole warehouse. The company would like to look into expanding and rebuilding the



current CW, in order to fit all the pallets located at the EW and addressing the space issues experienced within the CW.

## **1.4 PURPOSE**

The purpose of the study is divided into two parts, both contributing to a strong foundation for future decisions regarding an expansion of the CW. The first part of the purpose is to provide the company with a comparison between the in-house and outsourcing solution, using a cost structure. The second part of the purpose is to find areas of potential improvement, following a CW expansion.

### *1.4.1 Part one*

The purpose of the first part is to provide FN with a cost comparison. The comparison includes analyzing the cost structure of the current set up, using an external partner for goods reception and storage capacity. These costs are compared with a future expanded structure, where everything is received and stored in-house, at FN's CW. In order to analyze the how an expansion and increased capacity at the CW would influence the cost structure at FN, the following two objectives are formed:

- ❖ Identify how much storage capacity is needed, in the CW, in order to handle the volumes currently outsourced to the external partner.
- ❖ Compare the costs in the current outsourced set up, with a future in-house set up, showing the differences in each cost category identified.

### *1.4.2 Part two*

After the cost comparison has been made, the next step is to identify possible areas of improvement within the central warehouse. The purpose of identifying these areas of improvement is to provide the company with the prerequisites to solve the space related issues. This requires finding flaws in the activities related to the space issues at the central warehouse. In order to analyze possible areas of improvement in the current structure the following objective is formed:

- ❖ Identify flaws in the current operations at the central warehouse, connected to the space related issue, to see how they would be affected and utilized in an expansion.

## **1.5 SCOPE AND DELIMITATIONS**

The study is focused on the CW operations and does not strive towards developing any new types of frameworks or general conclusions. The attention is focused on the specific context of FN, as are the solutions provided. To narrow it down the study does not include any external construction costs related to the expansion, as the property is not owned by FN. An expansion of the property would therefore lead to an increase in rental costs, which is included in the calculations. The cost related to the transition period (potential disruptions in daily operations) when going from the present structure to the potential new structure are also excluded from the study. The study is also narrowed down to the current figures related to volumes and existing capacity. This means that there are no speculations about future needs or any assumptions regarding future demands.

Regarding the cost calculations conducted throughout the study, the focus lies on the incremental costs; meaning costs that would change following a reconstruction, and are therefore included in the calculations. The other costs that would not change due to the reconstruction, and that would remain the same regardless of the type of structure, are therefore excluded from the calculations. The results of the calculations would not consider whether or not it is financially beneficial for the company to invest in a reconstruction. The delivery is focused on pure cost calculations and it is fully up to the company to weigh potential investment costs versus benefits and drawbacks of it. To make a fair comparison, no efficiency improvements are included in the cost calculation.

The second part of the study includes potential improvements in conjunction with a possible expansion. The warehouse activities considered are all connected to the space issue. All other operating activities are excluded since they not have a direct connection with the space issue. An aspect connected to the space issue is the material planning and control, such as determining of safety stocks, re-order points and lead times of incoming goods. However, since the company want to offer high availability towards the customers, a higher stock level is tolerated. FN is not interested in investigating the possibility of changing the current material planning system and decreasing stock levels at this moment. This part is therefore excluded from the study.

## **2. THEORETICAL FRAMEWORK**

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*The subjects brought up in this chapter aim towards explaining important factors and relevant theories as well as providing a base for further analysis. Relevant literature is used in order to understand the empirical findings to later on analyze them, drawing conclusions from the results. The literature includes roles, activities and costs related to warehousing, that are connected to the specific case of FN and their space issues.*

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The disposition of the theoretical chapter is structured to systematically guide the reader from a holistic view, beginning with describing the concept of outsourcing. As FN outsource parts of their business to a 3PL provider, it is important to understand the theoretical view of outsourcing decisions. By collecting such literature, typical underlying reasons can be identified. This is later used to analyze if there are other reasons than cost reductions to actually use a 3PL provider, and to apply such reasons to this study. The next step of the theoretical frameworks consists of literature explaining the role of the warehouse and different activities within it, which are all connected to possible future improvements areas. This gives strong indications of what factors are important to consider and how to develop the activities, which is suitable for analyzing improvement areas connected to part two of the study. This also gives some insight into how the different factors and activities (meaning storage, goods reception, picking and layout) are connected and strengthens the understanding of how changes in one part of the warehouse can influence other ones. The next part of the literature research brings up different warehousing costs and how they are structured and interrelated. This part of the framework is connected to the first part of the study aiming towards comparing the cost of two different scenarios. It provides good assistance to the empirical research as it indicates what sort of costs are important to consider. The literature does not bring up exactly the specific names of each cost later used in the analysis but rather larger categories that the authors of this study later broke down to more detailed cost branches. Choosing literature related to these specific areas, including ergonomics, was based on empirical data as well as the results from the cost analysis in part one.

### **2.1 OUTSOURCING**

The purpose of this part of the framework is to identify the main reasons behind outsourcing and what benefits it may bring to the buyer. This is later used to analyze if it in FN's case is recommended to outsource some of the company's logistics functions as a complement to the cost analysis. Further, the role of the 3PL provider is explained. The study analyzes the cost structures of two alternatives where the current structure includes a 3PL provider, making it essential for the study to understand the 3PL role. Depending on the results of the first part of the study it can be interesting to bring up such aspects to further strengthen the future reconstruction decisions, adding an additional dimension to the problem.

Outsourcing is described by Van Weele (2014) as the shift from conducting certain activities within the company, to hiring a 3PL provider to handle them instead. The author further mentions that there are 4 different characteristics of outsourcing, namely:

- The activities have been conducted within the company but are now either partly or entirely handled by an external supplier
- Some assets, people and knowledge are transferred to the external company
- A partnership is established over time between the two parties
- The buying company would be exposed to new costs and risks, connected to the partnership

The phenomenon has increased rapidly during the last few years with companies outsourcing different activities and services in order to improve the total performance. Outsourcing has moved from only outsourcing single activities to outsourcing entire company functions. It is common that companies choose to outsource activities connected to IT, marketing, purchasing, production logistics etc. (Deepen, 2007; Lisle, 2003; Van Weele, 2014).

Logistics outsourcing is explained by Deepen (2007) as the usage of a 3PL provider for all or parts of an organizations logistics operation. Ziolkiewicz (2011) explains that companies are forced to adapt to volatile environments and need to be able to quickly adapt in order to stay competitive. Deepen (2007) argues that most companies do not see logistics as a core competence and are therefore willing to outsource such activities to a third party. The supplier could improve their current logistics structure and performance while the company can focus on other areas instead. The author further argues that it is of most importance to also include surrounding factors, before making any decisions regarding what activities to outsource and what company is most suitable to partner up with.

### *2.1.1 Third party logistics*

Marasco (2008) argues that a topic often related to outsourcing is 3PL that can be seen in different ways depending on the extent of usage. This means that the 3PL function can vary from only handling simple tasks to organizing complex logistics solutions. Deepen (2007) states that 3PL providers nowadays can provide customized solutions for the customers. The specialized network and knowledge among 3PL providers is used to create new options for the customers that would be difficult for the own company to create. Hertz & Alfredsson (2003) explain that the activities that are the most commonly handled by 3PL providers are transportation, inventory and warehousing, but also services within information, value-adding, design and reconstruction of the supply chain. The authors further state that some advantages are the connection to the logistics networks, granting extra bargaining power due to economies of scale, minimal learning curve, faster and smoother implementation and market knowledge. Deepen (2007) claims that the flexibility is very important for companies since the 3PL providers enable companies to turn fixed cost into variable. Jayaram & Tan (2010) argue that 3PL providers work as the link between other actors, having a great role when it comes to both the physical flow of products but also the intangible flow of information.

### *2.1.2 Consequences of outsourcing*

According to Harrington (1998) there is always a risk of not achieving goals set up between the two parties. The reactions to a failure can vary where some companies choose to bring back the activities while others choose to work on the flaws. Companies may have different expectations and risk assessments in place, which lead to different benefits and risks depending on each specific case. There are still some commonly mentioned reasons and problems behind outsourcing that will be further discussed.

Companies choose to outsource activities to a 3PL, as it enables the company to focus on their core competence (Andersson, 1998; Chopra & Meindl, 2012; Heikkilä & Cordon, 2002; Lisle, 2003; Van Weele, 2014; Ziolkiewicz, 2011). By focusing resources on the main value adding activities of the organization, improvements can be made within these areas while the 3PL handles the non-core activities. The activities are commonly outsourced to experts within the area and are therefore handled more effectively. This is supported by Andersson (1998) who argues that cost reduction and service improvements are some of the main drivers. He also mentions the changing investment structure, since fixed costs are turned into variable thus leading to more flexibility in the supply chain. Ziolkiewicz (2011) supports this argument but discusses risk sharing and increased knowledge, capacity and resources at main drivers as well. Another positive effect of outsourcing is that there is a possibility to learn more about different processes and have a closer access to new markets through the 3PL (Heikkilä & Cordon, 2002; Van Weele, 2014). The supplier may have connections to new possible customers in other markets, which may be used as a first step to expansion.

Growing customer demands and increased volumes often lead to a lack of capacity when it comes to warehousing. Chopra & Meindl (2012) argue that the main reason behind the success of 3PL providers is their economies of scale advantage. For instance, larger amounts of goods can be received without having to risk overfilling the warehouse. Solakivi et al. (2013) however argue that outsourcing logistics may lead to reduced innovation for the buying company. Since there is less pressure to actually improve the internal logistics processes the capacity improvements are left out. The authors further argue that outsourcing can have a negative impact on other areas as well, leading to an overall negative trend for performance improvements. Deepen (2007) states that the fluctuating demands experienced in warehousing activities can be seen as a reason for outsourcing. Chopra & Meindl (2012) explain that it is difficult to estimate personnel required in warehousing due the highs and lows that are connected to both seasonal demand and to specific activities like for instance goods receipts.

## **2.2 WAREHOUSE ROLE AND ACTIVITIES**

The sections in this part of the study explains different activities and influencing factors within a warehouse. These sections aim to both explain the concept as well as mentioning what factors to consider when improving it. This is directly connected to the second part of the study where the purpose is to identify improvement areas within the warehouse.

All four parts of this section are selected based on the problem and the theory was collected depending on the specific situation of FN. This further means that there may be other activities that are important but are not brought up in the theoretical framework as they are not applicable to FN's particular situation.

An important cornerstone of the distribution network is the function of the warehouse. Warehousing has developed a lot in the last few years and can nowadays be considered as an important success factor of the business (Faber et al., 2013). Dotoli et al. (2015) argue that warehouse management plays a decisive role in maximizing profit by optimizing material and informational flows. The authors further argue that the warehouse role performs useful services, such as responding quickly to changes in demand, reducing transportation costs as well as increasing customer service. Richards (2014) explains that warehouses were previously seen as cost centers that had no value adding function. Faber et al. (2013) explain that the increased supply chain complexity has put pressure on the warehouse to be able to handle larger quantities while still remaining efficient and effective. The authors claim that unpredictability and constantly changing customer demands have led to a need to constantly improve warehouse processes and management in order to stay competitive. Richards (2014) stresses the importance of increasing productivity, accuracy and at the same time to bring down the inventory levels and costs. He means that the warehouse nowadays plays a decisive role in being able to deliver the right products, at the right time and in the right quantity.

As warehouses make up for a significant part of the distribution network Chopra & Meindl (2012) argue that factors including response time, type of product, availability, lead times, customer expectations etc. are crucial to consider when designing the network. As Amiri (2006) explains, there are often tradeoffs related to warehouses and transportation. This means that there is a direct connection between these two factors to a specific point. This is brought up by Chopra & Meindl (2012) who explain that the transportation costs are directly related to the number of warehouses used, seen in Figure 1. This argument is based on the assumption that the warehouses are fairly spread out, shortening the distance to the customer. When this is the case the authors argue that the transportation cost decreases with the increasing number of warehouses. Another factor mentioned by Chopra & Meindl (2012) is the response time, which also is reduced with an increased number of warehouses, seen in Figure 1. This does require that the warehouses are capable to perform the same activities and handle the customer expectations.

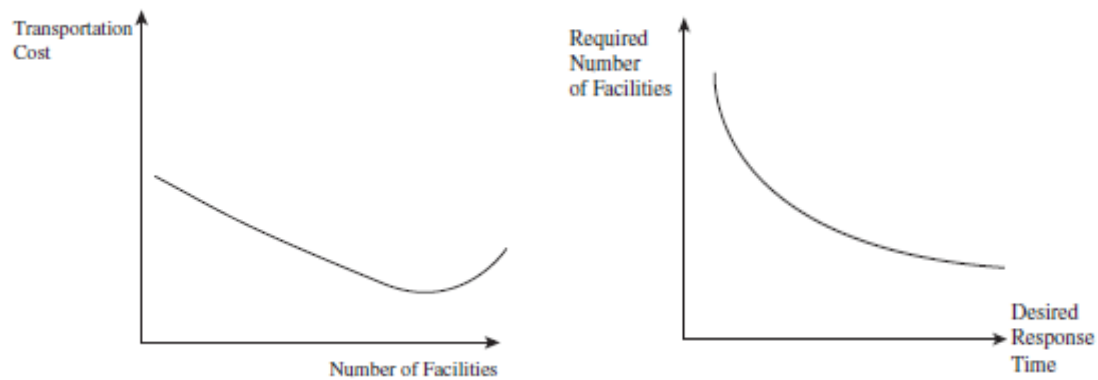


Figure 1 – Relation between number of facilities and transportation cost, and response time (Chopra & Meindl, 2012).

### 2.2.1 Warehouse layout

A major factor connected to the warehouse performance is the layout, and this is directly related to all warehousing activities. Koster et al. (2007) explain that major decisions made when designing the warehouse layout include the placement of all equipment, storage, receiving area, shipping area etc. Rouwenhorst et al. (2000) state that the layout needs to be determined in the tactical level of the design process with regards to the decisions made by the management in the strategic level. The authors further argue that common goals with the layout are to minimize operational costs, response time and throughput time, while keeping down the investment costs. This is further strengthened by Zhang et al. (2017) who argue that an efficient layout can clearly reduce the operational costs of the warehouse. By placing the right resources in the right locations the company can cut down the material handling costs as well as increase the space utilization. The authors further argue that many companies today struggle with space and that it in many cases is because of a poorly designed layout. Cardona et al. (2015) state that the same type of structure and layout is commonly used in warehouses all around the world. This layout consists of parallel aisles, stretching from one side of the warehouse to the other. The authors additionally state that companies can reduce the travel distance by up to 20%, by choosing an alternative layout for the warehouse.

Koster et al. (2007) argue that the company should consider the entire system when designing the layout. This means that the current demand and future expectations must be considered as well as planned picking routines, robots and other equipment. When the capacity requirements are known, the number of blocks and aisles must be decided together with the measurements for each storage location. Rosenblatt & Roll (1984) state that it can be complicated to determine the optimal size and layout of the warehouse and that clear goals to work towards are needed. No matter what layout option is used, the most important step is to actually integrate the layout with storage assignments, picking routes and warehouse policies. Optimizing a single activity would in many cases not give any actual effect and just lead to sub-optimizations. Each factor is in some way directly related to another, which means that companies must adapt a holistic approach and

determine each activity based on this, only then can an optimal layout be designed (Cardona et al., 2015; Koster et al., 2007; Rosenblatt & Roll, 1984; Zhang et al., 2017).

### *2.2.2 Goods reception*

One of the main activities of the warehouse is handling trailers and containers when receiving goods from different suppliers. This includes activities like unloading containers or trailers received from suppliers, updating the inventory levels, quality and quantity inspections and so on (Koster et al., 2007). These processes can impact the total supply chain performance as they affect both the carrier and the warehouse receiving the goods. The trailer or container must be received by the warehouse and the goods must be unloaded. The carrier is therefore locked up during this time, which is why it is important to have an efficient unloading process (Speredelozzi et al., 2006). The process of unloading the goods from the carrier to the storage can according to Lehnfeld & Knust (2014), lead to different problems related to storage and allocations. This means that the goods received must have some space to be stored before being assigned to a specific location. The authors further mention the importance of accessibility of carrying units in order to have an efficient loading or unloading process. Speredelozzi et al. (2006) state that it is important to have a continuous movement of goods during the unloading itself, in order to reduce the risk of blocking and causing queues. The right equipment, number of workers and type of products can all influence the unloading process and must be evaluated. Eko et al. (2016) argue that an evaluation is needed to be able to secure the process as well as being able to add value to both material and employees.

A common transportation unit used in long-distance transportation is containers. Tierney, Pacino & Jensen (2014) argue that the containerization has grown rapidly during the last several years since containers can be used by different transportation vehicles. The robust container design works well for all kinds of products since it provides good protection. The most commonly used sizes are 20' (foot) or 40' (foot) where products can be transported without reallocations from the supplier to buyer (Luo et al., 2016).

### *2.2.3 Storage and internal replenishment*

Storage mean much more than only storing a product in a warehouse location for a certain time. When it comes to material handling and warehouse management systems there are many different ways to handle storage, where the main objective is to minimize the total distance travelled for each product (Accorsi et al., 2014; Manzini et al., 2015). The selection of storage locations and assignment of products to these locations are important to consider together with the warehouse layout. As Koster et al. (2007) mention, the picking time is the most time consuming and costly activity in a warehouse, where travel time constitutes for about 50% of the picking time. This calls for a well-functioning storage assignment in order to minimize travel time. According to Koster et al. (2007) there are numerous ways of assigning products into storage within a warehouse, where common strategies are random storage, closest open storage, dedicated storage, full turnover storage, and class-based storage.



Random storage is a simple storage assignment strategy, where the employees themselves or the warehouse management system (hereinafter called WMS) randomly assigns a product to a location, which usually increases the average travel time (Accorsi et al., 2014; Koster et al., 2007). The next strategy is closest open storage, where the employee chooses the first location they encounter and place the products there, leading to a very full storage near the depot and more sparsely placement further away. Another strategy is dedicated storage assignment, where the products are assigned a specific location, which is kept even though the product is out of stock. This strategy comes with both benefits and drawbacks where it represent the lowest space utility of all storage policies, but where the employees get familiar with the locations, which can reduce the pick and search time (Koster et al., 2007). Full turnover storage is based on the revenue of the product. Products with high turnover are assigned to locations near the depot, where products with lower sales rates are placed in the back of the warehouse. Products with higher frequency will thus have shorter travel distance, which lowers the total distance travelled. However, as the customer demand varies through time this can change quickly, where the employees may have to spend a lot of time to move the products around (Kim & Seidmann, 1990; Koster et al., 2007). Class-based storage is a combination of the above mentioned policies where products are assigned into groups usually based on frequency. These groups are decided by performing a Pareto or ABC classification and assigning the product classes to different zones (Koster et al., 2007; Pan et al., 2014). The above mentioned strategies and policies can be used for both manual picker-to-part systems and automated part-to-picker systems. The use of part-to-picker systems, often called automated storage and retrieval systems (AS/RS), can increase space utility and reduce travel time (Accorsi et al., 2014; Atmaca & Ozturk, 2013; Manzini et al., 2015).

