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Improving retail store replenishment

A case study of Hemtex AB

Master of Science Thesis
in the Supply Chain Management Master's Programme

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ABSTRACT

Retailers are constantly struggling with the trade-off between cost and service requirements. From a service perspective, retailers are largely driven by the demand stimulating factor of inventory, which means that it is not sufficient to set in-store inventory levels solely based on demand variations. Retailers also have to consider the impact on sales, by ensuring a good shopping experience for the customer. For this reason it is challenging to determine suitable inventory levels that do not result in a too costly logistics set-up. To keep track of the logistics costs retailers emphasise the importance of measuring the inventory turnover rate. Another difficulty is to replenish order quantities that match the customer demand satisfactorily, as most items are delivered in case-packs containing a couple of consumer units. Following from this reasoning, the purpose of the thesis is to explore the logistical processes of a retail company in order to identify strategies for improving store replenishment that can increase the in-store inventory turnover rate.

In order to fulfil the purpose of the thesis a case study is performed at the Swedish retailing chain Hemtex AB. First, to get a general understanding of Hemtex AB and avoid potential sub-optimisations, the overall supply chain is mapped. Second, to understand the industry and to get insights about best practices, three companies are benchmarked to Hemtex AB, where the focus is on store replenishment and in-store inventory management. Third, by combining theory from the frame of reference an analytical framework is developed. The first step of the framework focuses on how retailers balance the cost and service requirements in the distribution channel while the second and third step analyses how lot sizing procedures and safety stocks can be improved to increase the in-store inventory turnover. Throughout the thesis a qualitative research approach is used for collecting and analysing non-numerical data from interviews and observations, whereas a quantitative approach is used for calculating different replenishment scenarios and how these affect the inventory levels.

The analysis shows that by disaggregating the in-store inventory levels into a safety stock and a demand stimulating psychic stock creates possibilities for inventory reduction. Thus, it is confirmed that solely basing the inventory levels on a quantity covering random deviations in demand is not feasible in the retail industry. The analysis also indicates that cost benefits can be achieved by lowering the case-pack size for items with high unit cost and low sales volume. Ultimately, the thesis shows that by lowering the in-store inventory levels and case-pack sizes it is possible to increase the inventory turnover rate.

Key words: the retail industry, store replenishment, lot sizing, safety stocks, psychic stock, inventory turnover rate, case-pack

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Johan Fredriksson Cedergren, Oscar Jonsson and Olof Karlsson

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEFINITIONS

3PL: Third-party logistics provider

Article: The lowest level in the product hierarchy (used synonymously to item in the thesis)

Case-pack: The packaging unit sent to the stores containing a number of consumer units, thus constituting the minimum possible order quantity

COGS: Cost of goods sold

Consumer unit: A single unit of an item/article

Cycle stock: The part of an inventory arising due to replenishment orders taking place at a different rate than consumption

DC: Distribution centre

Department: The highest level in the product hierarchy, e.g. the sleeping department.

Export package: The packaging unit coming from the supplier

Item: The lowest level in the product hierarchy (used synonymously to article in the thesis)

Main group: The level below Department in the product hierarchy

Minimum stock: The part of inventory aiming to cover random variations in demand as well as to stimulate demand.

NOOS items: Never-out-of-stock items - these items are part of the standard assortment

Psychic stock: The part of a retail inventory carried in order to stimulate demand

Retail: Is the process of selling consumer goods to customers – solely refers to the textile and fashion industries whenever mentioned in this thesis

Safety stock: The part of an inventory aiming to cover random variations in demand

Seasonal items: Articles/items with a life cycle of one to a couple of seasons

Shipping box: The packaging unit that is used in the distribution

SKU: Stock-keeping-unit

Subgroup: The level below Main group in the product hierarchy

1 INTRODUCTION

The introduction provides a background to the thesis followed by a problem description. This results in a purpose, which is subsequently divided into three research questions. The chapter also includes a case description, the scope and limitations as well as the outline of the thesis.

1.1 Background

The retail industry is in a constant state of change. Also, the pace of the change has accelerated during the last decade. The industry has gone from a dedicated focus on purchasing to achieve the optimal product assortment to a more holistic approach where the consumer is in the centre of attention. In other words, retailers spend more time trying to understand the consumers by interacting with them and gathering information about them in order to better meet their needs (Zentes et al., 2011).

Another emerging trend in the retail industry is market concentration as major players have intensified the consolidation in the market by taking market shares from smaller ones. This trend is driven by mergers and acquisitions among already large players. This is one of the reasons that retailing is a concentrated industry. In turn, this results in a shifted power distribution among supply chain parties, where the retailers have grown more influential in relation to manufacturers. Nowadays retailers use their role as intermediary between the manufacturers and the consumers to dominate the value chain. It is common that manufacturers depend on a few retailers for a large part of their profits (Zentes et al., 2011).

Given the increasingly important role of the retailer in the distribution channel, the need to optimise its core functions becomes acute. For instance, selecting the width and depth of the product assortment is a key matter for any retailer. Other important features of the retailer are shelf space management, replenishment and pricing (Hübner, 2011). All these factors have major implications for the ability to match supply and demand.

As the interrelated nature of the factors makes it necessary to handle them together, retail planning becomes a complex matter. The fact that consumers demand low prices and high product availability and that the retailers are constantly increasing the product assortment as well as striving for higher service levels increases the complexity (Hübner, 2011). Shorter product life cycles, shifting customer preferences and outsourced production processes adds to the complexity. On top of that, there are multiple factors influencing the demand volatility, e.g. seasonality, holidays, promotions and sales.

While manufacturers traditionally had the main responsibility for the logistics in the value chain, retailers are gradually taking control of their supply chains and the logistics activities within (Zentes et al., 2011). It is becoming increasingly important to improve the supply chain processes, why this has emerged as a key source of competitive advantage in the retail sector. To accomplish this transformation and to improve the planning and distribution processes, many successful retailers turn to the manufacturing industry to learn how to apply proven techniques and methods (Harwell, 2006). Despite this, the literature has primarily focused on developing sophisticated and stochastic models for managing inventory and store replenishment in the retail industry (Fisher et al., 2001).

1.2 Problem description

The major improvement potential from a logistical perspective is in the downstream part of the supply chain. Here, retailers are constantly struggling to balance the cost and service requirements. From a service perspective, retailers are largely driven by the demand stimulating function of inventory. (Larson & Demarais, 1990). This means that retailers have to consider the impact on sales when determining suitable inventory levels. Despite this, it has been shown that two-thirds of out-of-stocks happen at the store level (Falck, 2005).

The difficulty of determining suitable inventory levels in the stores, partly due to the challenges of establishing the inventory-sales relationship, can result in a costly logistics set-up. Another reason is large replenishment quantities that poorly match the actual demand, as most stock-keeping-units (SKUs) in the retail industry are replenished in case-packs (Waller et al., 2008). Supplying smaller quantities more frequently is an effective way to increase the inventory turnover rate. This is considered a top priority by many retailers (Larson & Demarais, 1990). This is especially important for the store replenishment as a large proportion of the total stock in a retailer's distribution network is held in the stores (Falck, 2005). This results in the fact that in-store activities are one of the main drivers of supply chain costs in the retail industry.

1.3 Purpose

The purpose of the master's thesis is to explore the logistical processes of a retail company in order to identify strategies for improving store replenishment that can increase the in-store inventory turnover rate.

1.3.1 Research questions

In order to fulfil the purpose of the thesis three research questions are formulated, which breaks down the purpose into smaller constituents.

First, no change or improvement is possible without creating an understanding of the current situation. Having knowledge of the focal processes, sub processes and other related aspects is a prerequisite to be able to establish any improvements. The understanding is also vital to avoid sub optimisation, i.e. making changes downstream that will have negative effects upstream. As a consequence, the first research question of the thesis is the following:

1. What are the main processes and activities in a retail supply chain?

A prerequisite to be able to improve the store replenishment through increasing the in-store turnover rate is also to create a thorough understanding of the balance between cost and service in the retailer's distribution network. This results in the second research question:

2. How can retailers balance the cost and service requirements in the distribution channel?

Thirdly, when intending to improve the store replenishment through increasing the inventory turnover it is necessary to examine the prime determinants of the in-store inventory levels. For this reason it is interesting to analyse the feasibility of lot sizes and safety stocks in the industry. However, when making changes to the safety stocks it is also important to keep in mind that inventory has a demand stimulating function in this industry. Thus, minimum stock is used throughout the thesis as the type of inventory that both covers random variations in demand and works to stimulate demand. Following from this, the second research question of the thesis is:

3. How can lot sizing and minimum stocks be improved to increase the in-store inventory turnover, while considering the impact on store display?

1.4 Case description

Due to the inability of studying an entire industry a case study is conducted to be able to reach the purpose of the thesis. The focal company in the case study is Hemtex AB. Hemtex was founded in 1973 and is today Scandinavia's leading retail chain for home textiles and other home interior related products. Hemtex faces many of the logistical challenges in the industry that was mentioned in the problem analysis. Therefore, Hemtex provides a suitable case in the thesis.

Hemtex operates a total of 157 stores in Sweden, Finland and Estonia, although Sweden is the far dominating market. The majority of the stores are corporately owned but there are a number of stores that are controlled through franchising agreements. The stores are supplied from a central distribution centre in Sweden by a third-party logistics provider (3PL).

Hemtex has divided the assortment into never-out-of-stock (NOOS) articles and seasonal articles, which are handled very differently from a replenishment perspective. This is because the seasonal articles only have a life-cycle of one to a couple of seasons whereas the NOOS articles have a permanent place in the assortment. The short life-cycle of the seasonal articles means that a large share of the purchased quantity is pushed to the stores and only a small quantity remains at the warehouse for replenishment purposes. In contrast, the NOOS articles are automatically replenished on a daily basis by the Enterprise Resource Planning (ERP) system. In average, Hemtex has around 1600 products in stock, of which 300 are NOOS articles.

As previously stated Hemtex faces similar problems to the ones described before. For instance, the firm has a tradition of keeping high inventory levels in the stores. This is because Hemtex has had a strong focus on customer service and actions to maximise sales. This has been a costly strategy why Hemtex is starting to revaluate how inventory is managed in the distribution channel. Another issue is the difficulty of matching order quantities with the actual customer requirements. This has largely to do with the case-pack constraint, which means that all items have to be supplied in multiples of a case-pack.

1.5 Scope and limitations

The thesis will primarily focus on the distribution between the DC and the stores. Hence, the suppliers will not be a part of the areas covered in the study. The main reason for excluding the suppliers is that their processes do not have any major implications for the efficiency of the store replenishment. Though, a supply chain mapping is conducted that includes the inbound transportation. There will not be any market research involving end customers, although sales statistics and demand data will be analysed throughout the thesis. The system boundaries of the thesis are illustrated in Figure 1 below, which shows how the suppliers and customer are excluded from the scope. These should not be considered as strict boundaries, which mean that analyses may include aspects outside the primary scope.