Products are usually replenished from a bulk storage into a forward area where the products are available for picking (Accorsi et al., 2014; Koster et al., 2007). The assigned location affects the internal replenishment in several ways. For instance, the size of the location determines the frequency and number of replenishments that are needed for a certain product. If the travel distance from the bulk storage to the picking location is quite far and the frequency is high, this leads to losses in total distance. Size is therefore an important aspect to consider both in product and location (Accorsi et al., 2014; Koster et al., 2007). Another factor to consider is the sales rate. The turnover and frequency of a product is connected to the size and directly affects replenishment. If a high frequency product is stored at the largest location possible but still frequently replenished, this product might be better suited to be stored in multiple locations, in order to replenish the product more seldom (Accorsi et al., 2014; Koster et al., 2007).

#### *2.2.4 Picking*

Order picking is defined by Koster et al. (2007) and Chan & Chan (2011) as: “the process of retrieving products from storage (or buffer areas) in response to a specific customer request”. Of all the activities in the warehouse order-picking is the most expensive, weighing up to about half of the total operative warehousing cost. Having a poor picking process has an immediate impact on the total performance of the warehouse as well as on

the entire chain (Koster et al., 2007; Petersen & Aase 2004). Many companies have chosen to try to improve the picking efficiency through different automated solutions, while others focus on improving the manual picking process. Flexibility and possibility to adapt to different customer needs are two benefits connected to automated solutions (Petersen & Aase 2004). Moeller (2011) argues that manual picking offers a variety of options while automated solutions often tend to be efficient for a small part of the assortment, and therefore suitable for more standardized processes and products. There are basically three different factors that need to be considered when looking at the picking process: the warehouse layout, storage assignment and picking policies and routes (Chan & Chan, 2011; Koster et al., 2007; Moeller, 2011; Petersen & Aase, 2004).

Koster et al. (2007) state that these factors need to be analyzed to be able to choose the fastest and most efficient picking route. But the authors state that the placement of goods has a large influence, since it often determines the route's length. Roodbergen & Koster (2001) argue that the main improvement aspect is the travel time, but that other sub-factors need to be improved in order to reduce the picking time spent. The authors mention the depot position as an example, where the time can be reduced by having it in the right place, thus shortening the distance to the products. As most picking processes begin with receiving a picking list, a correct depot point is important to adapt to the warehouse design (Roodbergen & Koster, 2001). Travel distance is an important factor, but far from the only one. Koster et al. (2007) mention that maximizing factors like space, use of labor, equipment and accessibility is as important to consider. The authors also mention that these can be connected, meaning that improving a single factor can have either positive or negative impact on another. The company must therefore find the right balance in order to improve the total picking performance.

When choosing the route some of the most commonly used methods, according to Moeller (2011) and Chan & Chan (2011), are:

- S-shape method: Where the picker follows an S-flow walking through the aisles from one end to the other
- Largest gap method: The picker chooses the shortest way to exit the aisle based on the picking location in the current aisle compared to the new picking location
- Return method: The picker always enters and exits the aisle from the same direction

Moeller (2011) also mentions the picking shelves as factors influencing the routes where two-sided shelves are often used. However, he also points out the importance of communicating the reasons behind the routes to the personnel, since a deviation from the optimal route is most likely to increase the total travelling time.

### **2.3 WAREHOUSING COSTS**

Identifying the cost connected to the warehouse is directly applicable to the purpose of the first part of the study. Since cost structures are compared it is important to consider

the influential costs in the calculations. This has given the authors of this study the appropriate tools to identify the real costs connected to this specific case of FN. The study aims towards analyzing costs connected to an in-house scenario compared to the current outsourced scenario. The theory is used both to identify which areas that needs to be investigated and to categorize the costs. The theoretical findings are later used to create a theoretical cost structure that will be used in the analysis.

When analyzing costs connected to warehousing it is important to map out all costs related to the specific objective of the analysis. According to Richards (2014) warehouse managers are pressured to reduce costs and at the same time increase customer service. Examples of cost reductions can be to decrease inventory levels while offering the customers a wider assortment, without affecting the delivery accuracy and service level (Huq et al., 2011; Richards, 2014).

Four categories that are often discussed connected to warehousing in literature are: space, inventory, handling and overhead costs. These categories can further be broken down into subcategories, such as: holding, labor, equipment, IT or administration costs. Each subcategory can also be divided into fixed or variable costs, where cost reductions can be identified individually (Abbasi, 2011; Huq et al., 2011; Richards, 2014; Solakivi et al., 2013). Costs can also be divided into direct and indirect costs, where direct are known and easy to measure while indirect may be known but difficult or even impossible to put a price on (Axelrod, 2004). According to Richards (2014) it is important to acquire good knowledge of each warehousing cost in order to further contribute with important information for the company budget. Additionally, Bortolini et al. (2015) state that the design of the warehouse affects storage capacity and operational costs, where different layouts can fit a specific purpose.

### *2.3.1 Space costs*

The cost of space includes storage rent, racking, insurance, maintenance, cleaning, etc. Space costs are among the largest costs related to warehousing and some of the most important to keep track of (Abbasi, 2011; Richards, 2014). A phenomenon that is well discussed and directly affecting space cost is utilizing space and storage capacity. Low utilization leads to higher cost per unit, which accordingly argues for high utilization and fill rates in the warehouse. However, if the warehouse capacity is overestimated or overbooked there will be other consequences such as lost sales and reduced customer service. As the incoming goods cannot be handled and stored, it further leads to delays for the customers. It is therefore important to keep an optimized level of storage utilization in order to lower risks and costs (Derhami et al., 2016; Houghton & Portugal, 2005). By customizing the warehouse according to the type of products a company can achieve higher capacity in the same amount of space.

### *2.3.2 Inventory costs*

Inventory costs can be directly connected to customer service. According to Abbasi (2011) the costs related to inventory are mainly holding, procurement and shortage costs.

Holding costs is basically the cost of storing a specific product for a certain period of time, and depends on the value of the product, tax and interest rates, insurance, space as well as risk of damages (Abassi 2011; Richards 2014). Procurement costs are mostly related to the purchasing department and all tasks involved in the procurement process, including planning, ordering, communication, monitoring etc. (Abassi, 2011; Van Weele 2014). Lastly, shortage costs exist when the company fails to satisfy the customer demand due to stock outs. Holding costs and shortage costs are therefore often compared against each other. In some cases it might be less costly to back order products than having large quantities in stock. However, this affects customer service due to delays, where additional freight costs may occur by multiple shipments and/or express shipments (Andersson et al., 2010). Andersson et al. (2010) further argues that companies use inventories as a buffer in order to handle uncertainties and variation in demand.

### *2.3.3 Handling costs*

According to Richards (2014) handling costs include two parts: labor and equipment costs. Manzini et al. (2015) express these as resources that are connected to movement of products within the warehouse. Moving products within the warehouse requires certain resources such as people and equipment, leading to costs of each activity. For instance, moving a pallet of products requires at least one resource that entails certain costs. Labor costs include cost of salary, insurance and social fees for the employees. If the pallet is moved by one person that also uses one pallet lifter or fork-lift truck, it leads to costs of both labor and equipment. Manzini et al. (2015) further state that movement or storage of goods does not add any value to the product, hence only being a cost for the company. However, storage and movement of goods are important fundamentals for customer satisfaction, as well as in the improvement of efficiency within the warehouse. The key is therefore to handle the products and customer orders as few times as possible and storing it as short as possible in order to minimize costs.

When improving the material handling and inventory management it is important to consider the operating context. Parvani (2011) explains material handling as ‘providing the right amount of the right material, in the right condition, at the right place, in the right position, in the right sequence, for the right cost and by the right methods’. The right cost however does not mean as low as possible, where minimizing cost is described as the wrong objective when designing the system approach. The objective should instead be focused on designing the system as efficient as possible while keeping the cost at a reasonable level. When deciding the system design, the proposal must be shown to top management, whom are given the possibility to approve or reject the proposition. Such an improvement can be related to automated flows that lower the manual handling of products. This can lead to efficiency improvements reducing handling time or even distance travelled through the warehouse, hence reducing the handling costs (Accorsi et al., 2014).

#### 2.3.4 Overhead costs

There are different kinds of overhead costs, where some are cost of management, human resources, IT and administration (Richards, 2014). These costs can usually not be associated directly with a product or service, but rather to a certain activity or process (Assaf et al., 2001). Examples of overhead costs are: managing operations of a warehouse; hardware and software to handle warehouse operations i.e. computers and enterprise resource planning (hereinafter called ERP) systems; development of current or new ERP/WMS systems; or administrating and maintaining partnerships with external companies (Richards, 2014). Costs of partnerships can be related to the very complex transaction cost economics. The basic idea of the transaction cost can be translated into the cost of partnerships; where all activities performed, information exchanged, and administrative work consist of costs (Thomassen et al., 2016; Yeung et al., 2013).

### 2.4 COST STRUCTURE OF THIS STUDY

The cost structure used in this study is developed in order to analyze FN's specific case. Out of the costs found in theory there are some costs that can be directly applicable with the problem at FN and these are shown in the cost structure created and presented in Figure 2 below. Further, this means that there are also some costs mentioned in theory that cannot be connected to FN's space issue. The main reason for excluding these costs from the study is that such costs and activities will remain the same, regardless of the current or future structure, meaning that the excluded costs will not have any significant impact on the result.

Both Richards (2014) and Abbasi (2011) explain that costs connected to storage, racking systems, maintenance, cleaning and insurance are all important when calculating the space costs. In FN's case, the costs of maintenance and cleaning are performed by the warehouse manager and personnel, where a larger area in a future expansion would not have any significant impact, since the new area is solely used for storage. The cost of insurance for the facility is embedded in the current storage rent, and will thus continue to be so in a future structure as well. The insurance costs for the products stored will remain the same as FN is responsible for the products at both the CW and EW, meaning that the specific location does not impact the cost and the volumes stored will be the same. This further means that the costs are included in total, but would not have a significant impact in shifting from an outsourced to an in-house solution.

Inventory costs are explained by Abbasi (2011) as the cost of holding, procurement and shortage costs. The costs of holding and procurement will, like the insurance costs of products remain exactly the same, regardless of the structure used. As all the products are owned by FN, all these costs and responsibilities are connected to the products, meaning that the cost will not differ depending on where it is stored.

Labor is the only handling cost analyzed in this study even though Richards (2014) point out equipment as well. As all of the products are at some point in time always transported to the CW, the total amount of products handled will remain the same. The equipment

currently used at the warehouse is fully sufficient to handle these volumes, meaning that no further equipment will be required after an expansion. The partnership costs from the 3PL provider are all broken down in detail, where none are connected to the equipment at the EW, meaning that this cost will not be influenced, making it negligible for this study.

Assaf et al. (2001) include costs of IT, administration, management and human resources in the overhead category. None of the latter two are included in the cost structure as they have no impact on FN or the 3PL provider. FN has no responsibility for the employees at the EW and there is no collaboration, sharing warehouse workers. The management's time spent in the partnership is also limited, where the negotiations regarding the contract rarely exist. As this study only aims towards analyzing costs that will differ depending on the solution, costs of both management and human resources are excluded.

Khooban (2011) argues that the external transportation cost constitutes of between 10 and 20% of the logistics costs. Looking at the internal transportation cost related to FN and the 3PL provider, there will be minimal differences in the activities related to the costs. Since the shift in structure will not affect the internal replenishment or affect the number of customer orders the costs for internal transports will remain the same.

The exclusion of all of the above mentioned costs makes up for the cost structure, see Figure 2, used to analyze FN's specific case. As mentioned before, the structure will be used later in the study in order to compare the two different cost scenarios.

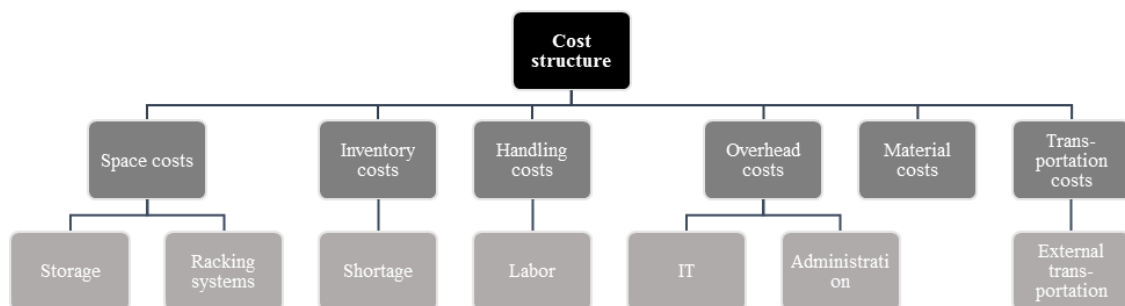


Figure 2 – The cost structure used to analyze and compare the current outsourced state with a future in-house solution. This cost structure is based on theoretical findings that can be directly related to the objectives of this study.

## 2.5 ERGONOMICS

This section is connected to the warehouse activities and has been used in order to analyze improvement areas at the warehouse. As ergonomics is a focus areas of the second part, the theoretical data have been used in order to evaluate the situation for the warehouse employees. It was also used to evaluate how it is related to the cost structure at the warehouse, and identify what possible approaches there might be.

Dul & Neumann (2009) discuss that managers often fail to realize the performance benefits connected to good ergonomics, only focusing on the legislations and safety

requirements from external stakeholders. In order to improve the working environment in it is important to understand what ergonomics are. The authors explain it as the interactions between the workers and different elements of the system, aiming at optimizing the health as well as system performance.

Companies still struggle to find a balance between warehouse efficiency and ergonomics and often struggle with workload questions. Kuorinka et al. (1994) explain that warehouse injuries are often related to poor ergonomics and point out that there are many different factors that need to be considered. The authors further argue that it can be very hard to follow lifting instructions and other standards when having manual handling, because these standards are often based on specific equipment, measures and space that may not exist in all warehouses. Battini et al. (2017) and Calzavara et al. (2016) argue that many warehouse activities require heavy lifts and repetitive work. The authors bring up manual order picking as an example where workers have to bend and lift items all day, often straining the body. The authors argue that the design of the warehouse racks and picking areas is crucial for improving the ergonomics, where factors like depth and height of the picking area in combination with the shape and weight of the item are important.

Dul & Neumann (2009) argue that the lack of ergonomic solutions can be related to the fact that companies often fail to integrate ergonomics early on in the design process. Ergonomics is often seen as extra costs that do not contribute to any value, and not prioritized. The authors disagree with this and argue that ergonomic working conditions often bring a lot of benefits to the company, including better quality and increased working morale. It is therefore up to the management to consider ergonomics in the strategic phase and include the working conditions of the employees when designing new solutions.

## **2.6 TRANSPORTATION AND ENVIRONMENT**

This part aims to explain the environmental issues that can be connected to transportation. As the study includes different transportation alternatives the environmental impact will differ depending on an outsourced or in-house solution. Even though this is not a primary goal of the study, it needs to be considered when analyzing the sustainability of future decisions and costs later on.

Khooban (2011) describes transportation costs as an important part of logistics and supply chains, where the costs constitute between 10 and 20 % of the total product price. By minimizing the number of shipments going to the same destination, the cost would decrease along with the carbon footprint (Gevaers et al., 2014; Moroz & Polkowski, 2016; Tilahun et al., 2016). Reisi et al. (2016) explain that the transportation sector has a large negative impact on the environment and is a main contributor to global warming. The authors further argue that urban areas are experiencing problems connected to noise, accidents and air pollution, which all lead to costs for the society. Congestions in urban districts are a major problem, increasing with the number of transportations. Increasing transportation within and around larger cities lead to delays that cause problems in the

planning process as well as in the transportation execution. The number of vehicles used, transportation distance and paths are all common sustainability indicators. It is therefore important to consider multiple indicators to be able to evaluate and choose the right solution for the specific network (Buzási & Csete, 2015).



### 3. METHODOLOGY

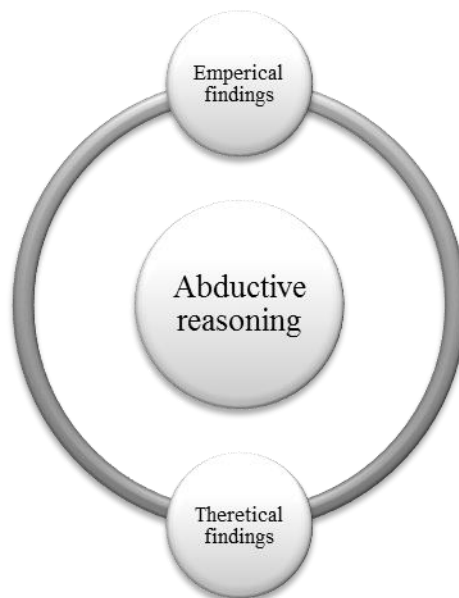
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*This chapter aims towards describing the approaches that were used throughout the study. The chapter provides an overall view of the research and method approaches used, in order to understand the underlying reasons. Further, it also explains how the data collection was conducted and why these methods are applicable for the purpose of this study. The chapter is concluded with societal, ethical and ecological aspects related to the problem, along with a discussion regarding the credibility of the collected data.*

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#### 3.1 RESEARCH APPROACH

In order to write this study and answer the research questions connected to the problems a flexible method was required since the authors of this study wanted to be able to continuously combine theory and empirical data. As the study is divided into two parts with focus on different areas, the width of the research had to include subjects related to both problems, and an abductive approach was used, see Figure 3. Romeijn (2008) argues that such an approach is effective when testing and developing theoretical approaches, although this is not the focus of this study. The approach is used due to the fact that both empirical and theoretical findings are of great importance in order to reach the purpose of the study. By using both continuously throughout the study, it was believed that a more detailed and less time consuming research could be conducted.



*Figure 3 – Research approach used throughout the study.*

According to Dubois & Gadde (2002) an abductive approach is a mixture between induction and deduction meaning that there is a constant relation between the theoretical and empirical results. The authors explain that the framework, empirical data, theory and the specific case are all combined to find new directions to the research. During the thesis study, this gave the authors of this study the opportunity to modify the theoretical framework based on the empirical findings at FN; the company in question. Ong (2012) explains that it in some cases may be beneficial to become a part of the studied company,

and thereby gain the knowledge of how it works and what new theory is needed to develop it further. This was why the authors of this study spent the majority of the time at the studied company, to fully gain a holistic view of the organization.

In this study the first problem was related to the cost analysis. Theory was collected in order to locate all possible costs related to the problem in order to set up a plan for what empirical data was needed. This helped the authors of this study in an early stage of the process and gave the opportunity to direct the focus onto areas, saving time on mapping out different costs without adding any value to the research itself. Re-modifications of the framework were also done during the first part of the study since there were new costs identified that were not found in the first theoretical search. New theory was thereafter added to the framework in order to broaden the understanding within the specific area, see Figure 4.