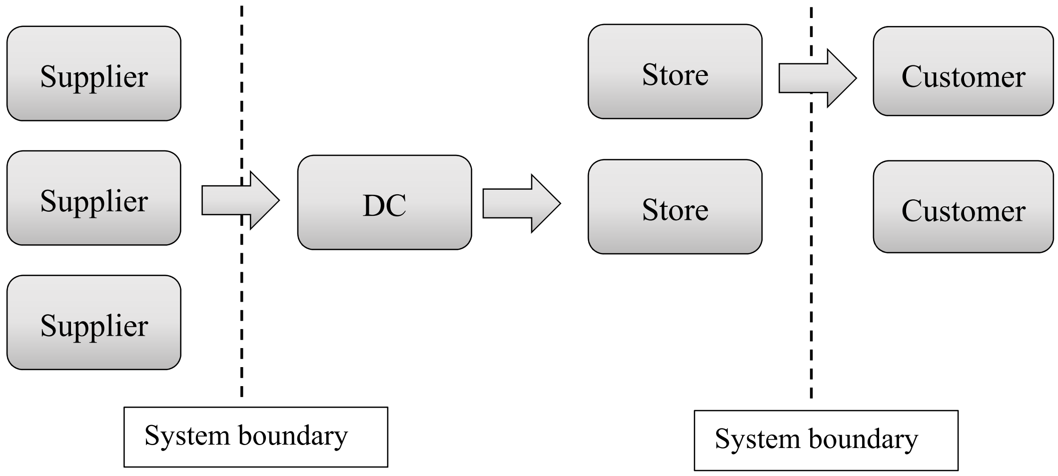

Figure 1 - A schematic illustration of the system boundaries in the thesis

The analysis of Hemtex's store replenishment will be limited to the NOOS articles. This is because Hemtex, and the industry in general, handle the store replenishment of NOOS articles and seasonal articles differently, as previously described.

The thesis will not include any route planning of the transport assignments between the DC and the stores due to Hemtex's limited ability to affect the physical distribution, given that a 3PL controls it. Ultimately, stores that follow a franchising agreement will not be included in the study as they are not a part of the automated store replenishment system.

1.6 Thesis outline

This part gives the reader an idea of how the thesis is structured and provides a rough description of its chapters.

2. Frame of reference

The second chapter describes the frame of reference that is based on the literature study conducted during the thesis. Relevant theory is explained, both from a generic and retail perspective.

3. The store replenishment framework

The third chapter describes the analytical framework that is developed by combining the theory presented in the frame of reference.

4. Methodology

The methodology chapter explains the research approach and design. The chapter elaborates on the methods for data collection as well as the work process followed during the thesis. Methodology reflections regarding the validity and reliability round off the chapter.

5. Empirical findings

The fifth chapter presents the empirical findings, including a description of the case company and its current store replenishment. Also, the chapter provides information about the companies that are benchmarked in the thesis.

6. Analysis

The analysis chapter combines researched theory and empirical findings to generate the analytical results. The first part focuses on how retail companies balances cost and service in the distribution channel while the remainder of the chapter analyses how minimum stocks and lot sizing can increase the in-store inventory turnover rate.

7. Discussion

The discussion chapter elaborates on the findings and results that were generated in the analysis both from a theoretical and a practical perspective. Further, the results are open to reflection and critique by reconsidering choices made and methods used.

8. Conclusions

The conclusions present the most important findings that were generated during the thesis on how to improve retail store replenishment.

9. Future research

This chapter provides ideas on other possible research areas that were identified during the thesis, but did not fit in the focal scope.

10. Recommendations to the case company

The final chapter provides more company-specific recommendations to Hemtex regarding improvement potential in store replenishment and inventory management. The recommendations are divided into short-, mid- and long-term actions.

2 FRAME OF REFERENCE

The frame of reference describes all the theoretical concepts and models that are deemed to be important in order to reach the purpose of the thesis.

2.1 The integrated supply chain model

In today's retail environment it is widely acknowledged that change is key in order to be competitive in the marketplace. As mentioned by Brown (1987), it is often said that the only constant in the retail industry is change. Making changes to retail supply chains requires effective retail supply chain management and broad skills in strategy-making (Ayers & Odegaard, 2007).

When it comes to strategic issues, companies tend to focus on areas like manufacturing, finance and marketing, whilst the focus on supply related issues often are of operational nature. If the supply chain is not considered in the strategic debate, companies are missing out on opportunities and the threat from the competition is increased (Stevens, 1989).

To be able to address supply chain issues more strategically, Stevens (1989) developed a structured model that aids in developing an integrated supply chain strategy. This model consists of three phases and these are presented in Figure 2 below.

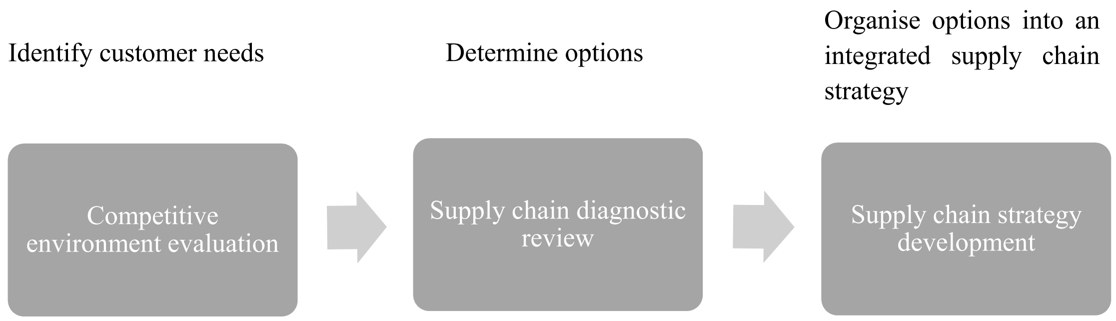

Figure 2 – The three phases of the integrated supply chain model (Stevens, 1989)

The first phase is focusing outside the four walls of the organisation, where the objective is to get an idea of what the marketplace looks like. Stevens (1989) stresses that, in order to develop a supply chain strategy, it is necessary to determine the areas of the market in which the customers demand the company to be competitive. Therefore, it is crucial to examine the characteristics of the market in which the organisation operates.

The second phase is about reviewing the current supply chain operations with the main intention of identifying areas that offer potential for improvement. As stated by Stevens (1989), the focus should be on identifying those activities that mostly affect the company's ability to answer to the customer requirements. These activities should have a major impact and offer some kind of improvement opportunity.

The final phase is focused on developing an overall supply chain strategy and a tactical plan for the implementation of that strategy. According to Stevens (1989) the outcome of this phase should be a strategy for the company, which is based on the work generated from the previous phases and consistent with customer requirements, management focus, market characteristics and the realities of the organisation.

The model for developing a supply chain strategy is not dedicated to a certain industry or a specific type of company, but can be used in many different contexts, in this case the retail industry. An application of this model was developed by Mason and Lalwani (2006). They used the overall theories of the supply chain integration model and adapted it in relation to their specific context, which ultimately generated a model called transport integration model. The transport integration model and its different components are presented in Figure 3 below.

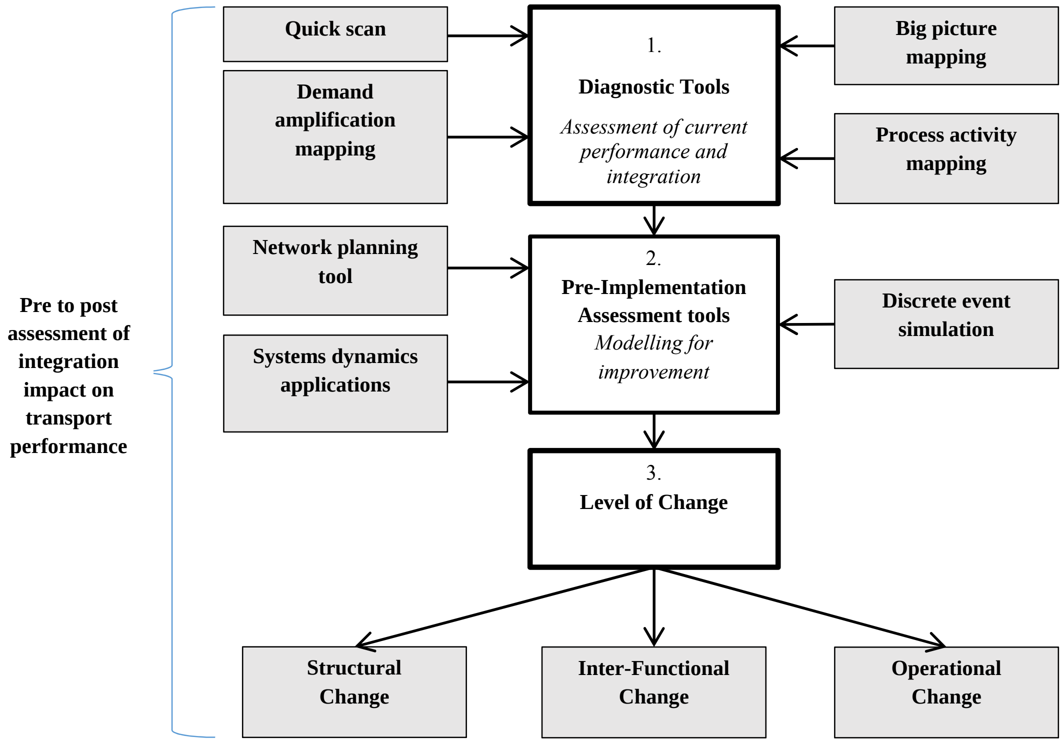

Figure 3 – An illustration of the transport integration model and its components (Mason & Lalwani, 2006)

The purpose of the transport integration framework is essentially to guide the selection and deployment of various transport integration tools with the intention of improving the overall supply chain management activities (Mason & Lalwani, 2006).

2.2 The logistics mix in retailing

Logistics in retailing is concerned with product availability. This is an intricate matter as consumers' patience has decreased to the point that they demand instant product availability (Fernie & Sparks, 2014). Simultaneously, retail logistics is characterised by multi-echelon logistics systems, i.e. there are many nodes from the suppliers to the stores, which makes it even more challenging (Kotzab & Bjerre, 2005).

Traditionally, logistics management has been divided into materials management and physical distribution management, as noted in Figure 4 below (Fernie & Sparks, 2014). As mentioned in the limitations, the focus of this thesis is on the latter. Managing the physical distribution means managing the components of the logistics mix, i.e. inventory, storage facilities, unitisation, transportation and communication, as seen in the figure.

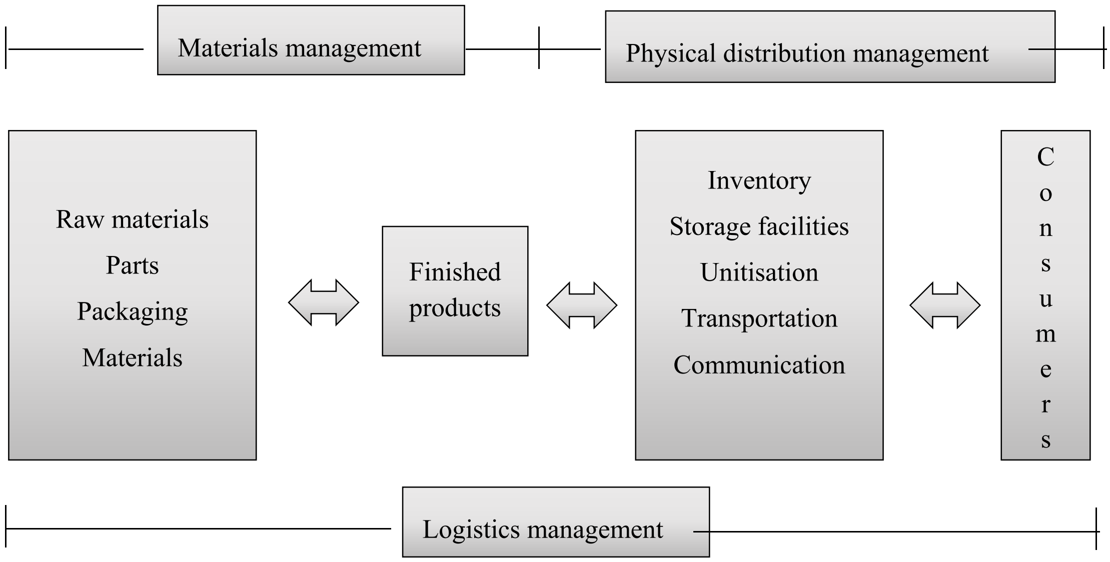

Figure 4 - Constituents in logistics management, including the components in the logistics mix (Fernie & Sparks, 2014)

Storage facilities are the points in the distribution channel where stock is being held, e.g. warehouses or stock rooms in retail stores. Managing these facilities is about being able to anticipate or react to consumer demands (Fernie & Sparks, 2014). Important decisions regarding facilities are to determine the number, location and size of warehouses (Gattorna et al., 1991).

When it comes to inventory, the key decisions are to determine the amount and location of the stock held in the distribution chain. Other important considerations are how often and how much to replenish to locations further downstream (Fernie & Sparks, 2014). This is a logistics component of major importance as the level of inventory directly affects the ability to offer a certain level of service to customers (Gattorna et al., 1991). Simultaneously, it is the main driver of the inventory holding cost that the firm has to bear. The key issue of any logistics manager is therefore to find an appropriate inventory level where the associated service level balances the cost of the inventory.

Transportation involves managing different means of transportation from point of production to point of consumption using various forms of containers and vehicles. Managing this logistics component is about determining the transport mode, whether to outsource the transport assignments, the delivery frequency and how to schedule the deliveries (Gattorna et al., 1991).

Unitisation and packaging is related to the package sizes of purchased goods and how these fit into larger unit sizes (Gattorna et al., 1991). This is another important component of the logistics mix as consumers usually buy products in small quantities whereas retailers are interested in developing products and packages that are easy to handle in the logistics chain (Fernie & Sparks, 2014). The type of packages used can have big effects on the logistics costs. For example, the ability to stack smaller load units on pallets may result in major cost savings.

The final component is communication, which concerns information. It is about gathering and using data in the distribution system in order to improve the logistics processes (Fernie & Sparks, 2014). It also refers to the demand-forecasting system and the order-processing system used by the firms in the supply chain (Gattorna et al., 1991).

In order to avoid making sub-optimal changes in the distribution chain it is important to recognise that all of these components are inter-linked. Therefore, it is advisable to integrate the logistics tasks by examining the effects on other components when making changes to another (Fernie & Sparks, 2014). As managing retail logistics aims to balance cost and service requirements, this should be the prime consideration when making adjustments to the logistics mix. The goal is to manage the components in the logistics mix in a way that ensures an appropriate trade-off between cost and service, as seen in Figure 5. The figure shows that all the components have an impact on the balance between cost and service. Whether the components are outsourced or not also affect the balance. Failing to find an appropriate balance may have dire consequences, either for business or logistics costs. For instance, being too focused on consumer demands, with correspondingly high service levels, will create a costly distribution set-up for the retailer (Fernie & Sparks, 2014; Zentes et al. 2011). Kotzab and Bjerre (2005) reports that logistics cost can take a large share of the total cost for a retailer, usually between 10 to 30 percent of total cost, which show the potential for cost savings if it is feasible to reduce the offered service level. In contrast, if the distribution system is too cost focused it may fail to meet consumer demands with lost sales as a consequence.

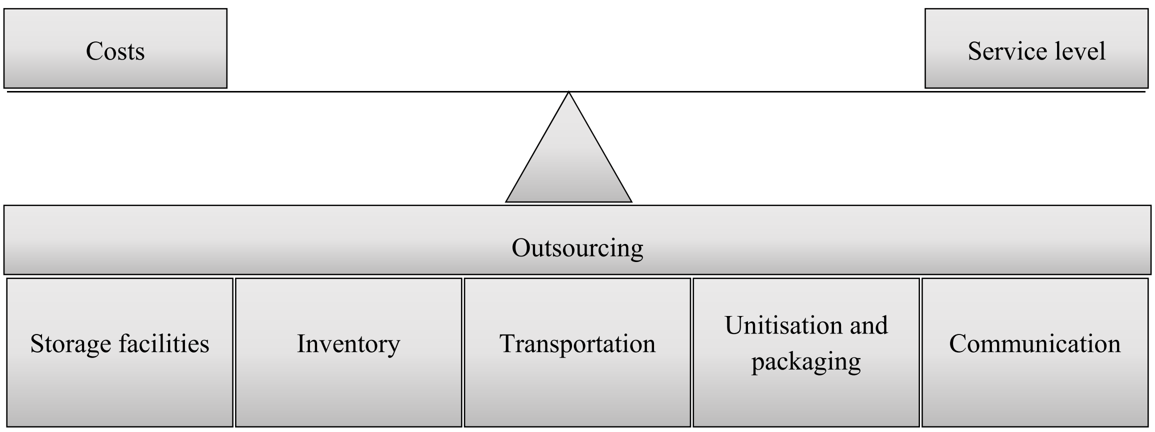

Figure 5 – Relation between the components in the logistics mix and the balance between costs and service (Fernie & Sparks, 2014)

2.3 Inventory management

Inventory management is the part of business management that is about planning and controlling inventories (Toomey, 2000). Therefore, inventory management is connected to all the logistics processes that cause a change in inventory, which requires a continuous mapping of physical stock (Kappauf et al., 2012). The aim of inventory management is to consistently keep a desired inventory level of a specific set of products. Inventory management is about satisfying customer demands by having the right product in the right place in the right time (Spratt, 2006). Ultimately, it is about balancing inventory levels against service levels. There are multiple factors that need to be considered when designing the system that plans and controls inventories, among them the process for supplying the products, the customers and the product itself.

2.4 Inventory turnover rate

The inventory turnover rate is a measure that expresses how many times, on average, inventory is replaced over a period of time (Muller, 2011). As the inventory turnover has big implications for a company's liquidity it is an important measure. It is a relative measure that can be used for comparability within the company or with other companies (Mattsson, 1997). The inventory turnover rate is calculated using Equation 1 below.

$$Inventory\ turnover\ rate = \frac{Cost\ of\ goods\ sold}{Average\ inventory}$$

Equation 1

Although it looks conceptually simple, there are many aspects to consider when calculating the inventory turnover rate (Muller, 2011). One question is whether the numerator and the denominator in the formula express the same unit. This is rarely any problem for finished goods stock as a product is the common calculation unit in this case. The consistency between the numerator and the denominator is also important when estimating their values. This may be a problem when the turnover is expressed in terms of invoicing sales and the inventory is valued as the average purchasing amount, as the inventory turnover will change when prices or markdowns change. These latter factors should not have any implications for the inventory carrying cost or inventory levels (Mattson, 1997). When calculating inventory turnover in the retailing industry, average inventory can either be measured in retail prices or in purchasing prices. For the sake of the argument just made, it is then important that these values are put in relation to net yearly sales and cost of goods sold respectively. One way for retailers to increase the inventory turnover is to reduce the stocks of slow moving items (Zentes et al., 2011).

Consistency is key also when determining the value of cost of goods sold in situations of dynamic purchasing prices. Two methods for valuing the cost of inventory are first-in, first-out (FIFO) and last-in, first-out (LIFO). FIFO is based on valuing the inventory from the purchasing price of the oldest item, i.e. the one that was first put in stock (Muller, 2011). LIFO inventory valuation on the other hand, relies on inventory value based on the most recent item put in stock (Toomey, 2000). Another method for valuing the cost of inventory is the specific cost method. This method relies on the fact that the company can track the cost of an item in the supply chain. Consequently, using this method allows the company to charge the actual cost of an item to the point of consumption (Muller 2011).

2.5 Service level

The main function of inventory is to accommodate the customer needs. It is the responsibility of the retailer to hold a stock level that ensures a sufficient service level for the end customer. All supply chain parties has similar responsibilities towards their customers. If the service level is not enough to cover the customer demand, stockouts can be the result. In turn, a stockout may result in a backorder if the customer is supplied, but at another time or in another quantity than expressed. This can cause customer dissatisfaction or loss of future business. However, if a product substitution is possible the negative consequences of stockouts can be diminished (Toomey, 2000).

Firms want to avoid the negative consequences of inventory shortages to the best of their abilities why the solution to stockouts is often to carry more inventory. Though, it is important to consider the cause of the problem before suggesting a solution. For instance, the problem may be related to the demand, or more precisely, the forecast accuracy, the customer's replenishment system, unreliable lead times or quality problems. Depending on the cause, the solution has to take different shapes. The ability to correct the problem is also strongly related to the willingness to pay for it (Toomey, 2000). The aim of the distributor is to identify methods for minimising the inventory carrying costs while improving customer service levels (Ross, 2004).

Service level can be defined in a number of ways. It can be defined as the cycle service, which is the probability of no stockout per order cycle (1). This definition expresses the probability that an order arrives before the stock on hand is finished. The major drawback of the definition is that it does not consider the batch size. Two alternative ways of defining the service level are as the 'demand fill rate'- fraction of demand that can be satisfied immediately from stock on hand (2) or as the 'ready rate'-fraction of time with positive stock on hand (3). Even though these definitions are more complex they give a better indication of the customer service. However, from a practical point of view it is more important that the service level is consistently defined and measured throughout the company than to make sure that it is perfectly defined (Axsäter, 2006; Mattsson, 2011).

In general, it is not suitable to have the same service level for all articles. On the other hand, to employ individual service levels for all articles may be unpractical. A common way of handling articles is to group them in some way and subsequently assign service levels for each group (Axsäter, 2006).

2.6 ABC classification

Even in organisations of moderate size, there might be thousands of SKUs to handle and control. It is not feasible for an organisation that purchases, stocks and controls thousands of articles to keep separate inventory management policies for each individual item (Hadad & Keren, 2013). In such environments, it is common to divide the inventory into different groups in order to apply different inventory control principles for different categories. For example, it is normally recommended to assign different service levels to different items (Axsäter, 2006).

ABC classification is an effective and widely used inventory management tool used to classify inventory items into specific categories that can be managed and controlled separately (Hadad & Keren, 2013; Ng, 2007; Yu, 2011). It is important to consider the needs of the organisation when grouping items since the conditions can vary a lot from company to company. The requirements may also vary within different parts of a company, e.g. the control requirements of a finished goods stock differ from work in process products (Axsäter, 2006; Mattsson, 2003). When the items have been grouped into categories, normally the same service level is set for all items in a class (Babai et al., 2010). According to Axsäter (2006) the selection of service levels should be made with the customer expectations in mind, or more precisely on the costs for giving adequate service as well as on the shortage costs. However, there are no clear guidelines for what those service levels should be (Millstein et al., 2014). It is often necessary to iteratively adjust the classes and service levels until a feasible solution has been found.

ABC classification can be divided into single criterion ABC and multiple criteria ABC depending on the number of factors that are considered when doing the classification. These two types are described below.