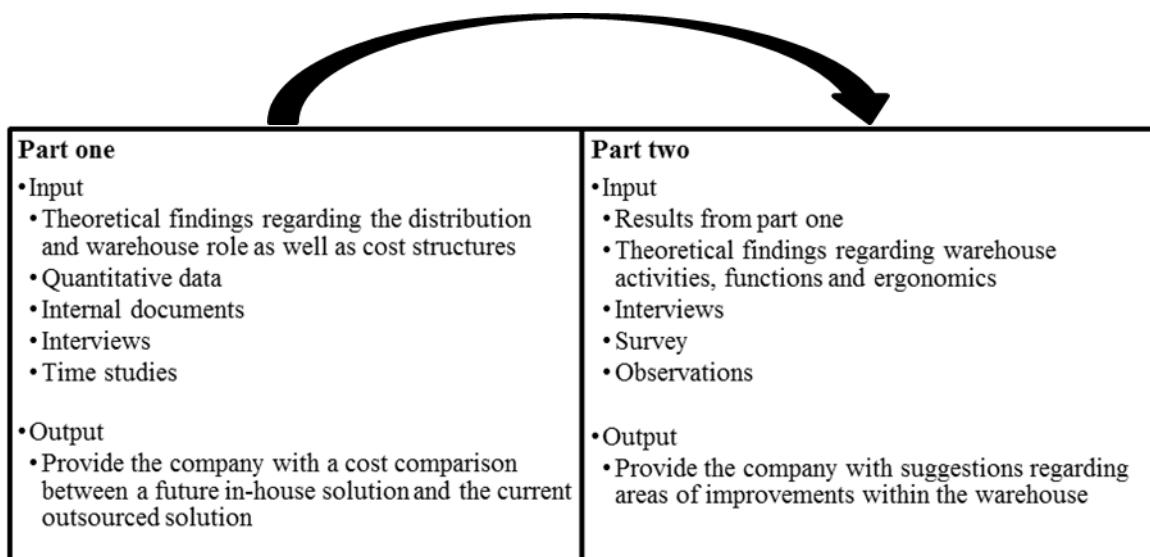


Figure 4 – Overview of the research process where the inputs and outputs of both parts are presented.

The second part of the study is connected to the findings in part one. Ong (2012) stresses the importance of understanding the empirical context to adapt further theoretical implications. During the process of the first part the authors of this study used both empirical and theoretical data in order to analyze the problem, and these findings were then used to identify the areas of improvement in the second part. This required new theory added to the framework to understand how these areas are to be handled, in order to answer the research questions in part two, see Figure 4.

### 3.2 METHOD APPROACH

The focus of this study is divided into two main areas, where the first area focuses on costs and the second area on improvements connected to these costs. To be able to analyze these two problem areas the authors of this study needed to use a combination of a qualitative and quantitative method approach. Allwood (2012) argues that a mixed

approach can be an efficient way when analyzing a problem but stresses that it is important to understand the difference between the two. It is further argued that some of the main characteristics of a qualitative approach are that no statistical data is used and the content is based on the study object. The quantitative approach on the other hand focuses more on numerical data where variations are analyzed (O'Gorman & MacIntosh, 2015).

The empirical data collection for the first part of the study, i.e. the cost analysis was primarily based on statistical and numeric data, meaning that a quantitative approach was used. As mentioned before, theoretical knowledge regarding costs connected to both outsourcing and warehousing were necessary to analyze in order to secure the quality of the research as well as identify the problem areas. The numerical data were collected from internal company documents as well as contracts and invoices. The research also required some additional information regarding activity times, which were collected through time studies at FN.

The qualitative approach was applied on the second part where the purpose was to identify possible improvement areas within the warehouse, which required an open approach. Taylor et al. (2016) argue that it gives the researchers the opportunity to gather and analyze data from interviews and own observations. Such approaches were used even though some of the improvement indicators are based on the results in part one of this study. The results were used to find possible research directions rather than clear indicators of improvements. This further means that the main analysis in part two was based on own observations, interviews and surveys conducted at the warehouse by the authors of this study.

### **3.3 LITERATURE STUDY**

The literature study is according to Bryman & Bell (2003) an important part of the research process and provides the authors with required information about the specific topic. The authors further argue that the development of electronic sources has provided great access to multiple sources of information. The literature for the theoretical framework to this study has been gathered by using online databases such as Chalmers library, ScienceDirect and Google Scholar. Bryman & Bell (2003) mention that it can be efficient to search for specific topics as well as synonymies to increase the possibility of finding the right type of information. When the literature searches were conducted, specific keywords connected to the topics of supply chain management, warehousing activities, cost analysis, ergonomics and distribution were used both separately and combined. Depending on the results of the search different approaches were also applied, thus using synonyms and similar areas to find relevant literature. The main focus has been to find relevant scientific articles as these are reviewed by experts within the same area of research. This gives the articles a higher prioritizing degree compared to books that can be published without any direct review. Books have also been used throughout the study and have been carefully chosen by the authors of this study to ensure reliability.

This information was often used for less complex information and as guidelines, e.g. for the method chapter. Online sources like web sites have been excluded from this study due to the large number of sources and insufficient control of the quality.

Bryman & Bell (2003) explain that a literature study of any kind is useful for the study as well as the authors. Some of the reasons behind a literature research were to gain knowledge of what has been done within the area, concepts and theories used in the area, possible controversies, etc. This study aimed towards providing the reader with such type of literature, thus answering these questions. The literature chapters provide both theories of how to develop the subjects studied as well as information to understand both the role of warehouses and the activities and costs related to them. Taylor et al. (2016) argue that new literature may need to be added during the process and that it can be useful to use information from other frameworks, to build up an own framework for the study. The authors further state that an own framework is often more suitable than forcing the data in to existing frameworks. The framework of this study was built up by literature and information from other existing frameworks, and has been re-modified during the process to either develop current structure or add new parts. As an abductive approach has been used there has been continuous writing and research during the process, especially between the two different parts of the study, where the research for the first part influenced the research for part two, and therefore also the literature used.

### **3.4 DATA COLLECTION**

When performing research for a certain area, whether it is a literature study or a case study, the collection of data and information forms the foundation of the specific research area. The collected data supports the researchers in understanding and interpreting the area observed, giving the knowledge to analyze the main objectives of the study. In order to conduct a reliable analysis, multiple information and data sources are more or less required (Bryman & Bell, 2003). This is why this study combined literature with both qualitative and quantitative data, gathered from internal documents, interviews, a survey, time studies and own observations. This approach provided the authors of this study with enough data to meet the company goals and deliver the result along with securing the quality of the study, in regards to credibility.

O’Gorman & MacIntosh (2015) argue that collecting data can be very time consuming, where the type of collection, the amount gathered, the quality and how accustomed to the research the group is, determines the time needed. It can be beneficial to get as much knowledge as possible in order to fully grasp a certain situation. However, it may be excessively time consuming for the researchers to handle that amount of data, where time might be wasted filtering out the unnecessary details of the data. It was therefore important to consider what data that was needed in order to conduct a feasible study, where the data collection was followed by a data analysis, which was quite time consuming, just as O’Gorman & MacIntosh (2015) argue.

### *3.4.1 Interviews*

O’Gorman & MacIntosh (2015) mention that there are mainly three parts included when conducting an interview, regardless of form: pre-interview, interview and post-interview. All three of these stages were conducted throughout the study and performed in the same manner regardless of research area or subject.

When preparing the interview there are a few important aspects to consider (O’Gorman & MacIntosh, 2015). If the interview strategy is less structured, it might be more suitable to perform it face-to-face since it is a more effective way of absorbing information. If the researchers lack experience in conducting interviews it is more suitable to perform a less structured interview, which was some of the reasons why the authors of this study chose a semi-structured interview. O’Gorman & MacIntosh (2015) state that the most important detail is to decide what to ask the respondent. The type of question and how it is asked affects the answer from the interviewee. In order to maximize the output of the interview it might be good for the interviewers to prepare themselves and the respondent. O’Gorman & MacIntosh (2015) further argue that by sharing the questions beforehand, both parties can be better organized and anticipate an answer prior to the question being asked. This is something that was very useful during the study. Access to internal documents led to deeper understanding regarding the different topics brought up and how these were situated at the company. Since the authors of this study gained knowledge of the internal processes within the company, some answers could be anticipated beforehand and the questions aimed towards confirming already known facts. This showed the importance of using triangulation as a methodology of analyzing the different problem areas.

According to Bryman & Bell (2003) the selection of questions is important to consider, by making sure that the respondent can understand and easily answer and elaborate on the matter. When conducting an interview it is important that the interviewer is effective by being able to listen to the respondent. In a semi-structured interview the questions have an open character, which can lead to any type of information being shared. This makes it difficult to receive all of this information in the short period of time. Further, O’Gorman & MacIntosh (2015) stress the importance of documenting the information in some way, either by taking notes or recording the conversation. This made it easier for the interviewers to focus on the answers and asking follow-up questions. The interviewers took turn in asking questions, thus acting in both roles, where the other always listened carefully and took notes. This helped the authors of this study to understand the situation better and any follow-up question needed for clarification were directly posed.

The semi-structured setup can help the respondent in feeling free to answer according to their own terms. This gives the interview more of a conversation character rather than a questioning one, which can put the interviewee in a secure and calm position (Davidsson & Patel, 2011). However, there are also drawbacks with such a structure; the respondents may for instance feel threatened, since it is unknown who may access the information shared. The interviewees may hold back with their output since the answers may be

viewed by the management. The authors of this study therefore offered the interviewees the opportunity to be anonymous, however none of those asked felt the need of being so.

After the interview has been conducted the post-interview stage commences. This is where the interviewer transcribes the gathered content. This should be done as soon as possible after the interview is performed, in order to keep the information fresh in memory (O’Gorman & MacIntosh, 2015). The authors of this study conducted all interviews in a closed conference room at the head office of the company. The authors also decided to not record anything, but rather to stay in the conference room and summarize the most vital information directly after the interviewee had left the room. The authors saw this strategy as effective since different inputs were shared between each other directly after information was freshly gathered. The interviews conducted are presented in Table 2, showing the topic of interest, interviewee, and the most important information discussed.

*Table 2 – Shows all interviews that were conducted throughout the study, where the subject, respondent, title, department and company, date, and most important content are declared*

| Subject                          | Respondent        | Title & company                               | Date       | Most important content  |
|----------------------------------|-------------------|---|------------|---|
| Problem, purpose and objectives  | Jonas Wernbo      | CEO<br>Focus Nordic AB                        | 2017-01-17 | The scope of the study was discussed and the deliverables were determined.  |
| Racking systems                  | Kristian Lundberg | Sale Support,<br>Constructor AB               | 2017-01-24 | Interview with an external sales person from a company selling racking systems, to understand the investments needed and identifying all related costs,   |
| Building/re-building a warehouse | Patrik Lööv       | Project developer,<br>Logistics Contractor AB | 2017-02-07 | Interview with an external consultant working at a logistics company building or rebuilding warehouses, where the focus was to identify important factors when reconstructing a warehouse.                  |
| Space issue in CW                | Pär Rhodén        | Warehouse Manager, Focus Nordic AB            | 2017-03-07 | Discussed the space issue together with the CW manager. The main purpose of the interview was to understand how the issue was experienced from the CW perspective with input from management and personnel. |

### *3.4.2 Observations*

According to Davidson & Patel (2011) observation is an efficient data collection method and is commonly used to get an overview over the current structures. The authors further explain that observations can be conducted by anybody and that the approach often varies depending on the specific situation, previous experiences and expectations. Since both the authors of this study have previously been working at FN's warehouse, they already have some basic knowledge about the processes and activities within the company. As this knowledge was already possessed, the focus was put more on details regarding the specific activities.

Davidson & Patel (2011) argue that a major benefit of observations is that the data collected is untouched by others, meaning that the information comes directly from the

source, and not influenced by others' opinions. The authors also mention that methods like interviews are dependent on what the interviewee remembers, and that this can increase the uncertainty in the answers. Observations on the other hand have a higher uncertainty level as the observers conducting the observation can have a difficult time distinguishing between isolated or common occurrences. This specific uncertainty was significantly reduced due to the authors' previous working experience at the company. The authors had a good overview of how the processes should be performed and could therefore choose to not consider isolated events that could be classed as anomalies in the observations. During the observation period the authors tried not to intervene while the worker was performing the activities but were in some cases forced to ask questions that were connected to specific events. These types of conversations with the warehouse employees were value adding, showing the functionalities of the activities and contributed a clear picture of the connected issues and problems.

Additionally, Davidson & Patel (2011) argue that there are mainly two different types of observations, namely structured and unstructured. The authors further explain that the unstructured method is less time consuming but requires that the observers possess some pre-knowledge about the problem and area of observation. This approach was used in the observations of the activities in the FN warehouse, since both authors of this study clearly lived up the requirement of having some pre-knowledge and could thereby save valuable time. Davidson & Patel (2011) mention that the unstructured observation approach is most efficient when gathering qualitative data or to get a holistic view of a process. This was also the main objective of the observations and was therefore especially suitable for the second part of the study, regarding possible improvement areas in the warehouse.

### *3.4.3 Time and motion studies*

One of the more structured ways of observing activities is according to Bryman & Bell (2003) time studies that are used to analyze the time of certain events and activities. As some of the costs and activities at the EW were based on time, the authors of this study needed to measure the time of doing the same activities at the CW, in order to estimate the costs. The activity that was measured was the goods reception process, where packages are unloaded from a container and packed onto pallets that are later transported to a specific storage location. Niebel (1955) explain that some kind of time equipment and that clear guidelines are needed to measure a certain activity, as well as when the activity starts and ends. He also argues that it is important to clearly inform the operator about the study and why it is conducted. During the time studies at the CW different operators were measured at four different occasions with different types of products. The mix of operators was used in order to get an average handling time in case there were any differences in working pace. The operators were all informed about the time studies and also participated by clearly stating when the unloading activity was started and finished. The time was recorded from when the container was opened until it was unloaded and cleaned out and closed. Niebel (1955) stresses the importance of not interfering with the operators during the process and thereby influencing the results. This was why the authors



of this study started up the time study and then backed away from the inbound area to let the operators work in their own pace without feeling pressured or watched.

One restriction of the time studies was the sampling number used. Due to the fact that there were few observations made and different products being received, it was difficult to get an accurate time of the reception process. This process was on the other hand not a significantly large part of the total costs, which means that the deviations from the real mean time does not impact the comparisons remarkably. The reason for the restricted sampling size was due to the low seasonal demand. The goal was to perform at least two measurements with different types of products, in order to get a mean value. The time studies ended up with four observations, two with lighter products and two with heavier products. Since there were quite large differences in unloading time on these occasions, the authors of this study also had to consider the product weight when comparing the measures.

#### *3.4.4 Internal company data and documents*

O’Gorman & MacIntosh (2015) mention that the data collection can include unpublished data located within the company. This can be information stored in paper files or internal servers and databases connected to the ERP or other similar systems. These documents are usually not published and available to the public eye, since the company wants to keep their discretion. The authors of this study were allowed to view all documents that were helpful to fulfil the purpose of the study, with access to contracts, agreements and invoices between FN and the 3PL company. Further, the authors of this study had access to FN’s ERP system where statistics of replenishments, sales data, storage assignment information, other invoices and fill rates in storage locations was retrieved. These sources of information helped the authors of this study to get the number of occurrences of different activities, costs of various activities and to identify flaws in some of the warehouse operations. This information was crucial to gather in order to fully cover all incremental costs and fulfil the purpose of the cost calculation. It was also important in order to fully understand and analyze the identified areas of potential improvement, where the internal data could strengthen the flaws that had been observed. This further showed the importance of triangulation throughout the study, where confirmations could be made on several levels. The authors of this study were also allowed to get help from an external consultant who is developing the ERP system. It was quite difficult and time consuming to go through all sales data and transactions in the system, in order to find the number of back order occurrences due to replenishments from the EW. The consultant therefore helped the authors of this study by creating a system report, simplifying the gathering of information, saving plenty of time.

#### *3.4.5 Surveys*

According to Davino & Fabbris (2013), surveys are time and cost efficient, when it comes to collecting information from a limited population. The authors further argue that surveys can be used to both analyze qualitative and quantitative data, depending on what the aim of the investigation is. The aim of the survey conducted was to gather information from

the warehouse employees about already identified problem areas. Iarossi (2006) recommends a literature review within the area of the survey to be able to grasp what is to be expected, and to interpret the results later on. As all the questions are related to the problem areas identified, a literature review was done to gain more knowledge about the areas of subject. This made it easier for the authors of this study to formulate the questions more clearly in order to bring forward the real essence of the survey.

The questions were formed in a way where the participants were given a grading system from one to five when answering the questions. There were a total of nine questions asked, where the first seven were answers in the grading system, all related to the problem areas identified. The eighth question was also related to the issues but gave the participants different alternatives. The last question was open for own thoughts where the employees had the possibility to suggest one improvement area that was found most important within the warehouse. The survey is found in Appendix 1. Worth mentioning is that the approach consisting of interviewee's own thoughts did not play a major role in the study, but was rather a confirmation used in an ethical kind of way: this way all the warehouse employees were involved in the study and got the opportunity to express their own opinions.

### **3.5 SOCIETAL, ETHICAL AND ECOLOGICAL ASPECTS**

When reconstructing a warehouse it is important to consider the change in environment for the warehouse employees. FN has both previously and currently experienced some issues with work related injuries among the personnel, both minor and some more extensive. This somewhat highlights the importance of not only improving the operations within the warehouse, but also the ergonomics and working environment for the employees. The authors of this study had to distinguish between the operational requirements and the social and ethical implications that are connected to them. The opinions regarding current issues in the warehouse brought up by the workers and future implications had to be considered, thereafter finding the right balance. The ecological impact that an eventual reconstruction might bring was also considered. Thus looking at the possible negative impact for the surrounding nature and if there would be less transportation pollution following a new structure.

### **3.6 RELIABILITY AND VALIDITY**

The trustworthiness of the study is an essential part that needs to be addressed. This study was mainly conducted using the triangulation approach, which according to O'Gorman & MacIntosh (2015) is effective for increasing the credibility of research findings. By combining different approaches the authors of this study aimed towards covering different angles to the same area, reducing the risk of misinterpretations. Taylor et al. (2016) argue that this is one of the main benefits of the triangulation and that it therefore reduces bias.

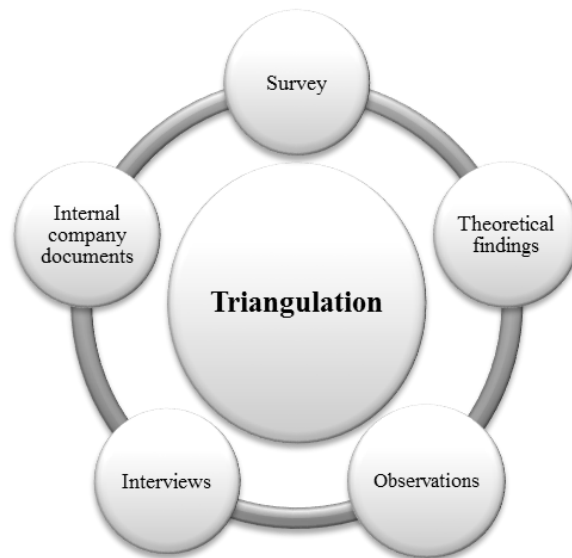
Other aspects that need to be addressed are the reliability and validity of the study. Holme (2007) explains that validity is to measure the right variables while reliability is explained as the ability to disregard from incorrect values. Multiple sources have primary been used

to identify the right type of variables to analyze. The theoretical approach also saved time as it provided clear guidelines of what factors are important to consider. As Holme (2007) explains it is of utmost importance to continuously and critically evaluate the material used in the study, in order to secure the quality of the data used. Much time was spent at FN to always have close access to information and employees, thus being able to evaluate the situation at the company from day to day.