2.6.1 Single criterion ABC

The traditional ABC classification approach is based on a single criterion, usually the annual usage value. The sorting of items into categories is done by putting the relative weight of each item's annual usage value in relation to the accumulated annual usage value of all items (Hadad & Karen, 2013; Mattson, 2003).

When using a conventional ABC classification, items are divided into three groups (A, B or C), usually based on annual usage value, where each group has different importance. One common division is where group A contains about 10 percent of the articles, which make up 70 percent of the company's annual usage value and group B items contains about 20 percent of the articles, which make up 20 percent of the annual usage value. Group C then contains the remaining 70 percent of the items, which comprise approximately 10 percent of a company's annual usage value (Ng, 2007; Hadad & Keren, 2013). This relation is derived from the Pareto principle, where about 20 percent of the articles account for 80 percent of the business value (Yu, 2011).

Another common way of subdividing the categories is by incorporating 15-20 percent of the stock items into group A, which make up between 45 to 80 percent of the company's annual usage value. Group B then contains roughly 30-40 percent of the items, which comprise around 15 percent of the annual usage value. The remaining 30-40 percent of the items is then included in group C, comprising 10-15 percent of the annual usage value (Hadad & Keren, 2013).

Single criterion ABC classification has its main advantage in its simplicity. This is the primary reason for ABC classification to become the leading technique for inventory control for a majority of companies (Hadad & Keren, 2013).

In the traditional approach, items are sorted by only a single measurement, most often annual usage value. This approach might be insufficient as other criteria also are important to consider (Flores & Whybark, 1985; Ng, 2007; Hadad & Karen, 2013). Rudberg (2007) and Mattson (2003a) state that the aim of the classification determines which criteria that should be considered. Examples of other criteria that might be used are contribution margin, criticality, lead time, inventory cost, order size requirements and picking frequency.

2.6.2 Multiple criteria ABC

Hadad and Keren (2013) state that sorting items based on just one criterion, such as annual usage value, may be insufficient to provide satisfying inventory control. Looking at several criteria at the time, i.e. using a multi-criteria approach, offers an alternative way to overcome the obstacles of single criterion classification (Hadad & Keren, 2013: Ng, 2007). Flores and Whybark (1985) developed a matrix method to handle bi-criteria inventory classification, called joint criteria matrix or double ABC analysis. There are also different multiple criteria approaches, which are able to consider a larger number of factors but those are computationally heavy (Hadad & Keren, 2013). Double ABC analysis on the other hand, only considers two criteria, which is easy to understand and use compared to other multi criteria methods. By adding one criterion, the number of article categories increase with the power of two. Figure 6 illustrates a double ABC classification with two inventory criteria. This generates nine different categories as seen in the figure. Furthermore, Rudberg (2007) argues that double ABC analysis often combines a volume based criterion with a frequency based one, e.g. annual usage value combined with picking frequency.

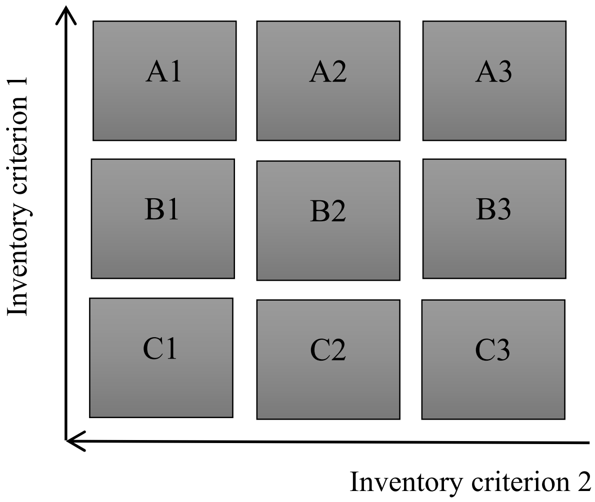

Figure 6 – A graphical illustration of a double ABC classification with two inventory criteria (Rudberg, 2007)

2.7 Stock classification

Literature on inventory management consistently classify inventory into different types. Besides the commonly mentioned safety stock and cycle stock this thesis also describes a third type of inventory called psychic stock. In comparison with safety stock and cycle stock, psychic stock is a retail display inventory carried to stimulate demand. Figure 7 below illustrates how these types of inventory relate to each other (Larson & Demarais, 1991) and how the re-order point is increased by an amount equal to the psychic stock compared to ordinary inventory management. Subsequently, each type is described separately.

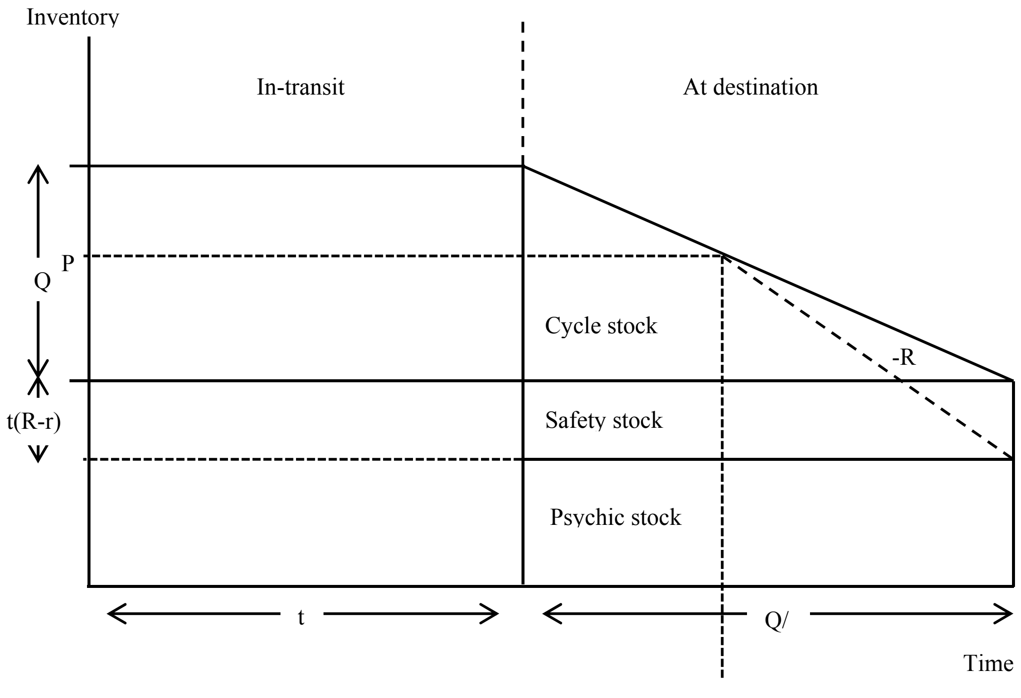

Figure 7 – Illustration of the relation between cycle stock, safety stock and psychic stock (Larson & Demarias, 1991)

Notations for Figure 7:

P = re-order point
Q = lot size
t = lead time
R = maximum sales/day
r = average sales/day

The illustration of the inventory classification is adapted from the original model presented by DeMarais and Larson (1999). This is because an adapted version of the model is more suitable for the thesis.

2.7.1 Cycle stock

Jonsson and Mattsson (2009) defines cycle stock as the part of an inventory that arises due to replenishment orders taking place at a different frequency and in larger quantities compared to the rate of consumption. Stock and Lambert (2001) state that, unlike safety stock, which is held to cover for uncertainty, the cycle stock is required in order to meet customer requirements under conditions of certainty. An item's cycle stock varies from zero to Q units, where Q is the lot-size quantity, and the average is Q/2. The average cycle stock of Q/2 assumes a constant rate of consumption or inventory depletion (Jonsson & Mattsson, 2009). Cycle stock is sometimes also referred to as lot size stock (Gattorna et al., 1991).

2.7.2 Safety stock

The purpose of keeping a safety stock is to compensate for uncertainty in the forecast. Even though the underlying demand is stochastic by nature, the demand is often treated as deterministic during the planning phase. If the demand is larger than expected, risk for scarcity arises. On the other hand, if the demand is less than expected, the purchasing orders will arrive to the inventory earlier than necessary, which is why an inventory cost develops. The role of the safety stock is to cover for the random variations in demand during the lead time, i.e. from the point in time where an order is placed until the products are available in, for example, an inventory serving the customer (Olhager, 2000).

The determination of a safety stock is either based on a desired service level or the cost of scarcity. According to Olhager (2000), a safety stock based on a desired service level is the most widely acknowledged method. This is confirmed by Jonsson & Mattsson (2013) who state that the theoretically most correct way is to determine the safety stock by using the standard deviation and the desired service level as a starting-point. As noted earlier, the service level can be expressed in a number of ways. Among the three definitions previously described, the cycle service is the most commonly used method. The cycle service is determined in accordance with Equation 2 below (Jonsson and Mattsson, 2009).

$$Service\ level\ in\ \% = \left(1 - \frac{Number\ of\ inventory\ cycles\ with\ shortage}{Total\ number\ of\ inventory\ cycles}\right) * 100$$

Equation 2

When a new replenishment order is placed the inventory level must cover for the average demand during the lead time plus an additional quantity representing a certain number of standard deviations (Jonsson & Mattsson, 2009). The number of standard deviations depends on the specified service level. The safety stock is determined according to Equation 3.

$$SS = k * \sigma_{DDLT}$$

Equation 3

Notations for Equation 3:

SS = Safety stock
k = Safety factor
σ_{DDLT} = Standard deviation of demand during lead time

Most often it can be assumed that the variation in demand is normally distributed. Then it is possible to determine the safety factor so that the desired service level is achieved through standard normal distribution tables (see appendix 3) given that the cycle service is used to determine the size of the safety stock (Jonsson & Mattsson, 2013). For example, a service level equal to 99 percent results in a safety factor of 2.33 according to the standard normal distribution.

The standard deviation of demand during the lead time is, in turn, calculated according to Equation 4 below (Jonsson & Mattsson, 2009):

$$\sigma_{DDLT} = \sqrt{LT * \sigma_D^2 + \sigma_{LT}^2 * D^2}$$

Equation 4

Notations for Equation 4:

LT = average lead time in periods from order to delivery
D = average demand per period
σ_D = standard deviation of demand per period
σ_{LT} = standard deviation of lead time

When it comes to the calculation as such, a more simple and practical approach to the standard deviation is to determine the mean absolute deviation (MAD). The mean absolute deviation is calculated as the mean value of the absolute value of the forecast error. Then the standard deviation can be estimated as 1.25*MAD (Jonsson & Mattsson, 2013).

Another way to determine the safety stock is to do it manually, without any quantitative calculations, based on previous experience. Manual determination of appropriate safety stock levels may include considerations concerning tied-up capital as well as consequences of shortages and late deliveries (Jonsson & Mattsson, 2009). The method requires manual revision of safety stock levels for every SKU in the ERP system, thus this work often becomes quite resource consuming. According to Mattsson (2008), this is not an appropriate method for determining the safety stock. The reason is that it is not possible to continuously follow up on the decided quantities for single articles in terms of costs and tied up capital, and therefore it is hard to say that one can learn anything from that kind of procedure. Even if this follow up is conducted, it would take several years of experimenting in order to come up with any reasonable conclusion, and that is of course not sustainable. Even though there are many drawbacks with this method it is widely used in the industry (Mattsson, 2008).

2.7.3 Psychic stock

As other types of inventory are held to service demand, psychic stock is retail display inventory carried to stimulate demand. It is an independent variable category of inventory unlike the traditional view on inventory as a dependent variable only servicing demand. It is built on the notion that more stock increases the probability that a product is seen and subsequently sold (DeMarais & Larson, 1999). Determining the psychic stock is done by considering requested service level and impact on marketing, for instance by taking into account the minimum number of items required to create an appealing shopping experience (van Donselaar et al., 2007). Psychic stock can be viewed as the minimum inventory level as it expresses a quantity above cycle stock plus safety stock, as seen in Equation 5 below (DeMarais & Larson, 1999). Thus, the inventory model that includes psychic stock divides stock into demand-servicing (safety stock and cycle stock) and demand-stimulating (psychic stock).

$$Total\ inventory = Psychic\ stock + Safety\ stock + Cycle\ stock$$

Equation 5

Depending on the stock-sales relationship it may or may not be economically beneficial to carry psychic stock. Psychic stock should not be carried if it does not show to have a positive impact on sales. However, there is strong evidence that there is a positive correlation between retail stock and sales in the retail inventory research. For example, Crouch and Shaw (1989) state that low stock levels are bound to reduce exposure to consumers and thus may result in reduction in sales. In addition, Dubelaar et al. (2001, pp. 98) claim that *'the empirical literature on retail inventory consistently models stock as a determinant of retail sales*'. It is also well known that there is an exponential relationship between sales of an item in a store and the space allocated to it (Cairns, 1962).

In practice, the psychic stock means that the retail inventory is expected to vary from a minimum level equal the psychic stock level to a maximum level corresponding to the psychic stock plus safety stock plus cycle stock. This is what was previously illustrated in Figure 7. Comparing to ordinary inventory management, the re-order point is increased by an amount equal to the psychic stock level (DeMarais & Larson, 1999).

2.8 Lot sizing

Lot sizing is used to accommodate the quantity dimension in material planning. Ideally, the requested quantity corresponds to the demanded quantity in every point in time, but for different reasons this is often not suitable. Larger quantities are ordered where demand, expressing consumption over a period of time, are consolidated (Jonsson & Mattsson, 2009). However, ordering larger quantities will accumulate stock and result in increasing tied-up capital. Therefore many lot sizing methods aim to minimise tied-up capital and ordering costs while simultaneously keeping delivery service and resource utilisation at sufficient levels (Jonsson & Mattsson, 2009; Ross, 2004).

Employing lot sizing can be attributed to both financial and non-financial reasons. One non-financial reason for ordering larger quantities than the demand may be the advantage of complete packaged quantities, e.g. full pallets. Though, the reason for ordering larger quantities are mainly due to financial reasons, as every order comes with an ordering cost, which usually is regarded as independent of the order quantity. The ordering costs per item will therefore be lower the higher the quantity ordered. As aforementioned, there are however disadvantages with ordering large quantities considering that the items have to be stored until they are needed. The result is inventory carrying costs, which normally also takes into account costs for depreciation and obsolescence (Jonsson & Mattsson, 2009).

As ordering costs per piece decrease and inventory carrying costs increase with increase in order quantity, the optimal lot size is thus a trade-off between these two costs (Jonsson & Mattsson, 2009; Toomey, 2000). The most advantageous cost solution is generated when the annual inventory carrying cost is equal to the annual ordering cost (Berry et al., 2005; Olhager, 2000). This balance of costs is the foundation for almost all methods for calculating economic order quantities.

Lot sizing methods can be categorised based upon the existence of fixed or variable order quantities between different orders. Also, the classification can be based on whether the expected covered time period for one order is fixed or variable. Hence, all lot sizing methods can be visualised in a four-field matrix, as the one shown in Figure 8 below. As seen in the figure there are no lot sizing methods that relies on fixed order quantities and fixed run-out times, simply because this would imply that the demand is entirely constant (Jonsson & Mattsson, 2009). It is also important to note that, although called fixed order quantity, the quantity must be revised on a regular basis to adjust to changes in the planning environment, e.g. permanent changes in demand. The same reasoning is valid for fixed run-out time.

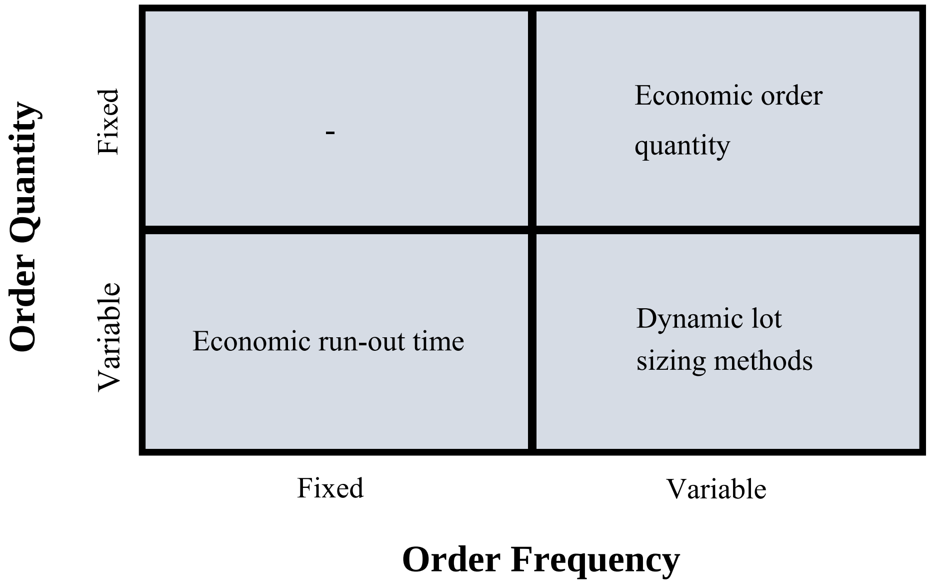

Figure 8 – Distinction between lot sizing methods depending on the fixed or variable nature of the order quantity and order frequency (Jonsson & Mattsson, 2009)

2.8.1 Economic order quantity

Economic order quantity (EOQ) or the Wilson formula is the most widespread lot sizing method for determining a fixed order quantity (Jonsson & Mattson, 2009). Order quantities are calculated based on the trade-off between inventory carrying costs and ordering costs by minimisation of the total costs an order generates (Berry et al., 2005; Jonsson, 2008). EOQ is quantity based, time invariant and non-discrete. Time invariant means that the order quantity is fixed over time. It does however not mean that it never changes, but only that it is not adjusted to short-term demand variations. As a result, the EOQ must be revised occasionally. The formula for calculating the optimal order quantity is illustrated in Equation 6 shown below (Berry et al., 2005; Jonsson & Mattsson, 2009).

$$EOQ = \sqrt{\frac{(2 \times D \times S)}{(I \times C)}}$$

Equation 6

Notations for Equation 6:

EOQ = economic order quantity
D = demand per time unit
S = ordering costs per ordering occasion
I = inventory carrying costs per time unit
C = unit cost / goods value per item

There are a number of assumptions behind the derivation of the formula: the demand is constant and known, the lead time is zero, the unit price is not dependent on the order quantity, there are no shortages and the entire quantity is delivered at the same time. As a result of the assumptions, there is no optimisation in a strict sense with respect to the prevailing conditions in normal planning situations (Jonsson & Mattson, 2009; Ross, 2004). When requirements differ from period to period, which often is the case in a normal planning environment, EOQ results in a mismatch between order quantities and actual requirements (Berry et al., 2005). Still, considering the flat total cost curve, the lot sizing method provides a satisfactorily and widely used basis for making decisions on order quantities from a cost perspective (Jonsson & Mattsson, 2009; Olhager, 2000). The flat cost curve means that EOQ is a very stable model, as a misevaluation of its parameters only results in a slight cost increase. For instance, Olhager (2000) claims that a 50 percent overestimation of one parameter value leads to a cost increase of only two percent. Figure 9 illustrates the flat cost curve where EOQ is achieved and how the inventory carrying cost and ordering cost relate to each other. Furthermore, the figure shows how the ordering cost per piece decreases and the inventory carrying cost per piece increases with increased order quantity.

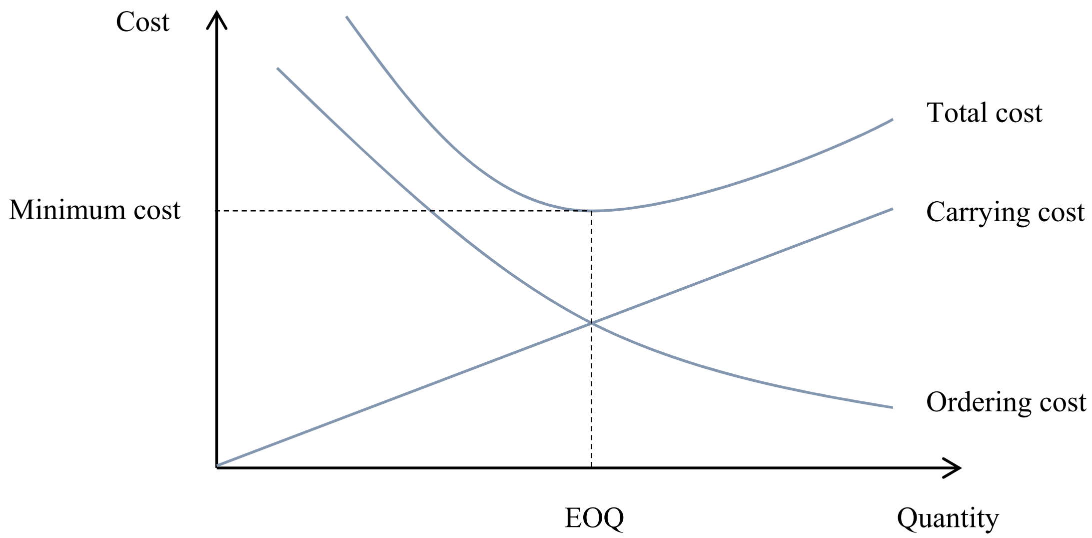

Figure 9 – Graphical illustration of how ordering cost and carrying cost adds up to a total cost and how EOQ is achieved at the minimum cost (Toomey, 2009)

EOQ is suitable for automatic calculation and storage of order quantities in an ERP-system. It is easy to update suitable variables when the planning conditions changes, e.g. when demand changes (Jonsson, 2008; Jonsson & Mattsson, 2009). Partly for this reason, EOQ can be used for items with demand variability by simply considering shorter time periods for the calculation. As a matter of fact, Dubelaar et al. (2001, pp. 98) state that '*retail inventory management is often based on EOQ principles*'. Also, Piasecki (2001) stresses that anytime there are repetitive purchases of an item, economic order quantity should be considered. It is however important to keep in mind that the model works most satisfactorily in environments where demand is stable.

2.8.2 Economic run-out time

As the name reveals, economic run-out time is based on the economic order quantity and expresses the number of planning periods that the order quantity covers. The method is based on a prior calculation of EOQ before deciding the economic run-out time in periods using Equation 7 (Jonsson & Mattsson, 2009).

$$Economic\ run\ out\ time = \frac{EOQ}{Average\ demand\ per\ period}$$

Equation 7

Economic run-out time builds on the same cost optimisation ambitions as EOQ, i.e. as a trade-off between ordering costs and inventory carrying costs. An advantage with economic run-out time is that it partly results in automatically adjusted order sizes to changes in demand. If demand increases, the order quantity will increase due to the higher requirements during the run-out time (Jonsson & Mattsson, 2009).