As there were clear limits of both time and resources available, there were difficulties in the possibility of improving both the reliability and validity of the study. The time spent on evaluating sources and data collection was restricted, which limited the reliability. All the interviews were held face-to-face, meaning that the direct contact with the interviewee influenced the answers (Davidsson & Patel, 2011). The authors of this study therefore chose the semi-structured approach to neutralize the situation and create a good environment for the interviewee. The close collaboration with the company gave the authors of this study the opportunity to clarify possible misunderstandings making it easy to secure that the right information was analyzed.

Most of the figures used in the calculations are gathered out of data from the years 2015 and 2016. It was impossible for the authors of this study to provide exact results because of the time gap. An average calculation approach has been used, combined with some safety margin in order to reduce the risk of opportunistic calculations. It was important to understand that the figures used varied from the real figures of 2017 and onwards, but were most definitely accurate enough to provide a fair comparison, satisfying the purpose of the study.

The concept of triangulation means that the researchers use multiple sources of information in order to confirm and strengthen the core content of the information (O’Gorman & MacIntosh, 2015; Taylor et al., 2016). Taylor et al. (2016) argue that by using this approach the researchers can be helped in validating certain information. O’Gorman & MacIntosh (2015) further state that this would help the researchers to reduce bias within the study, which increases credibility of the findings. During the study the authors of this study mostly used triangulation to confirm the information connected to the different issues identified, see Figure 5 below where all of the sources used are presented. This gave the authors of this study a clear and holistic view over the situation with enough information to fulfil the study, leading to the concluding remarks.



*Figure 5 – Concept of triangulation and the different method approaches used to strengthen the findings.*

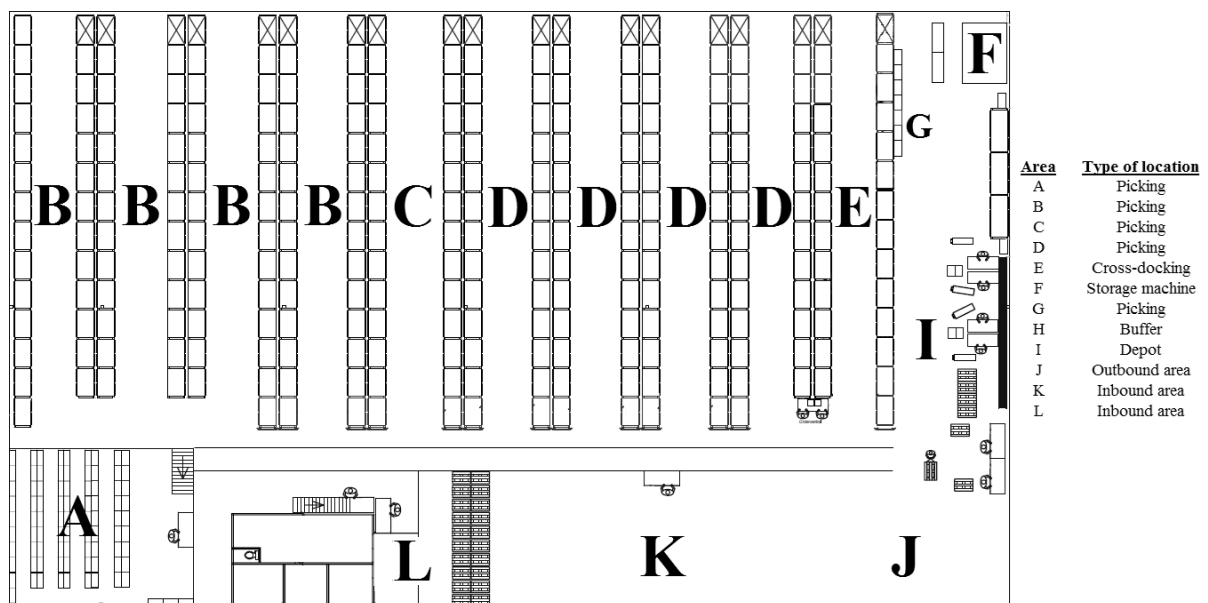
## 4. CURRENT SITUATION AT FOCUS NORDIC

*The following chapter contains empirical data aiming towards explaining what the current warehouse and cost structure looks like, thus providing enough information to conduct an analysis. The chapter includes both quantitative and qualitative information about internal and EW activities.*

FN currently has one CW located in Gothenburg. The warehouse is in direct connection with the head office where most departments of the organization are stationed. The size of the current warehouse building is 2 641 square meters and the size of the land owned by the landlord is 13 900 square meters. The land and facilities are as earlier mentioned owned by an external landlord and not by FN themselves, and they are therefore renting the property, paying a rate of 703 SEK/square meter yearly for the warehouse. This gives a total annual cost of 1 856 623 SEK for the warehouse, where all costs are included, such as heating, water and electricity. The landlord is quite flexible and willing to rebuild and extend the current property. If the CW would be expanded, all of the pallets currently located in the EW would fit into the CW, keeping everything stored in-house. This would lead to changes in the costs, which are transferred from the partnership and embedded into the current costs at the CW.

### 4.1 CENTRAL WAREHOUSE ACTIVITIES, FUNCTIONS AND CONDITIONS

The sections below explain the different activities that are performed in the CW at the areas, all shown in Figure 6. These activities are all connected to the space issue and describe what are included in these operations, in order to understand and identify potential improvements. The ergonomic situation is also described, which aims to give a clear understanding of the operating conditions within the CW.



*Figure 6 – Current layout of the central warehouse where each area is marked. The list of areas to the right describes what type of location the area is used for. Area H is not marked on the picture, whereas it is located in the same place as B-E in the upper three levels of the racking*

systems. The area L-K are both inbound where K is used for other extra purposes and L is where the administrative work is performed.

#### 4.1.1 Inbound area

The inbound area (L-K) is quite long and narrow, with an area of 400 m<sup>2</sup>. The area is mainly divided into two parts, where three quarters are assigned to goods reception and the last quarter is used for outgoing goods. There are a total of seven gates, where four are used for inbound handling, two for outbound and the last gate for retrieving empty pallets from storage out on the yard or to throw away garbage into the dumpsters located outside. The outbound area is close to the depot, where finished pallets are placed awaiting to be shipped. These are lined up at this area until the transport provider comes to pick up the shipments in the afternoon. The area is also used for charging mechanical equipment, such as fork lifts, cleaning equipment and a wrapping robot, which is usually done overnight when the area is empty.

The inbound area is mainly used as an unloading area, where the goods are placed awaiting to be handled and put away into storage. The goods are usually handled by one person, who performs a delivery inspection of all products. This is done at the opposite side of the outbound area. In this area there are certain equipment that is used to reduce the time spent on each delivery. The employees usually handle one supplier delivery at a time and start with the next delivery as soon as it is completed. FN also perform product checks of all new products coming in. This includes weighing and measuring products, as well as checking that the bar code is correct in the WMS system. Products are put away into storage, both manually and by using equipment, such as fork lifts.

The inbound area is also used for other purposes such as relabeling or repackaging of certain products (area K). However, during peak season it can be very crowded, and FN has to come up with temporary solutions in order to keep the daily operations going. This is something that affects all operations where employees waste time finding temporary solutions, which in turn lowers the productivity throughout the entire warehouse, as well as creates new space issues.

When receiving and unloading containers, there are two main restrictions deciding whether containers should be sent to the CW or to the EW. The first restriction is that FN would like to have a minimum of 80 buffer locations left after the goods have been put away into storage, constituting a maximum of 95% of the buffer capacity. The containers are filled with non-palletized packages, where the average number of pallets built from a large sized container (40') is between 70 and 100. Therefore FN needs at least 150 available buffer locations before the container is received. The second restriction is connected to the type of container. If the container includes products in the heavier weight class, the manager has to make sure that there is enough resource capacity to still manage the daily targets of customer order deliveries. If there are large quantities of customer orders that week he may redirect the container to the EW, even though it would fit into the CW.

#### 4.1.2 Storage and product assignment

There are four types of storage locations, varying in size and shape, located in separate areas of the CW. The first area is located at the start of the picking route (see A in Figure 6). This type of location can fit over 1400 unique products, where each location is approximately 40 dm<sup>3</sup>, see Table 3. These locations are assigned for small size products with low demand. The racks are established in sections of three locations per shelf, with five or six levels of shelves. The reason behind the location of this area is that the racks are built into the warehouse construction, holding up the mezzanine that is located above, which means that these racks cannot be moved. Since FN can fit a lot of products here and the space is narrow in the rest of the warehouse, these locations are an essential part of the daily warehouse operations.

The second area is where the largest and heaviest products are picked (see B in Figure 6). These products are stored on pallets and picked directly from. These racking systems are arranged in a total of five levels, where the bottom two are assigned to picking and the upper three as buffer. The picking locations are assigned in two levels, with a height of 13 dm each, hence a volume of 1248 dm<sup>3</sup> (13x12x8dm), see Table 3. In general the heaviest products are stored at the bottom level and the lighter ones above, on the second level. The same type of storage location is used in the first four aisles of the picking route. An aisle is approximately six meters wide and twenty-six meters long, which gives an area of 156 m<sup>2</sup>. Since one aisle contains a total of 260 pallet locations, including both picking and buffer, the area of one pallet corresponds 0.6 m<sup>2</sup> (156/260), when using five levels of racking system. This area includes all racking systems and the area of the aisle, where the personnel walks or operates the forklift. The storage racks are arranged in 13 sections, including both sides of the aisle, which means that each section constitutes 12 m<sup>2</sup> (156/13) and 20 locations (260/13), seen in Figure 7 below.

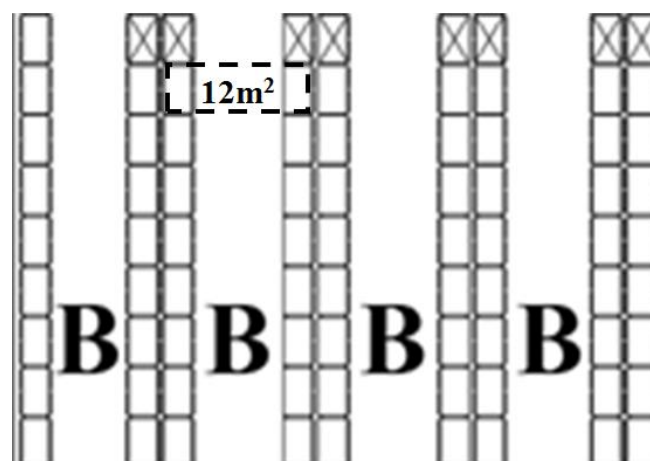


Figure 7 – Calculated section area of 12 m<sup>2</sup> and 20 locations

In the fifth aisle there is another size, unique for this aisle only (see C in Figure 6). The storage locations are arranged in sections of four locations per shelf, with four levels of shelves. These locations are the same depth as the pallet locations, and built into the same

racking system by putting the shelves directly onto the beams. The volume of this type is approximately 200 dm<sup>3</sup>, with over 400 unique locations, see Table 3. The sixth up until the ninth aisle are arranged in the same way with the exception of having three levels instead of four (see D in Figure 6). There are over 1200 locations of this type, constituting of approximately 350 dm<sup>3</sup> each, see Table 3. Previously these five aisles were all arranged in the same way of three levels, but the reason for having four levels in one aisle were to get more picking locations. The last and tenth aisle is used only for customer order purposes, as a cross-docking function (see E in Figure 6). All products that are back ordered upon arrival are put away into this area and directly prioritized and ready to be picked. This aisle is arranged with smaller locations all the way up to the pallet sized ones. As these are only used for the single purpose of customer orders, the area is not used for regular assigned picking locations. Above all these ten aisles there are three levels of buffer locations, with a size of 1248 dm<sup>3</sup> each.

The storage machine located near the depot is an AS/RS system with a possibility to store products of smaller size (see F in Figure 6). The number of products that can be stored in the system depends on how the location sizes within the machine are defined. Today there are six different sizes, giving the possibility to store over 2200 products of lower volume and in various sizes, see Table 3. This storage machine is about 7.5 meters high and was implemented when FN moved to the new warehouse. The products that are located within this system are put away into it directly from the goods reception. This means that the products are not stored at any other area of the warehouse and the whole quantity of that product is stored in the machine. Once the products are subject to customer orders they are retrieved from the system and put into the racks at the depot, ready to be picked onto the carriers (see G in Figure 6). The machine is operated by one person who handles both incoming and outgoing goods. On an average day the operator handles approximately 20 inbound- and 100 outbound assignments.

*Table 3 – Different location types, the volume as well as the total number of each location. The volumes of areas E-G are not presented since these are not applicable (N/A) to the study.*

| <b>Area</b> | <b>Type of location</b> | <b>Location volume (dm<sup>3</sup>)</b> | <b>Total number of locations</b> |
|-------------|-------------------------|---|----------------------------------|
| A           | Picking                 | 40                                      | 1437                             |
| B           | Picking                 | 200                                     | 416                              |
| C           | Picking                 | 350                                     | 1236                             |
| D           | Picking                 | 1248                                    | 400                              |
| E           | Cross-docking           | N/A                                     | 176                              |
| F           | Storage machine         | N/A                                     | 2280                             |
| G           | Picking                 | N/A                                     | 204                              |
| H           | Buffer                  | 1248                                    | 1669                             |

Products are assigned to certain picking locations mainly when received from the supplier for the first time. Since the employees at the warehouse have been working there for 5-



25 years, they have great product knowledge when it comes to dimensions, weight, demand patterns and shape. The employees are responsible for choosing a suitable location for the received product. The basic rule is to place the product at a location where it can easily be picked from, depending on the dimensions, weight and shape, but also to make sure that it will be replenished moderately often. The locations for the products are kept even though they go out of stock, which means that the products are assigned in accordance to a combination of random and dedicated storage assignment. Since FN has an issue with space and the number of available picking locations, some of the products do not have an assigned picking location. There are approximately 275 products that are only stored in buffer locations. This means that the fork lift operator has to retrieve the pallet from buffer, placing the items available for picking each time these are subject to customer orders. Such products have been chosen to only be stored in buffer due to the lower demand patterns. The retrieval activity includes a signal in the WMS system giving the operator a notification of a customer order, who then retrieves the pallet from the buffer location, transports it to the cross-docking area and then transports it back to the buffer location. The time of performing the activity is estimated to eight minutes in average, depending on the volume and type of product.

The type of location is directly affecting the internal replenishment from buffer to picking locations. If the size is too small the product has to be replenished much more often and vice versa. The level and height of the location also matters since some products are more demanding to refill. For instance, the picture frames FN is selling are received and stored in full-sized pallet packages, where hundreds of frames are fit in each box. These are later replenished onto the locations of size 200 and 350 dm<sup>3</sup>, where the box is replenished several times. Such product is therefore quite time consuming to handle and replenish onto these types of locations. The largest sized frames do not fit into these locations and are stored in the pallet picking location, even though the demand is quite low. All these aspects show the importance of finding a suitable size of location for each product. However, the space issue has forced the employees to choose the best place available and not the best possible, since FN has a limited number of unassigned locations.

#### *4.1.3 Picking routes*

The picking process at FN is mainly manually handled, aside from the storage machine. The process starts with the employees choosing a carrier type depending on the priority of the customer orders. The carriers come in several sizes depending on the order size, where the carriers have a capacity of a different number of orders. When the carrier is chosen in the WMS system the orders are distributed onto the carrier. The picking list is printed in paper where it follows the assigned route method, which is an S-shaped model. The employee then begins the picking by walking towards the start of the route. The depot (area I in Figure 8), where all customer orders are printed and later on packed, is located at the end of the picking route. This means that the personnel have to walk from the end up to the start of the route, each time a new pick run is begun. The distance from the depot to the start of the route is approximately 55-60 meters. The start of the picking route begins with area “A”, including over 1400 picking locations, which means that most pick

runs have products located here. Directly after this area comes area “B”, where the largest and heaviest products are stored. From this spot the picking route starts, where the pickers move from aisle to aisle in accordance to the S-shaped model. The picker walks from location to location travelling approximately 380 meters, which is the assumed average of a pick run. When the picking is finalized the picking order is registered in the WMS system and the carrier is parked, awaiting to be packed and shipped.

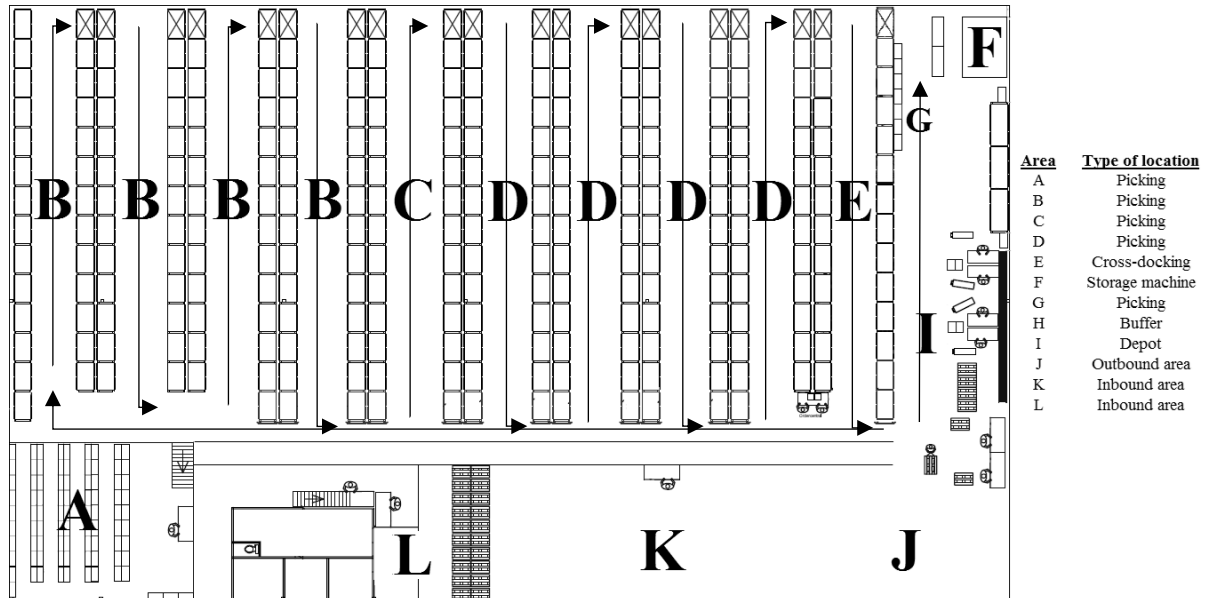


Figure 8 – Current picking route, following the S-shape method.

#### 4.1.4 Ergonomics

The ergonomic situation at the CW can be explained as quite varied, during the last couple of years there have been a multiple number of work related injuries, caused by long term stress on specific muscle groups. The most common injuries experienced by the warehouse workers are related to the upper body with neck, shoulder and back pain representing the majority of injuries. The absence statistics of the employees during the last couple of years shows that nine out of the total of twelve employees at the warehouse have been absent due to these types of injuries. Further, two of the employees that have not been injured have specific lighter working tasks, and are therefore excluded from the picking, packing and forklift activities. This means that 90% of the employees performing such tasks have been absent, arguably directly related to these handling activities.

The company has put more focus on ergonomics at the warehouse since the move to the new CW in 2012, although focused on the packing stations. During this period FN invested in height-adaptable tables at each packing station and a manual conveyor belt connected to the stations, transporting the product to the outbound area. The most recent investment made at the packing station is an automated robot used to wrap packages placed on pallets in a plastic cover. This was previously done manually causing a lot of complaints from the employees who experienced back pressure and pain. After this improvement the packing stations have improved a lot from an ergonomic perspective.