2.8.3 Dynamic lot sizing methods

Using dynamic lot sizing methods, both order quantity and order frequency vary between consecutive orders. These methods are demanding more complex calculations but also offer more optimal order quantities, at least in theory. Dynamic lot sizing methods put the cost of carrying inventory in relation to the ordering cost and strive for an equilibrium condition between these. For every order created, calculations period for period are being made to control if the quantity for the coming period is covered by the order (Jonsson & Mattsson, 2009).

The Silver-Meal heuristic is one of the most widely used dynamic lot sizing methods and is also called the least period cost method. The method is discrete and time variant, both regarding quantity and time (Jonsson & Mattsson, 2009).

When determining the order quantity for a period, demand for following time periods is successively considered. However, the order quantity for the first period must at least cover the demand for that period (Axsäter, 2006). The average sum of inventory carrying cost and ordering costs per period determine whether the order will cover the requirements for one period or more periods (Jonsson & Mattsson, 2009). When determining the order quantity for period 1 the demands for period 2, 3, … etc, are successively considered. When period 2 is considered, a simple calculation is made to decide whether this period's demand should be added to the order for period 1. If this is the case, the step is repeated for period 3, etc. Assuming that the next order will be generated in period *n*, the procedure is repeated with period *n* as the starting period (Axsäter, 2006). A calculation example of the Silver Meal heuristic is found in Table 1 below, including needed input data.

Table 1 – A calculation example of the Silver Meal heuristic

Input data			
Ordering cost per order (SEK)		75	
Inventory carrying cost per period (SEK)		1.5	
Period	1	2	3
Demand	30	40	35
Calculation of order quantity in period 1			
Period 1		75 SEK/period	
Period 2		(75 + 40*1.5) / 2 = 67.5 SEK/period	
Period 3		(75 + 40*1.5 + 35*1.5*2)/3 = 80 SEK/period	
The lowest average cost per period would be to order 30 + 40 = 70 items period 1.			

2.8.4 Components in lot sizing methods

This section describes ingoing components of different lot sizing methods. First, the inventory carrying factor is defined and thereafter the ordering cost is described.

Inventory carrying factor

The inventory carrying factor provides the basis for calculating the inventory carrying cost. More precisely, the inventory carrying cost for a product is determined as the inventory carrying factor multiplied by the inventory value for the product at the time of calculation (Mattsson 2003b). The inventory carrying cost, sometimes also referred to as holding cost, is the cost of having an inventory on hand. The carrying cost is related to the costs of inventory investments as well as storage (Piasecki, 2001). In general, the inventory carrying cost can be assumed to be directly proportional to the value of stock on hand, i.e. inventory carrying cost rises if the stock on hand quantity increases (Jonsson & Mattsson, 2009). The inventory carrying cost typically has a variable component and a fixed component.

Mattson (2003b) divides the inventory carrying factor into three categories, capital costs, inventory carrying costs and risk costs. Within each category, there are different associated costs. Table 2 shows all costs divided into each specific category. Capital costs are interests costs associated with having capital tied up in inventory. Consequently, inventory carrying is seen as an investment in current assets for which the firm needs to have a required rate of return as for all other investments.

Table 2 – Cost components of the inventory carrying factor divided into capital costs, inventory carrying costs and risk costs (Mattsson, 2003)

Costs related to inventory carrying factor		
Capital costs	**Inventory carrying costs**	**Risk costs**
Capital cost	Cost for premises	Costs for depreciation
	Costs for shelves, racks	Wastage costs
	Handling equipment costs	Scrapping costs
	Handling costs	
	Insurance costs	
	Administrative costs	
	Data processing costs	
	Costs for physical inventory	

According to Mattson (2003b) it is possible to disregard the majority of the inventory carrying costs when calculating the inventory carrying factor. This is because it is only the avoidable costs that are relevant to include, i.e. the ones that are dependent on the inventory levels. All inventory carrying costs except the insurance costs have marginal effect on the inventory carrying factor and can consequently be excluded from the calculations. Mattson (2003b) states that the insurance costs usually constitute around one percent of the inventory value.

Risk costs primarily include costs for devaluation and obsolescence. These costs can for instance be caused by short durability, seasonal changes and redesigns. The importance of including the risk costs in the calculations of inventory carrying factor has increased due to the trend towards short product life cycles (Mattson, 2003b).

Different costs can be relevant in different situations and it is always important to consider which ones that are relevant in the specific case. Mattson (2003b) even states that it can be recommended to differentiate the inventory carrying costs for different types of items within the same company. Subsequently, all relevant costs will be summed together and then expressed as an inventory carrying factor, which is a percentage related to the capital tied up in inventory, see Equation 8. As mentioned by Jonsson & Mattsson (2009), the relationship between inventory carrying costs and size of stock is assumed to be linear and the inventory carrying factor can be regarded as an interest. Piasecki (2001) underlines the importance of re-evaluating the inventory carrying factor at least once a year, considering changes in interest rates, storage costs as well as operational costs.

$$Inventory\ Carrying\ Factor = \frac{Capital\ Costs\ +\ Inventory\ Carrying\ Costs\ +\ Risk\ Costs}{Average\ Inventory}$$

Equation 8

Ordering costs

The ordering cost is the sum of all the incremental costs that result from preparing and processing a purchase order. Incremental in this case means that these costs will only arise as long as an ordering process is taking place (i.e. much like the marginal cost). Generally, the ordering costs do not depend on the procured quantities. In reality, each item is subject to a specific ordering cost, but for reasons of simplicity, the calculations are usually made in such a way that they generate an average incremental cost (Jonsson & Mattsson, 2009). The average ordering cost can be calculated by using Equation 9 illustrated hereunder.

$$Average\ ordering\ cost = \frac{Total\ ordering\ cost\ per\ time\ period}{Number\ of\ order\ lines\ per\ time\ period}$$

Equation 9

As for the inventory carrying cost, Jonsson & Mattsson (2009) have created a list of potential costs that can be used when determining the incremental ordering cost. These costs are primarily focused on personnel costs, data processing costs and transportation and handling costs. The full list is presented in appendix 4. All these costs do not apply to every purchase item. For example, in the case of call-off based procurement, the costs for request for quotation, supplier negotiations and selection of supplier should not be included (Jonsson & Mattsson, 2009). Similar to the inventory carrying cost, the ordering cost should be re-evaluated once a year (Piasecki, 2001).

2.8.5 Lot sizing in retailing

Most SKUs in retail stores are replenished in case-pack quantities. This means that store orders have to be in multiples of a case-pack (Waller et al., 2008; Eroglu et al., 2012). Many retailers use automated store ordering (ASO) systems to determine the order quantity per item to a store by considering the forecasted demand, delivery schedule and case-pack size. Normally, a store receives one shipment from the central warehouse per day at most, which contains all the requested items that day. The days of the week when a store can generate replenishment orders are expressed in the delivery schedule, which is the same for all items ordered through the system (van Donselaar et al., 2007).

The manufacturer normally sets the number of consumer units that fit inside a case-pack. When determining the case-pack size, different operational factors are taken into consideration, e.g. packaging machinery capabilities, sizes of pallets and truck utilisation (Waller et al., 2008).

Waller et al. (2008) stress that the case-pack size can be seen as an opportunity to increase sales in the retail stores as lowering the case-pack size may diminish stock outs. This is partly due to the fact that larger case-packs decrease the probability that all units can fit on the shelf. Instead some units have to be stored in the backroom, and if replenishment from the backroom occurs seldom, this increases the number of stockouts. This phenomenon, called the backroom logistics effect, is rather common due to the unreliability of replenishing the shelf from a storage area as opposed to replenishing directly from delivery. Reducing the case-pack size will result in higher service level and lower labour costs, as store personnel need to collect fewer units from the backroom (Waller et al., 2008; Eroglu et al., 2012). Instead they can focus on interacting with customers. According to Eroglu et al. (2012), the backroom logistics effect results because of a misalignment between the re-order point, the case-pack size and the shelf capacity.

Ketzenberg et al. (2002) underline another obvious advantage with reducing the case-pack size, or what they refer to as breaking bulk, which is the inventory reduction. A similar view is shared by Falck (2005) who stresses that large case-pack sizes makes it very difficult to optimise inventory levels, especially if the case-pack size is large in relation to the average daily demand in a store. However, smaller case-pack sizes and more frequent deliveries may increase costs as picking costs at the distribution centre and shelving costs at the stores potentially could go up. This reveals the necessity of identifying the optimal case-pack size that ensures a cost optimisation in the whole chain (Falck, 2005).

Van Donselaar et al. (2007) have a similar view by underlining the importance of considering economic trade-offs between important performance indicators when making the optimisation. For instance, the number of orders per year, the number of shelf refills needed, the total handling time needed, the total inventory needed and the subsequent service level to the customers are important considerations. According to van Donselaar et al. (2007), handling costs are far more important than inventory holding costs in line of this matter. Saghir and Jonson (2001) further enforce this claim by stating that 75 percent of the material handling in the retail chain occurs in the store. However, both the handling costs in the store and at the retailer’s DC may be severely affected by a change in the case-pack size.

In their research, van Donselaar et al. (2007) illustrated that it is common for retail store managers to deviate from the order quantities suggested by the ASO system. The reasons are multiple but greatly adhere to misaligned incentives. Misaligned incentives result when the ASO system works to minimise inventory carrying costs whereas store managers seek to maximise revenues. Therefore store managers have strong incentives to increase inventory carrying costs to be able to reduce stock outs and increase sales. To bridge the deviations from the ASO system caused by the store managers, van Donselaar et al. (2007) concluded that the case-pack size has the largest impact. In other words, the same authors claimed that reducing the case-pack size has the greatest effect on reducing the deviations from the ASO system.

2.9 Benchmarking

Change is an essential ingredient in business success. Every organisation changes and needs to do so. A change might be required because of external factors such as increased competition or shifts in customer requirements, or it can be driven internally through, for example, leadership. Companies that design new processes by using successfully demonstrated practices and insights from others will reduce costs and cycle time and ultimately create a competitive advantage in the market in which they operate. In order to discover best practices, leading companies have relied on benchmarking during the past decade (Coers et al., 2001).

Benchmarking refers to the process of measuring and comparing one organisation in relation to other organisations. The main intention of doing so is to gain information about philosophies, practices and metrics that will help the organisation conducting the benchmarking to take action and improve its performance and ways of working. Companies benchmark for a variety of reasons, and according to Coers et al. (2001), a few of the more common motives are to improve profit and effectiveness, accelerate and manage change, achieve breakthroughs or innovations, see “outside the box” or to create a sense of urgency. Rushton et al. (2010) summarises these reasons by stating that companies benchmark simply because they want to stay competitive.

There are many types of benchmarking procedures and they are of course more or less suitable depending on the context. The one that is described here is the so called competitive or industry benchmarking. The main goal of conducting a competitive benchmarking is to assess a company’s advantages and disadvantages by comparing them with those companies who are dealing with the same type of problems and challenges, i.e. to determine one’s place within an industry (Coers et al., 2001). Still, selecting companies must be done with caution even in competitive benchmarking, as organisations can be remarkably different although they are in the same line of business (Rushton et al., 2010). Coers et al. (2001) stress that it is often difficult to find companies who are willing to share the information required in order to do a thorough competitive benchmarking.

3 THE STORE REPLENISHMENT FRAMEWORK

The chapter describes an analytical framework that is developed based on the theory presented in the previous chapter.

Adapted from the supply chain integration model (Stevens, 1989) and the transport integration model (Mason & Lalwani, 2006) together with other theory presented in the frame of reference, the a new analytical model is developed. The new model presented in this thesis is called the store replenishment framework and it aims to ensure appropriate input and structure for the analysis of retail store replenishment systems, see Figure 10. In comparison with Steven's original model that focus on integration in the whole supply chain, the store replenishment framework is devoted to the retail distribution channel by analysing aspects that affect the store replenishment. Furthermore, as the original model was strategic in nature, the new analytical framework is more operational or tactical. The framework is adapted in this way to ensure a more dedicated focus on aspects that have an impact on retail store replenishment.

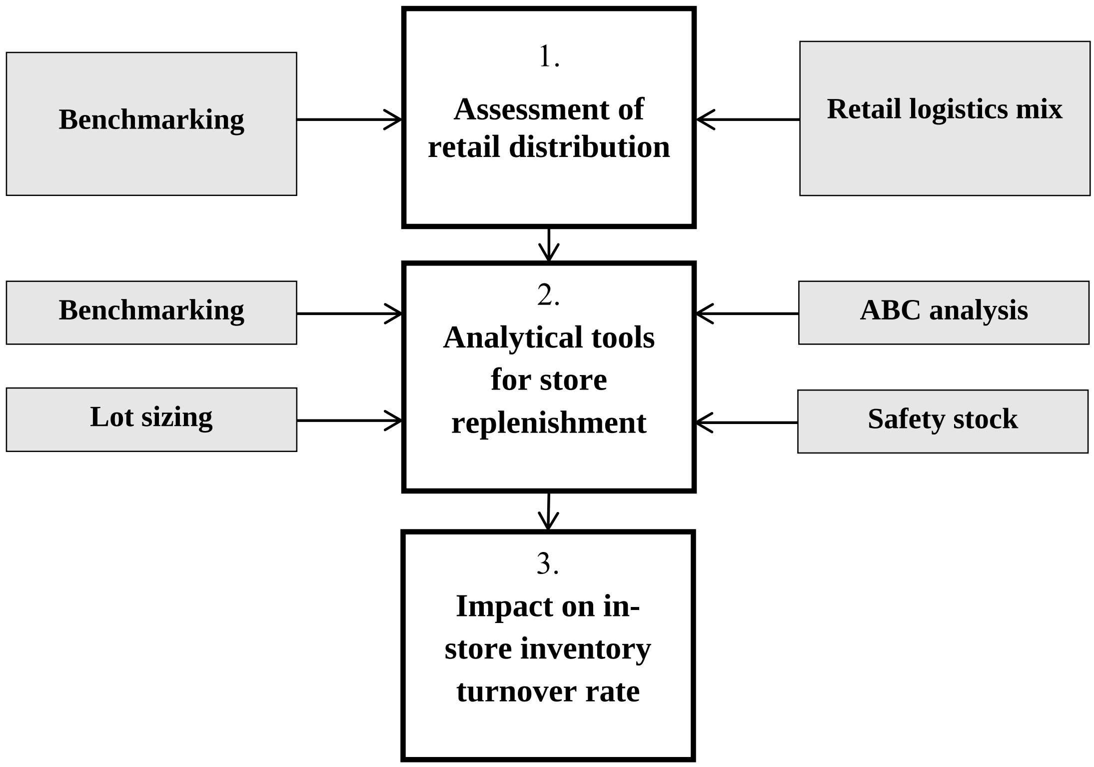

Figure 10 – An illustration of the store replenishment framework and its components (Adapted from Mason & Lalwani, 2006; Stevens, 1989)

The transport integration model largely inspires the store replenishment framework. However, other assessment tools and analytical tools have been used that better fit the needs of the thesis. The assessment of retail distribution consists of two major components. The role of the retail logistics mix, and its included elements, is to serve as a guideline for the benchmarking study, which is conducted in order to get an idea of how retail firms are dealing with the challenge of balancing costs and services within the distribution channel. The first step will highlight certain areas with improvement potential and highlight important considerations when making adjustments to store replenishment. The second step involves different analyses aimed to simulate possible store replenishment improvements. ABC-analysis, lot sizing and safety stock calculations are tools that are used to analyse improvement potential, while the purpose of benchmarking in this case is to gain insights into best practices as well as understand what practices that should be avoided. Ultimately, the third step intends to elaborate on which implications the suggested changes have on the in-store inventory turnover rate.

It is important to emphasise that there might be limitations with the store replenishment framework and the way that the original models are adapted. The store replenishment framework is intended to be used primarily for companies in the retail industry. This is not to say that the model cannot be used in other industries, but through further adaptions it might be possible to use it in other contexts as well.

4 METHODOLOGY

The methodology chapter describes the research approach and design. Methods for data collection and the work process are presented. Methodology reflections regarding the validity and reliability round off the chapter.

4.1 Research approach

The chosen research approach, and the associated method and techniques, entirely depends on the scope and purpose of the research (Ghauri & Grønhaug, 2005). A first distinction can be made between qualitative and quantitative methods. These methods are often associated with deductive or inductive approaches (Golicic et al., 2005). When combining these two approaches an abductive approach is applied (Patel & Davidsson, 2003). The research approach also includes the case study methodology, which has been applied in this thesis.

4.1.1 Qualitative and quantitative methods

Conducting an academic research normally requires both the use of qualitative and quantitative methods to derive to a solution to the focal problem (Ghauri & Grønhaug, 2005). The main difference between the two methods is that a quantitative approach includes the usage of statistical methods and requires the researcher to conduct measurement, which a qualitative approach does not (Bryman & Bell, 2011). The distinction between the two methods does not solely rely on the quantification of aspect in social life. According to Patel and Davidsson (2003), another difference between the methods is that a qualitative approach usually entails continuous analyses while a quantitative one means that all data are collected prior to any analysis.

Similar to the views of Ghauri and Grønhaug (2005) this study required employment of both qualitative and quantitative methods. This is in line with the view of Mangan et al. (2004) who recommend using both qualitative and quantitative methodologies in logistics research, commonly referred to as methodological triangulation, as this usually yields greater insights.

When it comes to qualitative research, among the most common research methods are participant observation, qualitative interviewing, focus groups and the collection and qualitative analysis of texts and documents. A mix of the different methods is also frequently used (Bryman & Bell, 2011). This was the case in the particular thesis where a qualitative approach was conducted using interviews and observations to collect information that has been coded without using statistical analysis. In other words, the information collected during interviews and observations has been analysed qualitatively, aiming to capture aspects affecting store replenishment that are not possible to analyse statistically. Quantitative methods have been used to analyse different lot sizing methods and safety stock scenarios and how they affect the in-store inventory turnover rate.

4.1.2 Case studies

Case studies are often used in exploratory or descriptive research (Ghauri & Grønhaug, 2005). They aim to take a small part of a big process and allow that part to represent reality (Ejvegård, 2009). As case studies are grounded in reality, a holistic perspective can be attained and is suitable for studies of processes and changes (Patel & Davidsson, 2011). The case study methodology is applicable when the area of investigation is difficult to study outside of its normal context. One commonly mentioned situation is when the idea is to study a phenomenon or aspect of an organisation or a department (Ghauri & Grønhaug, 2005). Noticeably, the focal thesis applied to this situation. With the intention of improving store replenishment through analysing quantitative and qualitative data it was more manageable to stick to one case. This was enabled by the fact that Hemtex's supply chain has the same challenges as the retail industry generally faces. However, as the supply chain of investigation is one of many possible to study, a certain degree of generalisation was required.

Another reason to use a case study was that the research area, i.e. store replenishment in a retail environment, showed to be rather limited when it comes to applying techniques and methods used in the manufacturing industry. The thesis was therefore characterised by a lot of testing, which is the main purpose of a case study in addition to theory development (Patel & Davidsson, 2011). Ghauri and Grønhaug (2005) confirm this view by stating that the case method works well in new research areas where there is a gap in existing research.

A case study involves data collection through a number of sources, e.g. financial reports, archives, budget statements, although personal interviews and observations are the main sources of data (Ghauri & Grønhaug, 2005). For this reason the case study method is usually associated with qualitative research. The method is useful in quantitative research also. As this study combined both qualitative and quantitative approaches, a case study design is in line with this.

4.1.3 Deductive approach

How to relate theory with reality is a central problem within all scientific work (Patel & Davidsson, 2003). A researcher that works according to a deductive approach is using existing theory to draw conclusions about a single phenomenon. According to Bryman and Bell (2011) this is the most common persuasion of the character of the relationship between theory and research. The theory is used to formulate hypotheses that are tested empirically to accept or reject the hypotheses. Usually, the hypotheses concern concepts that need to be adjusted to fit the specific research (Ghauri & Grønhaug, 2005; Bryman & Bell, 2011). This thesis somewhat applied to this description considering that fundamental logistics theories are applied and tested in a retailing context. However, the thesis was not solely driven by hypotheses that were to be accepted or rejected why a strict deductive approach was found to be inapplicable in this case.

The inability to follow a strict deductive approach was also because the particular study had its own characteristics and could not completely rely on theoretical foundation. It was sometimes necessary to form the theoretical models to fit the empirical findings. When following a deductive reasoning, the existing theory is determining what information to gather, how to interpret it and how to relate the results to the focal theory. This means that the researcher needs to determine how to approach the data collection, having the concepts embedded in the hypotheses in mind (Ghauri & Grønhaug, 2005). Considering that the research approach is governed by existing theories, a deductive reasoning is assumed to strengthen the objectivity of the research. According to Ghauri and Grønhaug (2005) deductive reasoning is often used when the research relies on quantitative methods.

4.1.4 Inductive approach

An inductive approach relies on the collected empirical data to construct a theoretical model (Ghauri & Grønhaug, 2005; Patel & Davidsson, 2003). The research does not have to be anchored in an existing theory, but rather the theory is an outcome of research (Bryman & Bell, 2011). This is somewhat in line with the way of working for reaching the purpose of the thesis. As aforementioned, previous research showed to be slightly limited why theory development was needed to some extent. For instance, it was necessary to develop an analytical framework to guide in the analysis of the research problem. It is however faulty to claim that the thesis followed a strictly inductive approach, considering that it included a lot of testing of existing theory.

By not following an inductive approach some pitfalls were avoided that have been emphasised by the literature. For instance, a researcher following the inductive approach aims to work completely impartially and use observations to formulate findings. Being impartial can be hard as the researcher has own ideas and experience that may influence the developed theory. Inductive conclusions are never completely certain as they are based on empirical data (Ghauri & Grønhaug, 2005). It is therefore hard to assess the ability to generalise the developed theory (Patel & Davidsson, 2003).

An inductive approach is often associated with a qualitative research approach where the focus is to develop theory (Bryman & Bell, 2011).

4.1.5 Abductive approach

Although useful ways to think about the relationship between theory and empirical aspects, it is difficult to make a clear distinction between deduction and induction and they should rather be viewed as tendencies. The reality is far too complex to be classified according to a specific type of research strategy. Many researchers argue that the two different research strategies can be combined in the same study (Bryman & Bell, 2011). An abductive approach can be regarded as a combination of the deductive and the inductive approach (Patel & Davidsson, 2003). This was the case in the following thesis as it was necessary to iteratively shape theoretical models and empirical data to solve the research problem. Doing so ensured that the research was not hampered by fixed ideas about either theory or reality. According to Patel and Davidsson (2003) this is one of the main advantages of the abductive approach.