But, even though the tables are height-adjustable many of the products are larger and forced to be packed on the floor, which leads to heavy lifts from the ground.

Some of the injuries at the warehouse are related to the forklift-driving. As an old forklift caused both much vibrations and an uncomfortable driving position, with a non-flexible seat, many workers experienced discomfort. The height of the racking system also required the forklift driver to look upwards a lot, placing the neck in a non-ergonomic position. FN has decided to buy a new forklift with both seat adjustments and other equipment that will make it more comfortable for the driver. This means that the driver does not need to look up to adjust the position when handling goods and can instead use a monitor placed by the steering wheel.

The operator driving the forklift is responsible for the replenishment process, which requires a lot of manual work. As many of the picking locations are not constructed for whole pallets, the product needs to be lifted from the pallet into the picking location. The forklift driver must retrieve the pallet from the buffer location and drive to the picking location. Thereafter he has to leave the forklift and manually lift the products onto the chosen location. There are three levels at these picking locations, with the bottom and top levels being the least ergonomic to refill. The worker has to bend in to the bottom location, or stretch out to reach to top levels.

There are basically two areas with few ergonomic improvements made, namely the goods reception and picking activities. Looking at the inbound area there are two types of deliveries that the workers handle. The first type is pallet goods, where both manual pallet lifters and forklift trucks are used in the process. These types of deliveries are not considered as heavy by the workers, as almost no heavier effort is needed. The second type is container deliveries containing non-palletized packages and these are perceived as heavy by the workers. Everything depends on the type of products, where both the weight and shape can vary. Some container deliveries contain backpacks and are quite easy to handle, but it still requires a lot of lifting and walking with packages, as the packages need to be placed onto a pallet. The same procedure is used when it comes to deliveries filled with tripods, frames, albums, binoculars etc., which represent the medium and heavy levels and therefore more uncomfortable to handle. Yet the medium levels are quite easy to handle as the size of the packages are medium sized and the weight not overwhelming. According to the warehouse manager a regular twenty-foot equivalent unit (hereinafter called TEU) contains between 35 and 50 pallets, depending on the type of product.

Table 4 – Number of twenty-foot equivalent units received in 2016 at both the external warehouse and central warehouse and the proportion of each weight class. The weight classes constitute different types of products where the weight is average of a typical box in the container.

| Weight class       | Number of TEUs | Proportion   | Accumulated  |
|--------------------|----------------|--------------|--------------|
| < 5kg              | 24             | 30 %         | 30 %         |
| 5-15kg             | 29             | 37 %         | 67 %         |
| >15kg              | 26             | 33 %         | 100 %        |
| <b>Grand total</b> | <b>79</b>      | <b>100 %</b> | <b>100 %</b> |

Looking at Table 4 it can be seen that approximately one third of the container volumes are filled with the heaviest products. As these are very time consuming and more difficult to receive at the CW, most of these are shipped to the EW. Out of the 79 (constituting 60 containers) TEUs received within the company 24 (constituting 18 containers) of these were received at the CW, where twelve were of lighter, six of medium and six of heavier weight classes. It is important to understand that the personnel emptying the container vary from time to time, but the same people that start the process are used until it is fully emptied. This means that the same two workers can spend between one to five hours lifting packages, all depending on the type of products and container size. As shown in Table 5 the lighter product variants often come in 40' containers, leading to a longer unloading time. Heavy products on the other hand often come in 20' containers meaning that there is often a lower amount to handle. The most time consuming and ergonomically stressful unloading process is when heavy products come in 40' containers. These types of containers often require a lot of time and are exhausting for the workers. Three warehouse workers are used in the emptying process, with two used to empty, sort and place the packages onto pallets, as the third worker helps to control the sorting, places the pallets ready to be put into storage and also performs the delivery check.

Table 5 – Quantity and proportion of 20' and 40' containers in 2016 of each weight class for both the external and central warehouse, constituting a total of 60 containers and 79 twenty-foot equivalent units.

| Weight class       | Qty / Proportion of 20' containers | Qty / Proportion of 40' containers |
|--------------------|------------------------------------|------------------------------------|
| < 5kg              | 6 / 40 %                           | 9 / 60 %                           |
| 5-15kg             | 21 / 84 %                          | 4 / 16 %                           |
| >15kg              | 14 / 70 %                          | 6 / 30 %                           |
| <b>Grand total</b> | <b>41 / 68 %</b>                   | <b>19 / 32 %</b>                   |

The picker experiences the same problems that both the forklift driver and packers have. When picking products, the low and high picking levels lead to very uncomfortable working positions. The lower levels often contain heavier products that are located far

into the picking location, forcing the picker to bend down and reach for the product. This is a time consuming technique and causes a lot of stress on the body.

## **4.2 PARTNERSHIP ACTIVITIES WITH THE EXTERNAL PARTNER**

The partnership between FN and the 3PL provider is divided into three main parts: goods reception, storing goods and replenishment of FN's CW. The partnership actually stretches further than only the external warehousing part as the 3PL company also handles the majority of FN's inbound transports. However, these two partnerships are handled separately and do not affect each other. The freight between the two partners are handled separately by a third actor, who are only operating these isolated transports for FN.

### *4.2.1 Goods reception*

By looking more closely at the first part, the handling of incoming goods from FN's suppliers, almost all of the connected activities are performed by the external partner. When there is a shipment on its way in from a supplier the transport provider contacts FN beforehand asking whether to ship it to the CW or EW. This can be determined already when ordering the transport, but where the 3PL company offers a certain flexibility handling both transports and warehousing for FN. Further, if the shipment is decided to be received at the EW, the purchase department of FN prepares the receipt form in the ERP system by adding the incoming products in a certain registration form.

The reception process contains certain routines that are performed by the external partner, including delivery inspection, placing the goods onto pallets with a maximum height of 120 cm, putting pallets into storage and registering the receipt into the ERP system. A delivery inspection is performed where any deviations are communicated and taken care of by the purchase department of FN. The registration that is performed into FN's ERP system is done through the prepared form, where the delivery is confirmed as correctly received from the supplier. The external partner has direct access to FN's ERP system, handling both in- and outgoing shipments. As FN wants to control the access of the ERP system by the external partner, they have set up their own computer at the external facilities where the external partner has a limited licensed access to the system. This means that the EW can only access the limited amount of information needed, in order to register incoming deliveries and replenishment orders that are sent to the CW. Once the receipt is registered into the system the available quantity is shown in the system and also on FN's web shop to the customers. The available quantity shown in FN's system is only a number and the external partner uses its own WMS system to keep track of the pallet locations in the EW.

### *4.2.2 Storage*

The second part of the partnership is storing of the pallets. This is a simple process where the cost is calculated per pallet and day. The pallet is located at the EW until FN triggers the move by ordering the product. The cost per pallet is the same regardless of the type of product and the external partner registers the current pallet quantity at the end of each day, which is later invoiced monthly. The average number of pallets located at the EW is

fairly stable over the year even though the demand is higher towards the end of each year. At peak season the demand is higher with greater fluctuations, where more pallets are received but also shipped out to the CW. As seen in Figure 9 below, the peak season takes place at the end of each year, demanding higher stock levels than usual. FN has done some internal improvements over the years, which has led to a higher fill rate in the CW. This has continuously helped to reduce the number of pallets located at the EW, hence lowering cost of storage rent.

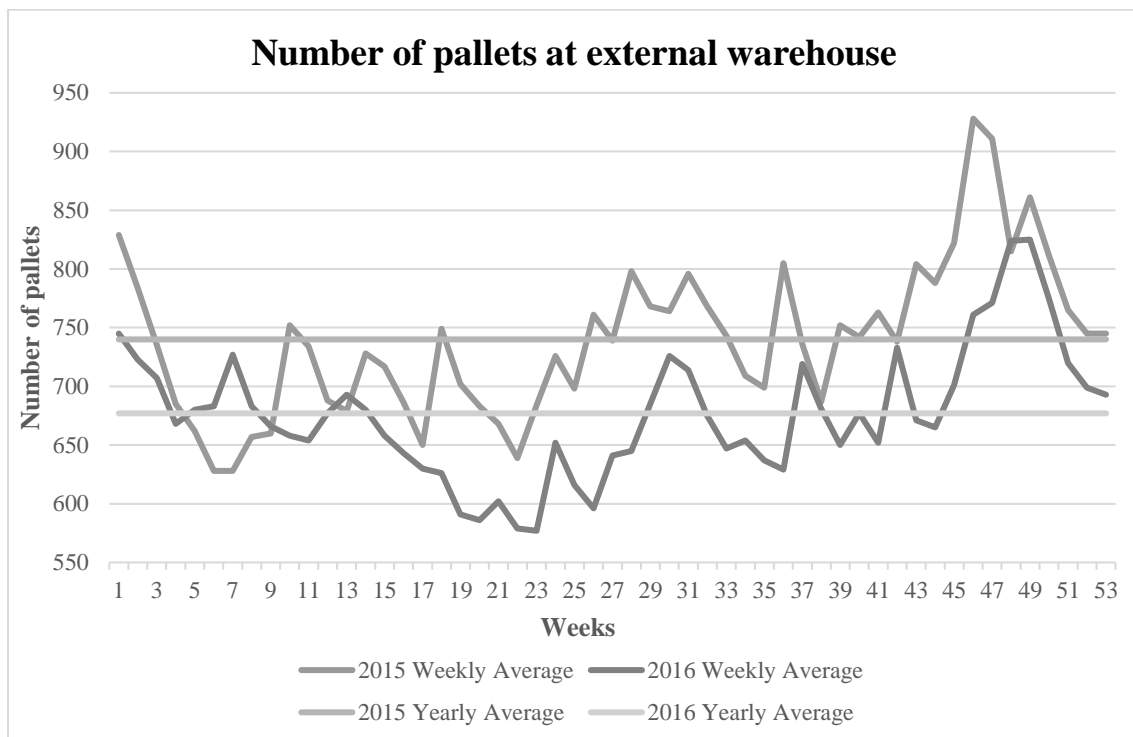


Figure 9 – Number of pallets located at the external warehouse over the year. The moving lines show the weekly average over one year for both 2015 and 2016. The straight lines show the yearly average for both years, where it clearly shows that the volumes have decreased over time.

#### 4.2.3 Replenishment

The third and final part of the partnership is handling of the outgoing shipments to replenish the CW. These replenishment orders are determined by the CW personnel working with incoming deliveries and replenishment. Towards the end of each day the demand is calculated in the ERP system, to see whether something needs to be ordered from the EW. The external partner is notified through an email where the CW communicates how many pallets have been ordered. In this email there is also a copy sent to the transport provider, notifying them to collect the pallets. The transport is picked up the following morning at 07:00, loaded and directly transported to the CW, arriving around 08:00 depending on the number of pallets and the amount of traffic. Once the transport has arrived the pallets are unloaded onto the inbound area and the warehouse employees perform a delivery inspection. FN rarely identifies any deviations, although in case of any errors occurring it is quickly solved by changing the order and notifying the external partner to adjust the quantity in their own WMS system. Once the inspection is

completed the delivery is registered into the ERP system, automatically creating an internal put-away order, where the pallet location is chosen and confirmed. All locations are registered into the system, whether placed for direct picking as a target of customer orders, or put into storage at buffer locations. When the replenishment is completed, the products are registered and available for sale. After that, the cycle starts over and the demand is calculated again in the afternoon. FN usually places an order one to two times a week, and two to four times per week during peak season. Since the order flow is quite fast (virtually overnight) FN rarely has stock outs due to storing the goods at the EW. FN keeps a safety stock for each product at the CW. The replenishment is triggered when the available quantity is calculated below the safety stock, or if there are customer orders for the product when the quantity is near the safety stock.

### 4.3 PARTNERSHIP COSTS

All activities related to the partnership with the external partner account for some kind of cost, both fixed and variable as well as direct and indirect costs.

#### 4.3.1 Direct costs

The known costs are gathered from operational activities between FN and the external partner. These costs include inbound handling costs at the EW, material costs (labels and pallets), storage rent, outbound handling from EW to CW, transportation costs as well as extra handling costs for additional services such as stock taking or relabeling. The costs have been gathered from historical data from a previous two-year period (2015-2016). By comparing and translating these costs to the literature found in theory, all handling and material costs include labor and equipment at the external partner. The storage rent is space costs and the freight cost is transportation costs.

The total cost for each type has been summarized individually and broken down into a cost per pallet; giving fixed cost per pallet for each type except one, the storage rent cost. The storage rent is variable depending on how many days the pallet is located in the EW, otherwise all other expenses are fixed and known. As seen in Table 6 the costs have been increased from 2015 to 2016 except for one, the transportation cost. This cost was reduced due to a renegotiation with the transport provider. Other costs are increased by an index covered in the contract between the two partners.

*Table 6 – Costs for each category per pallet going through the external warehouse.*

| Cost category           | 2015         | 2016         | Type of cost |
|-------------------------|--------------|--------------|--------------|
| Inbound handling        | 22,04 SEK    | 24,37 SEK    | Fixed        |
| Material cost (labels)  | 2,69 SEK     | 2,74 SEK     | Fixed        |
| Material cost (pallets) | 27,84 SEK    | 28,47 SEK    | Fixed        |
| Storage rent            | 1,45 SEK/day | 1,47 SEK/day | Variable     |

|                    |                   |                   |              |
|--------------------|-------------------|-------------------|--------------|
| Outbound handling  | 38,20 SEK         | 38,85 SEK         | Fixed        |
| Freight cost       | 63,43 SEK         | 59,54 SEK         | Fixed        |
| Extra cost         | 3,12 SEK          | 3,06 SEK          | Fixed        |
| <b>Grand total</b> | <b>157,32 SEK</b> | <b>157,03 SEK</b> | <b>Fixed</b> |

As Table 6 shows, the total fixed costs for one pallet travelling through the EW is about 157 SEK, for the past two years. Upon this minimum fixed rate comes the variable cost of the storage rent, which increases over time for each day passing, illustrated in Figure 10 below.

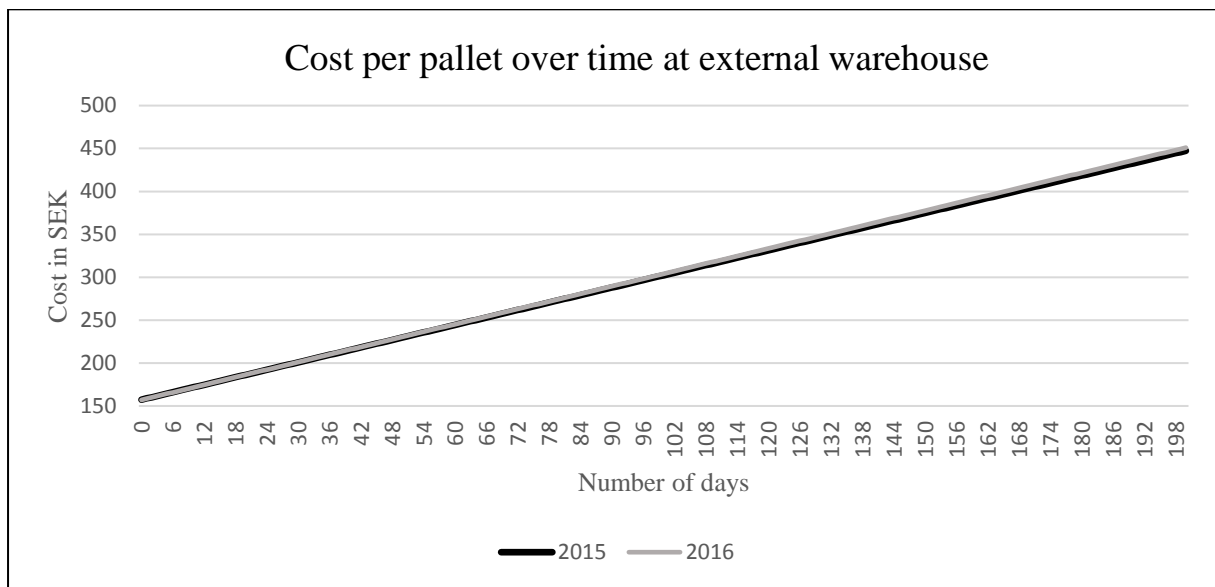


Figure 10 – How the cost varies over time for one pallet depending on how many days it is stored at the external partner.

Another aspect that generates costs is back orders. The majority of the back orders at FN are generated through stock outs at the CW and do not affect the partnership, except when the product is located at the EW. The back orders connected to the partnership can occur in two different ways: The first occurrence is when a product is located both in the CW and the EW, where the stock balance at the CW is unable to satisfy the customer demand. For instance, if the stock is 20 pcs at the CW and 100 pcs at the EW and FN receives a customer order of 30 pcs, the demand cannot be fully satisfied until a replenishment is made. This means that the customer either has to wait at least one day extra for a full delivery, or receive a partial delivery of 20 pcs and the remaining 10 pcs later. Since the available quantity shows 120 pcs on FN’s website the customer expects a full delivery on time, which means that FN fails to meet the customer’s expectations.

The second occurrence of back ordering connected to the partnership is the following. If there are stock outs at both warehouses all orders coming in would be back ordered. These orders would be back orders regardless of whether the EW is used or not. However, if the



next inbound delivery is shipped to the EW from the supplier there could be additional time before the products are available for picking at the CW, compared to if it would be sent there directly. This means that all customer orders received between the time of receipt at the EW, up until that the products are available for picking, would be delayed and back ordered. This is something that is difficult to evaluate, but impacts the company in several ways. If the order is partially delivered, additional transportation costs for that second shipment is added. If the order is delayed, FN is most likely to have losses of goodwill towards the customers, which may lead to lost sales in the future. The total number of times that both kind of back orders have occurred in the recent two-year period is 1073 times in 2015 and 921 times in 2016. FN has done some small improvements internally over the years in order to minimize the number of occurrences, which can be seen in these numbers. If all goods were to be received at the CW, FN would avoid all such occurrences.

Additionally, a fixed partnership cost that FN needs to invest in is one extra user license for the ERP system, where the cost per user is 2900 SEK annually. This can be translated as an overhead cost. Another cost that also exists is that if a container is sent to the CW instead of the EW this will cost 182 SEK more in transportation.

#### *4.3.2 Indirect costs*

Other costs that are connected to the partnership are from activities of more administrative character and therefore more difficult to measure. These activities include contact between the two actors, contracting and re-negotiating terms and invoicing.

The two parties have constant contact between both warehouses and other departments, for several different purposes. The CW has contact with FN's purchasing and logistics departments and also directly with the EW. The EW mainly has one person who is responsible for the contact between the two companies regarding all operation related activities. The purpose of the contact can be planning of incoming goods to the EW, which is mainly between the purchasing department of FN and the EW. It can also be related to the replenishment orders, which mainly concerns the CW and the EW. Other activities such as statistics, additional work such as stock taking or relabeling are usually conducted between the logistics department of FN and the management at the EW. The frequency of these contact occasions varies depending on who it encompasses, what the purpose is, how long it takes to solve and also how often that certain issue is raised. However, to get an approximation of the cost of contact the interviews have given a rough value of 90 minutes spent per week in the warehouse and about 60 minutes per week in the other departments.

Looking at the contracting part FN usually spends very limited time annually and the agreement is proceeded with the same terms for each year passing. When the contract was first established, plenty of time was spent on the details to negotiate the terms of the agreement as well as the price of each activity. The agreement includes appendices with the price lists of each activity. These appendices are the only parts of the agreements that

are updated yearly and the agreement states that the external partner can update the prices once per year according to a weighted value in form of an index. This is done at the end of each year and takes effect for the coming year. Contracting is therefore something that FN does not spend much time on, compared to the initial set up.

The invoicing part is, as mentioned before, performed monthly. As the invoice is received electronically the paperwork is not something FN needs to consider with this supplier. The invoice is interpreted directly from the email address that is set up, which means that the whole process is done automatically. The only manual activity performed by the finance department is to get an approval of the invoice from the logistics department, and then process the invoice through the system as well as executing the payment. This activity is estimated to be done in approximately 5-10 minutes per invoice, hence per month.

## 5. RESULTS AND ANALYSIS

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*This chapter aims towards analyzing the data connected to the purpose of the study by combining the theoretical framework with the empirical findings. The objectives of the study will be brought up and answered throughout this chapter.*

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The results presented and analyzed throughout this chapter are based on a number of assumptions. These assumptions are identified using all data combined from the different gathering methods, and had to be made to reach a result regarding both warehouse costs and activities. The empirical data gathered could not always be determined in a decisive way, where two types of assumptions had to be made. These were either that no exact answers were given to some issues identified, or that differences between the current and future state were non-existent or negligible. The assumptions are presented to show the underlying reasons and conditions used, analyzing both costs and potential improvement areas. The thirteen assumptions made are presented below, where their impact on the result are later discussed.

- The handling time to put away the pallets into storage in the CW would remain the same when receiving a full container versus divided into several shipments from the EW
- Only one product type per pallet in the EW
- The holding cost is assumed to be the same regardless of if it is stored at the EW or the CW
- The cost of equipment is assumed to be the same in both the current and future structures
- Fluctuation patterns at the EW would be the same in the CW
- The difference between the number of bought and sold wooden pallets are assumed to be the annual consumption
- The reconstruction would be possible to conduct without having any major impact on the daily operations performed in the warehouse, meaning that the daily work is assumed to continue on as usual until the construction is completed
- All costs that are not affected by a restructure in the warehouse are assumed to remain the same regardless of the type of structure
- A pick run in the CW is estimated to be an average of 380 meters, which is the total distance of the S-shaped model
- The new area that could be extended in the CW is assumed to be built in sections of 120 m<sup>2</sup>
- The safety level of 80 buffer locations is assumed to remain the same in a possible new structure
- The cost per square meter in the CW is assumed to be the same in a new structure
- The average time of handling one pallet when emptying a container of the middle weight class is assumed to be the average of the other two weight classes

## 5.1 COST COMPARISON OF FOCUS NORDIC

The purpose of part one was to compare the current cost structure at FN, where an external partner is used to receive, store and handle goods, with a new cost structure with all of the goods received, stored and handled in-house. The objectives were aimed to map out all costs related to the partnership and to consider the annual volumes, in order to determine how much space that will be needed in a new, expanded CW. The current cost structure was therefore compared with a future one. The analysis of this part has given a result which shows that an in-house solution would decrease the annual cost structure with between approximately 304 000 and 384 000 SEK, if the CW was to be expanded by 600 m<sup>2</sup>. Further, the result shows that some investments need to be made in order to store all pallets in-house, with an initial investment cost of 471 000 SEK, providing a payback period of 15 to 18 months.

### 5.1.1 *Direct costs connected to the partnership*

As presented in the previous chapter regarding the direct costs of the partnership, the minimum fixed rate for one pallet is approximately 157 SEK, including handling (66 SEK), material (31 SEK) and transportation (60 SEK) costs, which are all important to consider according to Derhami et al. (2016); Lai et al. (2016); and Manzini et al. (2015). To summarize the total average cost of one pallet travelling through the EW, the average number of days one pallet is stored there is needed. FN orders and replenishes roughly 2400 pallets from the EW on average each year. The average number of stored pallets at the EW is 709, giving an inventory turnover rate of 3.39 (2400/709), meaning that during one calendar year the average pallet is stored approximately 108 days. This further gives an average cost of 158.76 SEK for one pallet (108x1.47).

Looking at the fact that FN have experienced two types of back orders when the products have travelled through the EW, there are costs following these back orders, as mentioned as shortage costs by Andersson et al., (2010). These costs are as mentioned difficult to measure and put a price on, where the type and shape of the products, order volume and frequency will all play a part in the cost of each occurrence. The cost can be calculated for each back order line, where each back order means that the order has been picked and shipped at least once before, generating extra handling, material and transportation costs. The cost of an order line depends on how many lines are sent to the customer at the same time. If the back order includes a single product the cost will be much higher since the transportation cost is based on a minimum rate. The usage of packaging materials is roughly the same for each package, however when sending more than one product the cost per product decreases, to a point where it becomes almost negligible. If the back order includes five or more products, the cost for each order line will be lower than if a single product was to be sent. The exact cost is impossible to determine since it depends on how many order lines are sent together, picking location, country of destination and customer goodwill. The costs included in the back order process have been estimated through interviews, observations and internal documents at the warehouse in the following way:

- Handling – Minimum cost of 10 SEK per order line for picking and packing
- Packaging materials – Minimum cost of 5 SEK per order line. Including carton, wrapping paper, plastic bubbles, tape and freight label
- Transportation – Average maximum cost of 84 SEK per order line. The cost depends on the country of destination and the size of the product where 84 SEK is the average cost based on FN's current freight price list. If the back order line is sent together with other products the cost will become lower and lower and almost negligible for smaller products sent together with as many as 100 products.

To summarize, the minimum back order cost can be estimated to approximately 20 SEK but in the worst case as much as 100 SEK for a single order line. Further, this means that for the 997 occurrences, which is the average number in the previous two years, it will cost FN between 20 000 and 100 000 SEK to back order this many lines each year. Upon that comes the fact that the cost of goodwill affects the company in a negative way, where the customers receive several number of shipments for the same order, as outlined by Andersson et al., (2010). This means that the customer satisfaction will be lower the longer the delay becomes. This is not something that is attempted to put at cost on, however, it is a very important aspect to consider since the company should try to meet the customer expectations as extensively as possible on the first shipment of each order.

To summarize the direct cost identified and calculated, the total annual cost is between approximately 781 000 and 861 000 SEK. The costs of the different categories are presented below in Table 7.

*Table 7 – All direct costs identified in the current structure, broken down into each category. The table shows the cost per pallet for each category and the total cost for the annual volume of 2400 pallets.*

| <b>Cost category</b>    | <b>Cost per pallet</b> | <b>Number of pallets annually</b> | <b>Current structure</b>     |
|-------------------------|------------------------|-----------------------------------|------------------------------|
| Handling cost           | 66,28 SEK              | 2400                              | 159 072 SEK                  |
| Storage cost            | 158,76 SEK             | 2400                              | 381 024 SEK                  |
| Transportation cost     | 59,54 SEK              | 2400                              | 142 896 SEK                  |
| Material cost           | 31,21 SEK              | 2400                              | 74 904 SEK                   |
| User license ERP system | N/A                    | N/A                               | 2 900 SEK                    |
| Backorders              | N/A                    | N/A                               | 20 000 - 100 000 SEK         |
| <b>Grand total</b>      | <b>315,79 SEK</b>      | <b>2400</b>                       | <b>780 796 - 860 796 SEK</b> |

In Figure 11 below the costs related to the external throughput of pallets are broken down into the cost for each month throughout the year. The costs are presented for both year 2015 and 2016 where a clear trend is shown of the peak season towards the end of the year. This means that a lot more containers are received and there are more pallets going in and out of the EW, leading to higher handling costs.

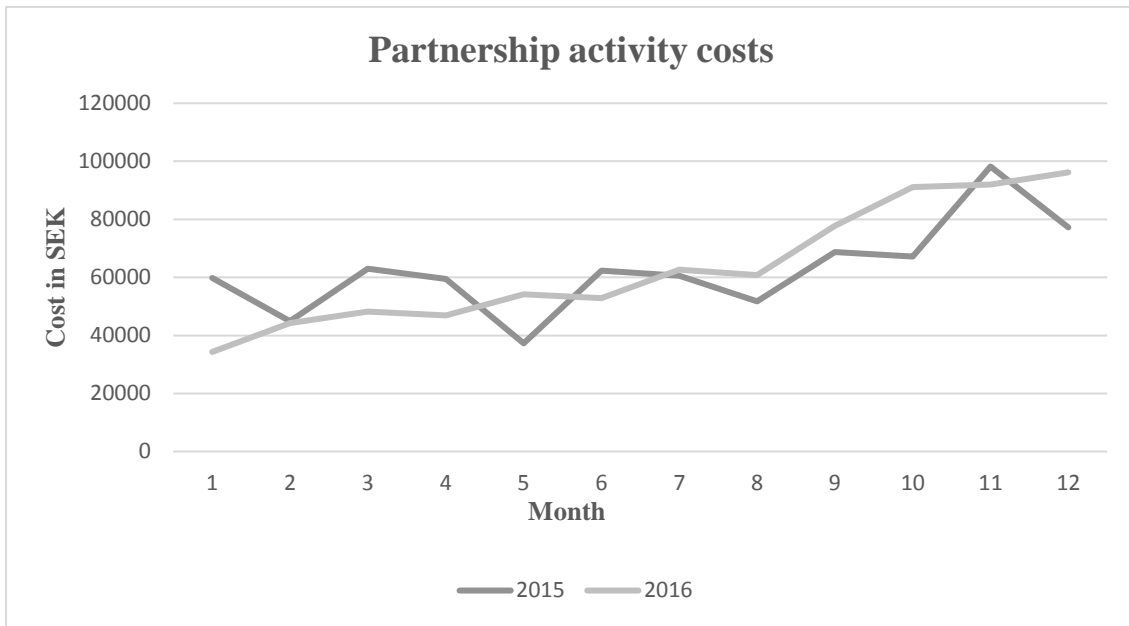


Figure 11 – Total cost over the year of pallets going through the external warehouse. This includes cost of handling the goods receptions, materials, storage rent, handling replenishment order to the central warehouse, transportation cost, and additional extra handling

### 5.1.2 Indirect costs connected to the partnership

The indirect costs that are associated with the partnership are difficult to determine, either by time spent on a certain activity or the cost of one occurrence. The exact time spent each week is impossible to determine since there are various numbers of occasions of contact between different individuals of the companies. Depending on who is actively engaging the contact the cost of the employee differs, as mentioned in the chapter regarding the current situation. The rough values of 90 minutes spent in the warehouse each week and about 60 minutes from the other departments of the contacting process is used to calculate the costs. The other two activities of contracting and invoicing are excluded since these are negligible. The average hourly rate of a warehouse employee is set at 250 SEK including social charges and 300 SEK for a white collar employee, which gives a total of 35 100 SEK annually ( $1,5h \times 52 \text{ weeks} \times 250 \text{ SEK} + 1h \times 52 \text{ w} \times 300 \text{ SEK}$ ). Although this overhead cost will not save FN any capital if the partnership were to be terminated, since the personnel still will be employed at the company, it will free up time for the employees to use for other value adding activities (Yeung et al., 2013).

Another activity generating costs is connected to the fact that FN currently has around 275 products not assigned to any picking location. These products need to be handled by a fork lift operator when these are subject to customer orders. Each time the operator

retrieves the product from the buffer location and places it in the cross-docking area available for picking, it generates handling costs. By looking at the statistics in FN's internal WMS system, the number of times this activity was performed in the past year was 1482. By breaking it down into the daily need, FN performs about six retrievals each day (calculated from 254 working days in one year). As mentioned, the time for retrieving a single product and placing it back into storage is eight minutes on average. This means that the total time spent each year for this type of activity is around 198 hours ((8 min x 1482) / 60 min). As a result, this generates a cost of labour constituting 49 500 SEK annually (198h x 250 SEK). This is not a direct cost that FN will reduce in a future in-house structure, but since the employees can spend 198 hours less of replenishment, the time could be used for other purposes. Furthermore it can reduce the need for extra personnel brought in when the workload is higher, and their corresponding labor costs. This is something that can be connected to handling costs: where Manzini et al. (2015) mention that moving a product does not add any value to the product, thus it should be handled as few times as possible in order to minimize costs.

To summarize, the indirect costs identified and calculated amounts to the total annual cost is 84 600 SEK. The cost of the different categories are presented below in Table 8.

*Table 8 – All the indirect costs identified in the current structure.*

| <b>Cost category</b>         | <b>Total costs</b> |
|------------------------------|--------------------|
| EW partnership communication | 35 100 SEK         |
| Internal extra handling      | 49 500 SEK         |
| <b>Grand total</b>           | <b>84 600 SEK</b>  |

### *5.1.3 Cost summary of today's structure with the partnership*

The costs presented in Table 9 below are a summary of the costs brought up in the previous sections. The first cost type in this table shows the total cost for all pallets travelling through the EW, including handling, materials, storage, transportation and additional costs. The second type represents the user license that is currently used by the external partner. The third type is the cost of backorders due to that goods are stored in the EW and therefore not available for customer order deliveries. These three would be removed if the pallets were stored in-house instead, which means that FN would save between 780 796 and 860 796 SEK annually. The last two costs will in fact not be removed, since these are embedded in labour cost of regular employed staff. However, since time is freed up and FN will postpone future new recruitment, money will in practice be saved.

*Table 9 – Summary of all costs related to the partnership with the external actor, which represents the current cost structure of today.*

| <b>Type of cost</b> | <b>Value</b> |
|---------------------|--------------|
|---------------------|--------------|

|                           |                              |
|---------------------------|------------------------------|
| External throughput       | 757 896 SEK                  |
| User license ERP system   | 2 900 SEK                    |
| Backorders                | 20-100 000 SEK               |
| Partnership communication | 35 100 SEK                   |
| Internal extra handling   | 49 500 SEK                   |
| <b>Grand total</b>        | <b>865 396 - 945 396 SEK</b> |

#### 5.1.4 Expansion and capacity in the CW

If FN would decide to expand the CW covering the pallets located at the EW and ending the partnership with the 3PL provider, the extra storage capacity requirements are needed. The recent improvements that have been made internally have helped reduce the volumes externally because of higher space efficiency in the CW. Looking at the volumes below, the average number of pallets located in the EW is lower in 2016 than 2015, due to these improvements. However, to make sure that the volumes can be covered, the average number of pallets has been calculated using both years, which is 709. As seen in Figure 12 below, the demand pattern is roughly the same in both years presented. The peak season at the end of the year clearly affects the number of pallet locations needed, and is therefore directly connected to the space issue.

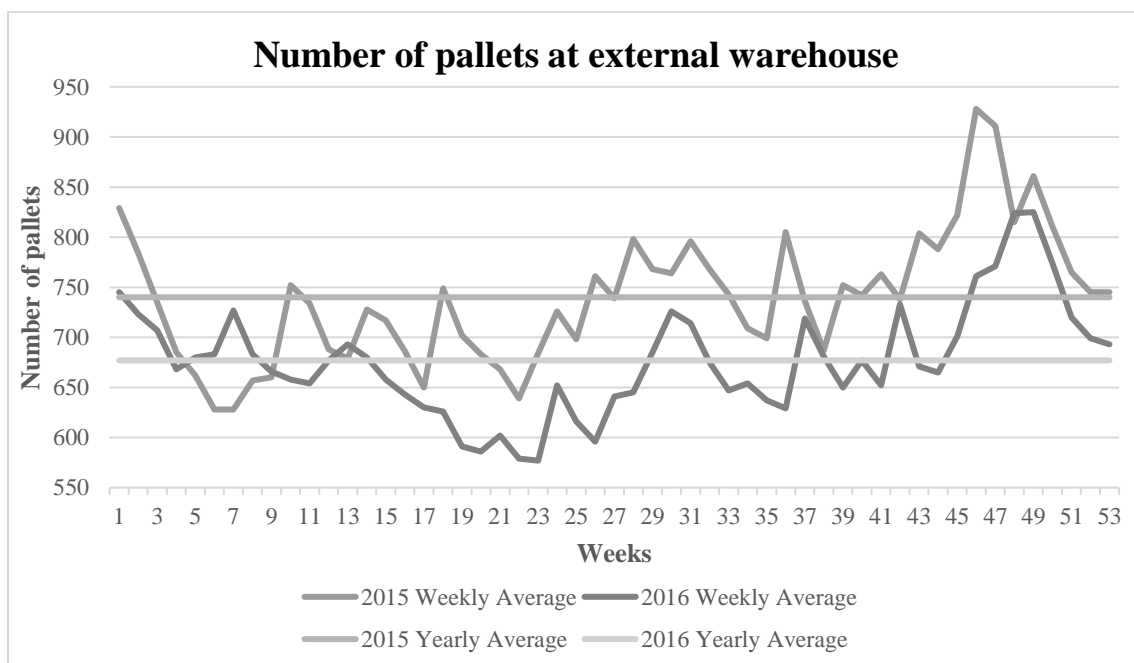


Figure 12 – Number of pallets located at the external warehouse over the year. The moving lines represent the weekly average over one year for both 2015 and 2016. The straight lines show the yearly average for both years, where it clearly shows that the volumes have decreased over time.

To determine how much the peak season affects the number of pallet locations needed, the deviation from the average number has to be analyzed. This is presented in Table 10



below where the deviations range from 32% to 38%. To make sure that the pallets are going to fit into the CW, the highest deviation is used to calculate the number of pallet locations needed, hence 38%. Further, the average number of pallets over both years, 709, is used even though the volumes have decreased over the years. This is also to avoid calculating a lower value than possibly needed in the coming years. To fit all pallets stored in the EW at any time of the year FN therefore need to consider filling an additional 978 pallets ( $709 \times 1.38$ ). The warehouse manager wants to keep at least 80 buffer locations empty in today's structure, and these are assumed to remain the same in a possible new structure. This means that if all of the 978 pallet locations would be used, FN would still have at least 80 locations available since these exist in the current structure.

*Table 10 – Number of pallets located at the external warehouse per year in average as well as the maximum value. The percentage value shows how much the maximum number of pallets during the year deviates from the average number.*

| <b>Year</b> | <b>Average</b> | <b>Maximum</b> | <b>Deviation</b> |
|-------------|----------------|----------------|------------------|
| <b>2015</b> | 740            | 979            | 32,3%            |
| <b>2016</b> | 677            | 932            | 37,7%            |

The new area is assumed to be built in the same structure as today. In the current structure one pallet location constitutes  $0.6 \text{ m}^2$ , which means that FN would need a minimum of  $587 \text{ m}^2$  in the new area ( $978 \times 0.6$ ). The warehouse is assumed to be extended with an area of whole racking system sections in all of the ten aisles existing today. This means that the area built would be filled with racking systems without wasting any of the square meters. Since a single section constitutes of  $12 \text{ m}^2$ , the minimum number of square meters to build is 120 ( $12 \times 10$ ). This means that if FN needs  $587 \text{ m}^2$  to cover the 978 pallets estimated in the peak season, a corresponding area of five new sections, hence at least  $600 \text{ m}^2$  ( $120 \times 5$ ) would need to be built. Adding  $600 \text{ m}^2$  constitutes an area where FN will be able to store 1000 pallets ( $600/0.6$ ).

#### *5.1.5 CW costs in new extended structure*

An extension of the CW and decommissioning the partnership with the external actor would lead to a new cost structure for FN. First of all the rent would increase, simply because the area would be larger. Secondly, FN would receive more containers to the CW, leading to an increased handling. The company would also have to start buying wooden pallets from other suppliers, since all pallets are bought from the external partner today. The material cost of a single wooden pallet is 24 SEK on average, if a supplier currently used for other similar purchases were to be used.

If the CW would be extended with  $600 \text{ m}^2$  the annual rent cost would be increased by 421 800 SEK, since the cost per square meter is 703 SEK annually. When it comes to emptying containers, the handling time for emptying the packages onto pallets varies depending on the type of products. Four time studies were conducted to measure the handling time of a container, where all of these were 40' containers. An average value of

both the lighter and heavier weight classes was calculated, where the middle class is assumed to be the average of the other two. The results are presented below in Table 11.

*Table 11 – Results from the time studies performed of emptying containers in the central warehouse. The total time represents the man hours of three warehouse workers, sorting and placing the packages onto pallets that are lined up to be retrieved by a fork lift operator.*

| <b>Time Study</b> | <b>Weight Class</b> | <b>Total Man Hours</b> | <b>Number of pallets</b> | <b>Time per pallet</b> |
|-------------------|---------------------|------------------------|--------------------------|------------------------|
| 1                 | > 15 kg             | 13,5 h                 | 90                       | 9 min                  |
| 2                 | > 15 kg             | 15 h                   | 94                       | 9 min 34 sec           |
| 3                 | < 5 kg              | 6,75 h                 | 87                       | 4 min 39 sec           |
| 4                 | < 5 kg              | 7,5 h                  | 89                       | 5 min 3 sec            |

As mentioned by the warehouse manager the number of pallets included in one TEU is between 35 and 50, which is strengthened by the result in Table 11. The total average time for emptying and completing one pallet of the heavier weight class is a little over nine minutes. For the lighter products the average time is measured to just below five minutes. The average values are rounded up to make sure that the costs are not underestimated. The values are presented in Table 12 below, where the time is used to calculate the cost of one pallet, using the warehouse labour cost of 250 SEK per hour.

*Table 12 – All costs related to emptying one pallet in a container for the different weight classes. The material cost corresponds one wooden pallet from a current supplier.*

| <b>Weight Class</b> | <b>Average time per pallet</b> | <b>Handling cost per pallet</b> | <b>Material cost per pallet</b> | <b>Total cost per pallet</b> |
|---------------------|--------------------------------|---------------------------------|---------------------------------|------------------------------|
| < 5 kg              | 5 minutes                      | 21 SEK                          | 24,00 SEK                       | 45 SEK                       |
| 5-15 kg             | 7,5 minutes                    | 31,50 SEK                       | 24,00 SEK                       | 55,50 SEK                    |
| > 15 kg             | 10 minutes                     | 42 SEK                          | 24,00 SEK                       | 66 SEK                       |

The costs in Table 13 below are based on the fact that FN will bring in additional work force to empty the containers. This is a prerequisite if the regular work load of picking, packing and shipping customer orders, which is the main focus in daily operations, shall remain unaffected by the reception of all the extra containers. However, if the work load is lower in some periods when these containers are received, FN will be able to empty the containers using the regular staff, whom are already included in the current cost structure. This is something that will have to be determined by the company since it might affect the daily delivery targets.

*Table 13 – Number of containers received in 2016 at the external warehouse which constitutes the future increase of receptions at the central warehouse. The handling and material costs are calculated based on the volumes from 2016 summed up in total costs for each weight class, using the average number of pallets of 43.6 (2400/55) based on the containers received in 2016*

| <b>Weight class</b> | <b>Number of TEUs</b> | <b>Total handling and material cost</b> |
|---------------------|-----------------------|---|
| < 5kg               | 12                    | 23 544 SEK                              |
| 5-15kg              | 23                    | 55 655 SEK                              |
| >15kg               | 20                    | 57 552 SEK                              |
| <b>Grand total</b>  | <b>55</b>             | <b>136 751 SEK</b>                      |

The costs presented in Table 13 will be the maximum costs for receiving the same volumes as of today, where three extra workers are brought in to handle these containers. This means that the costs of emptying containers can be reduced significantly if the company would use regular staff when emptying containers, without affecting customer service. The general view from interviewing the staff and observing the situation in the warehouse is that the regular staff have better product knowledge, which will reduce the handling time for one container.

#### *5.1.6 Investment costs for extending the CW*

If FN would decide to extend the current CW capacity by adding a certain amount of space this would lead to some investment costs. Since the warehouse is owned by an external landlord the construction costs of the new facility will not be covered by FN, but by the external landlord. However, all costs related to filling the interior within the warehouse are assumed to be covered by FN and are issues to space cost (Abbasi 2011). Depending on how FN choose to design the interior there will be various costs added and/or removed. The costs for racking systems have been gathered from FN's supplier of such materials, where all costs are embedded and broken down into cost per pallet location. All costs of investments are related to racking systems, where there are three different costs identified. The first cost is of the actual systems, which is 299 SEK per pallet location. The second cost is the cost of added safety equipment in the racks as well as other materials such as labels to mark up the new locations. This leads to a cost of 63 SEK per pallet location. The last cost is installation, where external staff and equipment from the supplier is needed, in order to perform the assembly and mounting of the whole racking systems, constituting of 55 SEK per pallet location. The total sum for each pallet location will therefore be 417 SEK, which gives a total investment cost of 417 000 SEK (calculated for 1000 pallet locations). This cost is gathered out of a first quotation from the current supplier, where FN might be able to renegotiate to reduce the cost. All costs are summarized in Table 14 below.

Table 14 – Presents a summary of the investment costs that will follow an extension of the central warehouse.

| Type of cost       | Cost per pallet location | Number of locations | Total cost per location |
|--------------------|--------------------------|---------------------|-------------------------|
| Racking systems    | 299 SEK                  | 1000                | 299 000 SEK             |
| Extra equipment    | 63 SEK                   | 1000                | 63 000 SEK              |
| Installation       | 55 SEK                   | 1000                | 55 000 SEK              |
| <b>Grand total</b> | <b>417 SEK</b>           | <b>1000</b>         | <b>417 000 SEK</b>      |

### 5.1.7 Comparison between current and future structure

To be able to analyze the shift in cost structure for each cost category the total cost needs to be broken down and compared with the same type in a future structure. As seen in Table 15, most of the cost categories would be reduced in the future structure. The only cost that would be increased in the future structure is the storage cost. Since this is the only cost that will increase, FN should focus on re-negotiating it. If FN would decide to build more than 600 m<sup>2</sup> the space cost would be increased significantly, where the cost per square meter could reasonably be reduced since the landlord still would increase the total income. To summarize, the cost reduction would be between approximately 304 000 SEK and 384 000 SEK in a future structure, using an in-house solution.

Table 15 – Cost comparison between the current structure and a possible future structure. The numbers are based on the current volumes and do not consider any improvements or changes in the flow of the current structure. In the column of cost reduction the reduced costs are presented in bold. The cost that would be increased are presented in italic and with a negative factor.

| Cost Category                | Current Structure            | Future Structure   | Cost Reduction               |
|------------------------------|------------------------------|--------------------|------------------------------|
| Handling cost                | 159 072 SEK                  | 79 199 SEK         | <b>79 873 SEK</b>            |
| Storage cost                 | 381 024 SEK                  | 421 800 SEK        | - 40 776 SEK                 |
| Transportation cost          | 142 896 SEK                  | 3 276 SEK          | <b>139 620 SEK</b>           |
| Material cost                | 74 904 SEK                   | 57 552 SEK         | <b>17 352 SEK</b>            |
| User license ERP system      | 2 900 SEK                    | 0 SEK              | <b>2 900 SEK</b>             |
| Backorders                   | 20 000 – 100 000 SEK         | 0 SEK              | <b>20 000 – 100 000 SEK</b>  |
| EW partnership communication | 35 100 SEK                   | 0 SEK              | <b>35 100 SEK</b>            |
| Internal extra handling      | 49 500 SEK                   | 0 SEK              | <b>49 500 SEK</b>            |
| <b>Grand Total</b>           | <b>865 396 - 945 396 SEK</b> | <b>561 827 SEK</b> | <b>303 569 - 383 569 SEK</b> |

## **5.2 POTENTIAL AREAS OF IMPROVEMENT IN CENTRAL WAREHOUSE**

The purpose of this part of the study is to evaluate what type of activities related to the space issues at the CW that could be improved together with a potential expansion and increased capacity at the CW. During this process four areas of improvements are identified through a combination of theory used and empirical findings at FN. The analysis presumes that an expansion will be conducted and therefore analyze potential improvement areas connected to such a decision. The analysis will not focus on direct suggestions of what should be done, but rather to create a foundation for future decisions regarding storage capacity, by providing FN with the prerequisites.

Four areas have been identified through a combination of own observations, internal documents and knowledge. FN has also limited the research area through own restrictions, where as previously mentioned internal planning and control have been excluded. Other areas have been looked into but not considered to have a significant improvement potential due to an expansion. The packaging activity for instance works quite well in today's set up, and would not be influenced significantly by a future in-house structure. This is why the authors of this study have chosen not to bring up such activities in the report, and rather focus on activities with a clear connection to the space issue and improvement potential.

### *5.2.1 Goods reception*

As seen in part one, an expansion of the warehouse would increase the number of container receptions at FN. The most significant difference between the current and future reception is the type of units on which the products are received. The volume of goods received in total will not be any different since all the pallets are brought to the CW eventually. However, as the container receptions require the employees to manually put the packages onto pallets, the total workload at FN will be increased. Speredelozzi et al. (2006) argue that continuous movement of products from the inbound area is very important, in order to reduce the risk of blocking and delaying the reception process. The current reception process from the EW can be seen as quite efficient since the goods are already stacked on pallets and can therefore be handled by the forklift operator as soon as these are unloaded from the truck. This process is less time consuming from FN's point of view, making the inbound area an important area to analyze in regards to a future expansion.

In today's structure FN receive approximately 24 TEUs per years, a number that would be increased to about 79 TEUs after an expansion, where 19 are 40' containers and 41 20' containers (constituting 60 containers). This means that FN would have to receive 1.15 containers per week, making it crucial for the company to look over the entire process to find improvements. Manzini et al. (2015) argue that one of the benefits of having an efficient reception process is that the goods become available for sale in a faster pace. This means that pending orders can be handled faster by the warehouse employees, to become available for picking sooner.

To actually handle all the pallets and improve the flow of products, Eko et al. (2016) argue that the company must have the right resources available. The warehouse manager at FN discussed the possible need of having more than one forklift to handle the increased amount of products delivered for each time. Since the current structure enables the CW to order smaller quantities of goods each time, the forklift operator is used for shorter intervals, compared to the container deliveries where all volumes are received at one occasion. The need to quickly handle all pallets from a container shipment can be connected to the current space issue, due to that the pallets will take up space inbound area. As the inbound area is divided into different sections, where other activities are conducted, the actual space used to handle new arrivals is quite restricted. This creates a need to handle all pallets (not just the ones with pending orders) as soon as possible to free the space.

Looking at the survey conducted at the company a clear majority of the employees felt that the space currently intended for the goods reception process is insufficient. The survey showed an average rating of 2.4 at a five-point scale where one was considered poor and five very good. What needs to be considered when analyzing the goods reception are the quantities handled (Eko et al., 2016). In this case it means that an expansion would not actually increase the total amount of goods handled, but the number of container receptions would more than double in quantity. As mentioned before, this process is both more time and space consuming, meaning that the already congested space would probably be further pushed to its limit.

One of the main problems with the inbound area at the CW is that there are many different activities that have been placed there as a consequence of the space issue. As mentioned by Koster et al. (2007) it is important to consider as many functions as possible to create the best layout. This has been a problem for FN as the company more or less has been forced to place certain activities at the inbound area, since it causes the least number of disruptions. As the outbound area is placed right beside the inbound area, all activities more or less point towards this area, making it congested and especially so during peak seasons. Zhang et al. (2017) stress the importance of having activities, processes and resources placed at the right locations and by that, lowering the operational costs. FN would therefore benefit from evaluating the positioning of the in- and outbound area and thereafter possibly spreading out the workload to separate areas of the warehouse. During the survey there were even employees that felt unsafe during peak seasons, due to the congestion problems. These workers mentioned that the combination of activities, such as forklift driving, packaging, wrapping pallets at a congested inbound area lead to temporary solutions that are time consuming as well as unsafe to some degree.

Due to the increased container receptions, the goods reception process will be the one most influenced by excluding the external partner from the flow. It is therefore recommended that the routines and processes connected to this area are evaluated and improved, in order to secure both the availability of space to handle the containers as well as to improve and reduce operational costs, and in the process reduce the safety risks.

### *5.2.2 Storage assignments*

One of the main goals of the storage assignments is to reduce the travelling time in the picking routes (Accorsi et al., 2014; Manzini et al., 2015). To reduce the time spent, theory suggests different storage policies in order to place the product at the best suitable location. Koster et al. (2007) explain that random storage is the strategy that most commonly results in the longest travel distance, and therefore the picking time. This strategy is currently used at the CW in combination with dedicated storage. Koster et al. (2007) further argue that dedicated storage leads to the lowest fill rates among the different methods. As previously explained the personnel that puts away the products into storage are responsible for choosing a suitable location for the products. Long working experience and product knowledge is seen as sufficient to choose the best location, due to the fact that no other routines are in place. The workers try to fulfil the ergonomic requests and place heavy products in more suitable locations. The current space issue leads to a lack of picking locations at the warehouse, which can cause difficulties when choosing the picking location. This further means that the employees have to choose the best available rather than the optimal location. Looking at the survey, the space issue is the most common problem highlighted by the workers, with 77% of the participants experiencing that this disturbs both the in- and outbound processes. This leads to heavy or large products being placed on the highest or lowest shelf levels, making it difficult to both replenish the picking location and retrieve products from it, which was also mentioned by the employees in the survey. Poorly chosen picking locations in some cases required the pickers to help each other to reach or retrieve products from the shelves. This leads to a lot of extra time and frustration for the employees, especially during stressful periods with higher demands.

An expansion of the warehouse could indeed provide the company with extra picking locations, but there are still other aspects with potential for improvements. FN should investigate the possibility of changing the storage policy from random storage to a more organized approach, such as full turnover or class-based storage strategies. Kim & Seidmann (1990) argue that these types of strategies tend to reduce the travelling time and increase the share of actual picking time, of the total time spent. This may lead to a lot of movement of products due to fluctuation and changing demands. However, as Koster et al. (2007) mention, since the picking activity makes up for half of the operational cost it would still be worth looking into this area further.

The racking system at the CW basically consists of four different kinds of picking locations, where three kinds require the forklift driver to manually move products from parts of the pallet into the storage locations. Accorsi et al. (2014) explain that the size of the picking location has a direct impact on the replenishment frequency. As FN currently do not use any type of classification of the products, there is a possibility that frequent and large products are placed onto small locations. This is of course related to the lack of picking locations, forcing the employees to choose small locations for larger products. This is something that according to Manzini et al. (2015) is costly and unnecessary since

the handling time does not add any value to the product. Even though the warehouse has different sizes of picking locations, all pallet locations are of the same size. This leads to opposite problems, where the stored pallet fills up a very small part of the entire volume of the storage location. An example of this is when camera lenses are stacked and placed onto a standardized pallet, leading to a total height of 7 dm including the pallet. As the pallet locations are 13 dm high, approximately 46 % of the storage locations volume is not utilized. If the company would be able to improve such an issue, a lot of extra buffer locations could be created with limited investments since the main equipment and materials are already in place.

One of the most time consuming activities identified is the replenishment process and mainly the manual movement from pallets onto smaller locations. This activity does not add any value to the process itself, as it in many cases does not improve the accessibility for the picker. Some picking locations are equipped with pull-out units enabling the forklift driver to place an entire pallet on the location, as well as improve the accessibility of the products for the picker later on in the process. The company would clearly benefit from overlooking the fill rates and storage sizes based on volumes to get a better overview over an area that clearly has potential for future improvements, which according to Abbasi (2011) is related to space costs.

### *5.2.3 Picking routes*

Koster et al. (2007) argue that order picking makes up for approximately 50% of the operational cost at a warehouse. This is why FN would benefit from reviewing the current picking process and thereafter adapting it to the new conditions that would come with the expansion. Many authors bring up the importance of integrating the picking policies with storage assignments and warehouse design (Chan & Chan, 2011; Koster et al., 2007; Moeller, 2011; Petersen & Aase, 2004). An expansion would lead to a larger area to cover and therefore longer picking routes, meaning that efficiency improvements are more or less needed to improve the performance and keep down the cost levels.

One important aspect that influences the picking time is the placement of the depot (Koster et al., 2007). The current layout at FN leads to a large distance between the depot and first picking location, which most of the times is in area A, see Figure 13.



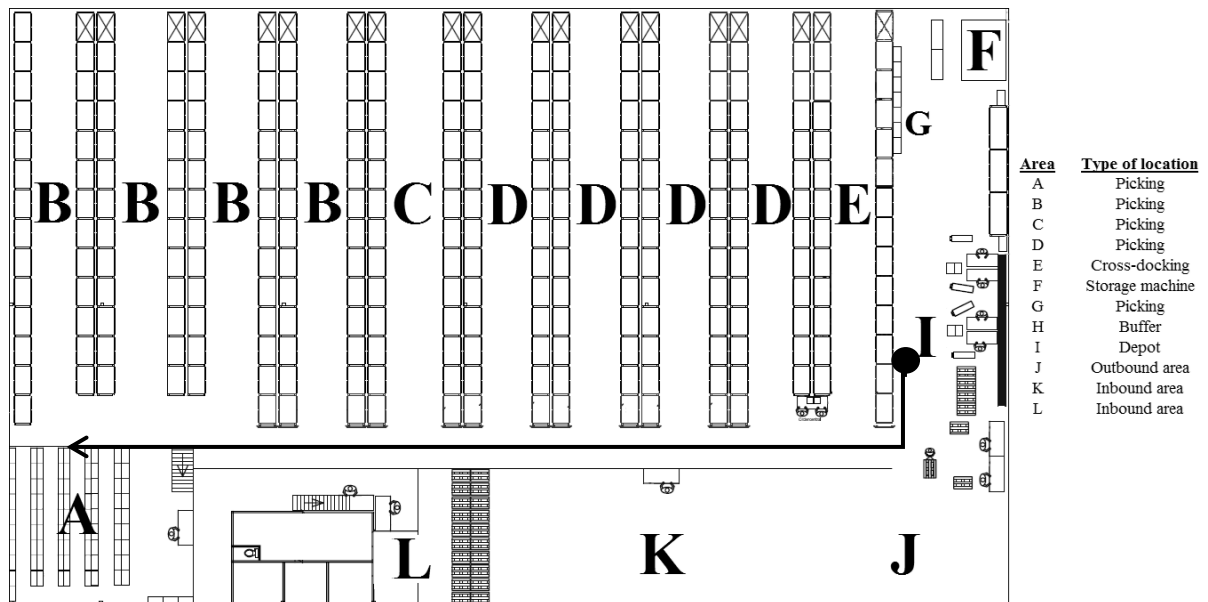


Figure 13 – The first walking distance from the depot to the most likely first picking area A.

The main problem with the location of the depot is that even though the second picking location could be in area C of the layout, the picker still has to walk to area A to retrieve the first product. This leads to a significantly longer picking route than necessary, and should in some way be addressed by the company. Petersen & Aase (2004) explain that companies use automated solutions in order to improve the picking efficiency, which FN also have done by using the storage machine. The products placed in area A would technically all fit in to the storage machine but there is not enough capacity in the current situation. It would therefore be beneficial for the company to look further into such solutions to handle to problem with the often unnecessary first long walk from the depot area.

Area A is also seen as more time consuming than other locations by the employees. The survey showed that roughly 40% of the employees thought that this area was more time consuming. This can be related to the very narrow aisles that make it more difficult to access some products, but also make it impossible to bring the carrier into the aisles. This forces the picker to leave the carrier on one end and then walk back and forward through the aisles multiple times.

Another potential improvement connected to area A can be found in the fact that the picking route starts with picking small and lighter products: This leads to small and in some cases sensitive products taking up a lot of the bottom space at the picking carrier, forcing the picker to reorganize the products during the picking process. This takes both time and focus from the picking activity and can also lead to damages on smaller products if these are stacked under heavier and larger ones. Such an aspect can be classified as a sub-factor that according to Roodbergen & Koster (2001), needs to be addressed to reduce the picking time.

The warehouse employees use the S-shaped method to pick orders, which is explained by Chan & Chan (2011) as an S-flow, where the picker walks through aisles from one end to the other. This technique is quite simple to learn and follow, where FN has developed the picking list, instructing the picker to follow this strategy. The survey shows that the warehouse employees, according to themselves, follow the instructions quite well, scoring 4.2 on a five-point scale. When it comes to how the workers grade the structure of the picking route, the score is 3.5, where one is poor and five is very good. This indicates that the majority are rather satisfied with the current structure but seem to think that there are ways to improve it. Accessibility was commonly mentioned to have a large impact on the total picking time of the products, also explained by Koster et al. (2007) as an important factor. The employees lose a lot of time while reaching far into the picking locations to retrieve the products, as well as having to climb on the racking system to reach the upper products. This is not directly connected to the picking routes but as mentioned in the theory, picking is closely related to the storage assignments, meaning that improvements in one area will likely have a positive impact on the other.

As touched upon previously an expansion would lead to a different layout for the warehouse. Depending on what type of system would be used and the structure of the new storage area, the picking route needs to be considered. Issues in the current structure are important to address to avoid having the same type of problems in the future. As the picking activity makes up for a large part of the costs, small improvements can result in significant savings. The picking activity has shown to have flaws in the current structure, therefore making it an important area of review.

#### *5.2.4 Ergonomics*

According to Calzavara et al. (2016) warehouse activities often lead to work related injuries due to the lack of equipment and heavy lifts. This is clearly shown in the case of FN where discussed in previous sections, roughly 90% of the warehouse employees have during the last three years been absent due to work related injuries. As mentioned before, the company has made some investments in the last couple of years in order to improve the situation at the warehouse, but there is still a lot of room left for improvements. Even though such investments may lead to extra costs connected to the expansion, there are according to Dul & Neumann (2009) positive effects not just for the ergonomic situation, but also an improved operational performance. This would in the future lead to lower handling costs for the company, identified as a main cost category in part one. FN has made other improvements that have been positively received by the employees and also lead to efficiency improvements. The new wrapping robot saves time and reduces the workload for the employees. The warehouse employees can now use the time for other activities while the robot handles the wrapping, which is a clear example of how ergonomic solutions also can contribute to the total performance.

As mentioned earlier in the study (chapter 4.1.4) there are two areas where relatively few ergonomic improvements have been made, namely in the goods reception and picking area. These two are handled separately in the study and would be influenced on different

levels by an expansion. The goods reception would experience direct impact by an expansion as it would influence the type of goods and the delivery quantities. The picking activity would not directly be influenced by an expansion, but there are still many improvements that can be combined with the expansion and these will therefore be further discussed. The ergonomic aspects covered in the survey are specifically focused on these two areas where the results pointed in the same direction.

Starting with the picking activity the results of the survey showed that the average experience of the ergonomic factor is rated 2.4 on a five-point scale, where one is poor and five is very good. Many of the employees also commented this question by explaining that heavy products are placed on high and low levels, making the pick uncomfortable to handle. The employees also mentioned that it is difficult to reach in to the lower levels when the products are placed far into the picking location. Kilborn & Violante (2000) explain that the design and resources used are important factors, both influencing ergonomics and performance. This is why this area is important to further investigate and improve. There are according to the survey some locations that are less appreciated from an ergonomic perspective by the warehouse staff. Many commented that it can be quite difficult to retrieve products both due to bad accessibility but also because of the heavy weight in combination with the height of the storage location. Nine out of twelve employees pointed out the lowest level specifically, which is in accordance with Calzavara et al. (2016) who mentions that lower lifts put a lot of pressure on the lower back.

FN currently uses pull-out units, in order to simplify the picking from the lower location. These are intended for entire pallets that are placed directly on the unit and then pushed into the location, which can be seen in Figure 14 below.



*Figure 14 – Two types of pull-out unit used in the central warehouse.*

The pull-out units were left behind by the old owners of the warehouse and there are only a limited number of these available. This type of solution is appreciated by the employees, reducing the need to reach far into a picking location. The survey shows that the employees grade the accessibility of the picking locations with pull-out units as 4 at a five-point scale, where one is poor and five represents very good. This solution can be seen as beneficial from a picker's perspective, where it improves the ergonomics as well as reduces the picking time.

As previously mentioned an expansion of the warehouse would have a direct impact on the workload at the goods reception, thus the ergonomic situation as well. Battini et al. (2017) argue that the lot size is important to consider since it is directly related to the work load and ergonomic pressure within an activity. The expansion will as discussed lead to more container receptions, with loose packages that need to be palletized. The survey shows that the ergonomic situation during container receptions is rated 2.2 on a

five-point scale, where one is poor and five represents very good. Many employees also explain that the emptying process is very time consuming, making it tough to work in a higher pace during the entire time. Due to the fact that the same employees often empty an entire container, the workload and time varies depending on the weight and size of the packages. The worst case scenario includes a 40' container packed with heavy (>15 kg) products while the best represents a 20' container packed with lighter (<5 kg) products. The current statistics show that roughly 47% of the 40' containers are packed with light goods under 5 kg while the heavy products come in 20' containers 70% of the time. Since six of the 40' containers are of the heaviest type, it further means that the worst case scenario with heavy products packed in a 40' container occurs only once in every ten container deliveries (6/60).

The expansion and increase of container receptions by 200% makes the goods reception an important area for improvements. The employees find the current routines as insufficient and will most likely not find the increased number of container receptions as positive, making it even more important to find possible solutions to ease the workload within the inbound area. These types of improvement can be related to Battini et al. (2017) and their arguments of the lot sizes impact on ergonomics. The authors argue that the ergonomics can be worsened with an increased number of products handled in a limited period of time. FN has currently no routines for who handles the containers and how often. There is only one employee that is involved in all receptions, but this employee's responsibility is to perform the delivery check and sort the packages/pallets, thus not lifting or engaging in heavier work. The two workers actually emptying the un-palletized packages from the container are more or less randomly selected and the same people can be used for multiple containers in a row. As the amount of containers will increase it becomes quite important to look over this routine and try to spread out the total workload on all the employees.

If ten employees would be used in such an emptying routine, a total of five groups could be made. This means that each group would have to empty a container once every fourth week (five groups divided by 1.15 container per week), compared to every week if the same people were to be used. It is according to Dul & Neumann (2009) important for the managers to be engaged and realize benefits that ergonomic solutions may bring. This is why it is important for the managers at FN to engage and involve as many employees as possible in such a solution, as the workload per employee decreases with the total number of people involved.

Even though it might be difficult to find the right equipment and design to improve ergonomics, Dul & Neumann (2009) argue that it is worth taking the time and making some investments, as these are often appreciated and can increase the work morale of the employees, thus also the performance and results at FN. During the survey approximately half of the participants wished for improved ergonomics within both the picking and reception activities. This in combination with the morale argument strengthens the picture of ergonomics as a clear area of improvement.



## 6. DISCUSSION

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*The following chapter focuses on discussing the results of this study, along with additional aspects to the problem. These aspects have directly affected the result, but also other influencing factors that could be considered by FN, and are not connected to the purpose of this study.*

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The results presented are based on empirical findings, where most of the data collected are facts and actual figures. To fulfil the purpose of the study some assumptions had to be made, that were presented in the beginning of the previous chapter. These assumptions directly influence the study, leading to an uncertainty level of the results. Some assumptions are more basic than others, and are presented to show the prerequisites in which the study is built upon. Examples of such assumptions are that the holding cost, equipment and picking route length will remain the same, and along with that the daily operations are possible to conduct without any disturbances during the expansion. Nonetheless, these assumptions are needed for the study in order to either clarify or further discuss specific approaches, and are believed not to have any significant impact on the results.

Assumptions that are directly connected to the calculations made, like for instance the average time of emptying a medium weight container, need to be further discussed. In this case the actual value of the time might vary from the assumed time. Due to both time and resource restrictions, there was no possibility of measuring all container types. The low number of measurements and the assumptions regarding the medium weight containers lead to uncertainty in these calculations.

Another important assumption is that 80 free buffer locations will be used in the future. As FN does not have any specific strategy regarding the total fill rate at the CW, except that about 80 locations should be available, it is assumed to remain at the same level. But in today's structure 80 locations lead to a fill rate of 95 %, a number that would be increased if using only 80 free locations in the future, with a higher total number of locations. FN may therefore want to increase this number, to more than 80, meaning that the total number of buffer locations need to be increased, hence more than 600 m<sup>2</sup>.

The assumption regarding the storage rent in the CW is a crucial aspect for the result. The square meter rate of 703 SEK annually is assumed to be the same, where no plans of adjusting the rate exists between the two stakeholders. However, if the rate would change, either up or down, this would have a great impact on the total costs. Since the storage rent is the only cost that would increase in a future structure, this category will have a significant impact on the result if altered, thus making this assumption crucial for the result of the study.

The results in both parts of the study are based on the assumption that the expansion would follow the exact same layout structure that is used today. This means that the authors of this study have based the calculations of space and storage locations based on

a simple extension of the current aisles in the new building part. This is far from the optimal solution since the current aisles are structured based on the pillars in the warehouse, making the corridors wider than necessary. According to the logistics expert and interviewee during this study Patrik Lööv an expansion of 1000 m<sup>2</sup> or less is possible to reinforce with beams in the ceiling, thus leading to a high flexibility when choosing the design and structure of the layout. The authors of this study have not considered this aspect in the calculations, since speculations regarding the new design are avoided, leaving it for future research. The total required space can therefore be reduced if using an optimal design. Another aspect to the expansion is that the authors of this study have assumed and calculated on expansions of 120 m<sup>2</sup>, while it in fact might be possible to use other approaches in the expansion, using less space. However, these assumptions were needed in the report in order to further analyze costs using a realistic expansion scenario.

During the study at FN, both activities and routines were analyzed closely. The company chose not to evaluate internal planning and control of inventory levels, yet it is still an important factor that must be discussed. It was found that the company does not have any specific routines regarding the inventory levels, meaning that the purchased quantities are not optimal for some products. Looking at the storage at the external partner a pallet is stored approximately 110 days on average before it is transported to the CW, where it can be stored further before actually being needed. The purchased quantities for some products are clearly greater than needed, which can be a risk when dealing with some technological products that may quickly become obsolete due to new versions, leaving FN with expired products in stock. The company would therefore benefit from investigating both routines and inventory system in order to deal with such issues as well.

It is important to understand the underlying reasons behind the current outsourcing decision and analyze to the situation through a theoretical point of view. Even though these are not connected to the main objectives of the study there are still subjects that must be discussed in order to grasp the impact of the managerial decisions. As explained by Perez-Franco et al. (2016) there is a growing focus on the supply chain perspective where a well-designed chain can improve the total performance for all actors. FN now has a greater role by recently entering new markets in the Baltics and Poland, thus reaching new customers with new demands. This makes it important to improve the internal operations to be able to secure both prices and lead times. As FN's role has evolved to more complex operations including more products and markets, an expansion would indirectly influence many different actors and operations.

Looking at the theoretical perspective of outsourcing and third party logistics it becomes quite clear that there are many benefits connected to the concept. The main reasons behind outsourcing, discussed in the theoretical chapter, are cost reductions, service improvements, risk sharing, flexibility and that the company can focus on core competence. As FN is a distributor their core competence is sorting, warehousing and selling goods to other companies. This means that part of the core competence is outsourced, which does not go in line with the theoretical suggestions. This also leads to the fact that



other benefits like new knowledge, new markets, service improvements and customizations are excluded since FN does not have this type of connection with their partner.

The only reason behind the outsourcing decision appears to be the lack of space at the CW, forcing FN to buy more capacity. The outsourcing on the other hand provides the buyer with more flexibility according to Ziolkiewicz (2011). FN does not need to worry about fluctuations in demand and extra personal when using a 3PL, which reduces the complexity in the planning at the CW. However, as mentioned by Solakivi et al. (2013) outsourcing may lead to a reduced innovation at the company. FN may therefore feel comfortable due to the flexibility at the external partner, leading to less capacity improvements in the CW. Having a fixed capacity will put more pressure on the internal processes, forcing the staff and management to come up with more innovative solutions.

Using a 3PL provider means that FN basically uses two warehouses both located in the Gothenburg area. According to Amiri (2006) there is often a tradeoff between the number of warehouses and transportations. Chopra & Meindl (2012) further show that the total transportation cost and response time will decrease when the facilities increase. This correlation requires that the facilities conduct the same activities. The CW and the EW are not the same, meaning that these benefits are not applicable in this case. The external partner is only used as extra capacity thus only sending products to the CW and not to any customers. In this scenario the usage of the EW only increases both the response time and the number of transportations.

FN should also evaluate how an in-house solution would affect the partnership with the external partner. Since the 3PL company handles all of FN's incoming transports (both land and sea transportation) the connection will not be broken and continue even with an in-house solution. According to the management this scenario have already been discussed with the partner, meaning that they are well aware of the situation. It can still be important to evaluate the situation and how it will influence both prices and information shared between the companies.

Reisi et al. (2016) mention multiple environmental problems connected to transportation, such as being main contributors to global warming, air pollution, noise and accidents. The last three mentioned problems are also known to increase in and around urban areas such as Gothenburg. The usage of the EW leads to a need of shorter transportations through the areas of Gothenburg. Even though the environmental aspect is not the focus of this study, the decisions made will have an impact in this area. Buzási & Csete (2015) argue that distributors play a key role in decreasing the total transportation consumption, which is why FN should consider sustainability in the decision making process. An in-house solution would lead to large container transportations coming directly to the CW, thus avoiding smaller and more frequent truck deliveries and reducing the environmental footprint.



## 7. CONCLUDING REMARKS

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*This final chapter gives a summary over the results from the study, answering the objectives set up to fulfil the purpose.*

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In order to answer the objectives of the first part of the study, a comparison between the current and future in-house structures were conducted. The objectives of this part of the study was to see what would happen with FN's cost structure if the CW was to be expanded, and if so how much capacity would be needed. The costs of the current structure amount to a total of between 865 396 and 945 396 SEK, depending on the actual cost of the back orders that are generated due to storing the products externally. The new capacity needed in the CW is 600 m<sup>2</sup> in order to fit the volumes stored in the EW. The future cost structure will be a total of 561 827 SEK meaning that the annual cost would be reduced by between approximately 304 000 SEK and 384 000 SEK.

The second part of the study aimed towards identifying areas that could be improved in combination with a potential expansion. The study showed that there were four main areas of improvement at the central warehouse, namely goods reception, storage assignments, picking routes and ergonomics. These four areas are discussed in regards to an expansion of 600 m<sup>2</sup>, but to improve all areas more space would be needed. The situation in the warehouse is, according to the study, in urgent need of being look over, especially if an expansion would take place. The increased container receptions would put a lot of pressure on the ergonomic situation and the employees, with improvements in routines and strategies being required. Improvements can basically be made in each warehouse activity, whereof some could be conducted during an expansion.

The first area of improvement identified in the study is the inbound area. This area is currently used not only for receptions but also for other activities, making it very congested during some periods. This makes activities more difficult to conduct and contributes to potential safety risks for the workers. The space issue is the main problem at the inbound area, where FN would benefit from evaluating the scale of the expansion in order to include enough space to solve space issues not only directly connected to the number of picking locations.

The current storage assignment strategy leads to insufficient ergonomics at the warehouse. The company lack clear assignments and routines for the storage assignment, leaving the personnel responsible for the decision of storage locations. Due to the lack of space the personnel are unable to choose the best possible locations and are instead forced to choose the best available locations from their own point of view, which can vary depending on the worker. This directly affects the ergonomic aspects of the storage assignment, where heavy products can be poorly placed. Since there is no actual assignment strategy used, this would be a good starting point for the company's future improvements. FN further handles products that are packed and received in different sizes, yet the company only uses four different sizes of locations, which further leads to a lot of unused volume in each location.

Storage assignments are directly connected to the picking routes, with the company currently using an S-shaped method. Improvements connected to both the location of the depot and placement of the picking area for smaller sized products could significantly reduce the distance travelled. An expansion would require a new layout at the warehouse, thus having a significant impact on the picking activity. Since picking makes up for a large part of the operational costs, picking routes becomes an attractive area of improvement.

Regardless of the type of improvements, FN would truly benefit from over-viewing the total layout of the warehouse, in order to synchronize the improvements, thus enhancing all operational activities.

The major conclusion of this study and suggestion to FN is to not only reduce the costs in the warehousing structure, but also to include the potential benefits of investing in certain activity improvements. The main objective of a restructure should not be to reduce the costs, but rather to focus on the improvements while keeping the cost at a reasonable level.

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## APPENDIX A

### Survey - Focus Nordic Warehouse

1- Poor

5- Very good

#### **1. How do you perceive the design of the picking route?**

1                      2                      3                      4                      5

#### **2. To what extent do you follow the provided picking route? (following the s-shape method)**

1                      2                      3                      4                      5

#### **3. How to you grade the usage of space at the inbound area, including activities such as labeling, pallet stacking, wrapping, etc.?**

1                      2                      3                      4                      5

#### **4. Do you experience that there is enough space to be able to conduct picking and inbound activities in the aisles without any disturbances?**

1                      2                      3                      4                      5

#### **5. To what degree do you feel that pull-out units facilitate the picking process?**

1                      2                      3                      4                      5

**6. How do you grade the accessibility at the picking locations from an ergonomic point of view?**

1                      2                      3                      4                      5

**7. How do you experience the ergonomic situations with today's routines regarding container receptions?**

1                      2                      3                      4                      5

**8. Are any of the following picking locations more time consuming? (You may choose more than one location)**

|         |         |         |         |          |
|---------|---------|---------|---------|----------|
| B11-14  | F21-24  | H31     | H32-35  | K41      |
| Level A | Level B | Level C | Level D | Level E- |
| F       |         |         |         |          |

**Comments:** \_\_\_\_\_  
\_\_\_\_\_

**9. What improvement area is most critical to assess?**

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**Thank you for your participation!**