The abductive approach was also applicable for the ability to test theoretical concepts and adjust them to the empirical context, which is a normal approach in a case study (Ghauri &

Grønhaug, 2005). The feasibility of applying an abductive approach was further strengthened by the fact that the study relied on a combination of qualitative and quantitative research.

The thesis started inductively in order to understand the retail context and create a thorough understanding of the current state. Subsequently, this understanding was used when shaping the frame of reference and its included theoretical models. This is the advocated approach by Patel and Davidsson (2003) who state that abduction normally starts inductively when a specific case is used to form hypotheses to explain the reality. Consequently, the second phase was characterised by deduction. This enabled to extend or further develop the theory.

4.2 Data collection

When conducting a research study there is a need for collection of data. The information has to be collected in some way, but in some cases information already exist and needs to be located. There is a distinction made depending on the source of the data, a first distinction is made between primary and secondary data sources (Ghauri & Grønhaug, 2005).

4.2.1 Primary data

Data collected by the researchers themselves through various data-gathering methods are defined as primary data. There are both advantages and disadvantages with primary data. The main advantage is that the data are collected particularly for the study at hand (Ghauri & Grønhaug, 2005; Patel & Davidsson, 2003). The main disadvantage is that the gathering of primary data can be both time consuming and costly (Ghauri & Grønhaug, 2005).

Interviews

An interview is a method for collecting primary data. Interviews can be classified into different categories depending on their level of structure (Patel and Davidson, 2003). Interviews were used as one of the main methods for the collection of primary data within the thesis. According to Ghauri and Grønhaug (2005), this is the advocated as the main data collection method in a case study. Most of the conducted interviews were of a semi-structured character, which means that the topics of the interview are fairly predetermined and formulated in an interview guide but the interviewer continuously forms questions depending on the respondent’s responses and reactions (Bryman & Bell, 2011). Questions may follow a different order than what is expressed in the interview guide. Still, all planned questions were asked and basically in the same format from interviewee to interviewee.

The interviews were initially of a more open character. As advocated by Leech (2002), this enabled the interviews to provide information that might have been missed otherwise. Another reason for this was the ability to get a holistic understanding of the situation at first. As a better understanding of the context was developed, the need for more targeted information collection increased. Therefore, a more structured way of interviewing was used in the later stages of the thesis.

The vast majority of the interviews were conducted face to face with respondents, however interviews via email and telephone have also been performed. The main reasons for conducting telephone and email interviews were to avoid travelling and to get hold of hard-to-reach people. To make sure that no information was missed, all interviews were performed by at least two authors. Interviews were recorded when allowed in order to concentrate on the topic of the interview, as suggested by Brinkmann & Kvale (2015). This is also in line with the views of Bell and Bryman (2011) who stress the advantage of recording interviews as it diminishes the distraction of having to concentrate on writing down notes. The respondents were also allowed to review the notes to make sure the information was interpreted properly. This was especially important in cases when the interviewee did not allow audio recording.

The majority of the interviews that were organised and booked beforehand went through an iterative interview process, as can be seen in Figure 11. The preparation phase included booking an interview appointment and creating an interview form that was sent to the interviewee prior to the interview. After conducting the interview, it was transcribed and summarised. Depending on characteristics of the interview, various types of material was sent to the respondent in order to validate the interpretation of the interviewee's answer. If any incorrectness were identified these were revised, and if found necessary, adaptions were made for the next interview cycle. All persons that were interviewed during the thesis are presented in appendix 1.

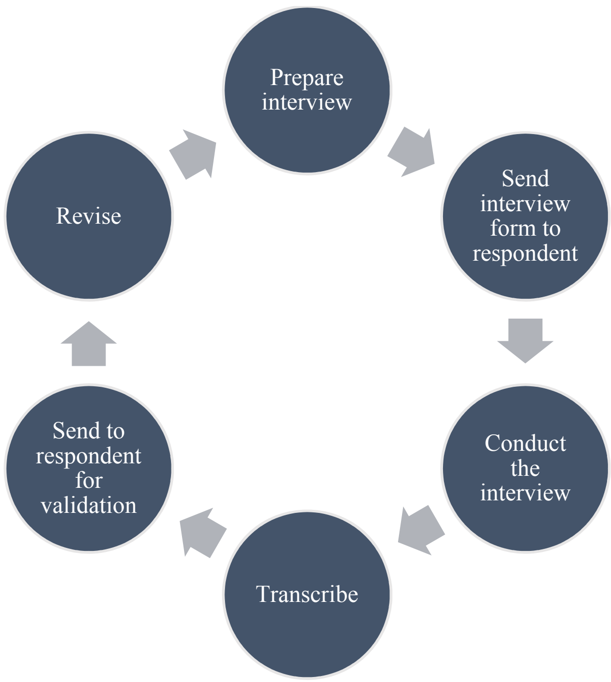

Figure 11 – The iterative interview process followed during the thesis

Observations

Observations were also conducted in order to collect primary data. Observation implies watching and listening to people, processes and cultures (Ghauri & Grønhaug, 2005; Kawulich, 2005). Also observations can be categorised depending on their level of structure. Structured observations require a well-defined problem in order to know what circumstances and behaviours to observe. Also, structured observations are characterised by specifically formulated rules for how to conduct the observation (Bell & Bryman, 2011).

Unstructured observations on the other hand, are usually performed in an explorative purpose in order to collect as much information as possible on the subject of investigation (Patel & Davidsson, 2003). The initial observations conducted within this thesis aimed to provide a better general understanding of the different supply chain entities, and was therefore performed in a more unstructured manner.

In-store observations generated a visual understanding on the importance of minimum stock, i.e. how the display of products drives sales. The observations also provided the authors with information on how the material handling processes are performed, both in the stores and at the distribution centre. A visual experience was also beneficial when mapping the current state and conducting the analysis, as it provided with a better understanding of the reality.

During the store visits, time studies of activities related to in-store material handling were conducted. These studies were made on several occasions in two stores with different characteristics to reduce the impact of random variation and obtain more accurate results.

4.2.2 Secondary data

As most research requires some kind of literature review, secondary data provide a necessary data source. Secondary data rely on previous data collection and are thus not a first-hand source (Ghauri & Grønhaug 2005. In the thesis secondary data have been collected primarily from books, journal articles and webpages. The data collection for the frame of reference was mainly done by using databases and search engines, primarily through Summon and Google Scholar. Company documentation like the financial statement, internal process descriptions and promotion plans provided important types of secondary data.

According to Ghauri and Grønhaug (2005) many researchers recommend that secondary data should be the starting point of all research. The logic behind this reasoning is that secondary data sometimes are sufficient to answer the research questions. This was not the case in the particular thesis. Secondary data were first and foremost an important input during the initial phases of the thesis as it provided a solid understanding of the focal company, the research problem and relevant theoretical models for analysing the problem. Secondary data also provided an important data source for generating an extensive and relevant literature study on retail logistics and inventory management and associated methods.

The majority of the secondary data collected during the thesis were withdrawn from Hemtex ERP system, primarily through business intelligence software. An introduction to the ERP system was helpful for the understanding of the current situation and its possibilities and limitations. The introduction was the basis for the selection of data. The data aimed to provide a basis for the situation analysis as well as for the analysis of different lot sizing methods and the safety stock calculations. The extracted data are of different kinds but primarily concern sales statistics for items and stores. For instance, sales data for all NOOS articles in all stores during 2014 provides a foundation for many of the analyses.

When collecting secondary data it is important to keep in mind that the information from a secondary data source may have been collected for a different purpose and in a different scope, thus ensuring that the data are not exaggerated or biased (Ghauri & Grønhaug, 2005). This was an important learning point in the thesis, especially when collecting data from company documentation as all firms do their best to shed positive light on their own matters.

4.3 Work process

In order to fulfil the purpose of this thesis, the work process has gone through four distinguished phases. The work process and its four phases are illustrated in Figure 12. The figure should be seen as a schematic outline and the phases should not be viewed as isolated from each other.

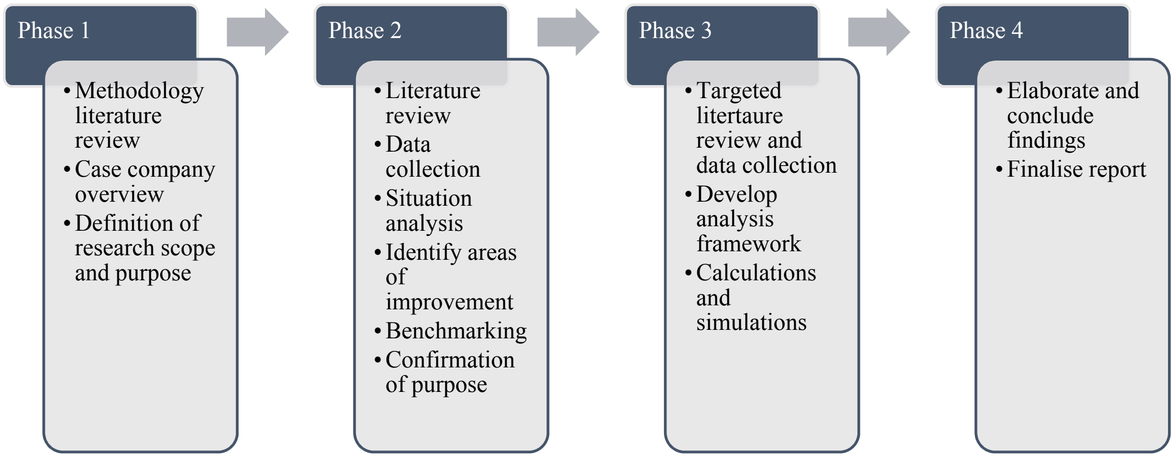

Figure 12 – A schematic illustration of the different phases the work processes has gone through

The first phase concerned the definition of the research scope and methodology. In this phase a methodology literature review was conducted in order to define a methodology framework. During the first phase, initial interviews were held at the case company in order to obtain a better understanding of the environment Hemtex is acting within. Once the research scope and methodological approach were set, the work of data collection in phase two was initiated.

The aim of the second phase was to map the current state and identify improvement potential. Data for the mapping was collected by performing interviews with different stakeholders in the supply chain. Observations at the distribution centre and in different stores were also performed.

In order to attain a more holistic understanding of the industry in general and store replenishment in specific, phase two also included benchmarking of three other retail companies. This enabled to identify best practises and examine practises that should be avoided when improving the store replenishment. One more reason for doing a benchmarking study was to achieve an understanding for how retail companies balance cost and service requirements in retail distribution. The benchmarking study was done by performing semi-structured interviews with suitable stakeholders from each company. The interview guide that was used can be found in appendix 2.

Secondary data were a useful input for the understanding of the current state. For instance, the second phase aimed at generating a solid body of theory related to the topics of the study through a general literature review. The literature review was successively more targeted as a better knowledge of the topic was acquired. With a solid theoretical base and the situation analysis performed, areas with improvement potential were identified and this acted as a gateway for continuing with the third phase. During the second phase, the purpose of the thesis was slightly modified and later confirmed in accordance with the findings of the situation analysis and the identified improvement areas.

With the input on hand from the second phase, the third phase continued with a deeper examination of the identified areas of improvement. The data collection was targeted towards respondents of interest. Additional literature reviews were made in order to generate a framework to act as a guide in the analysis. Moreover, the collection of ERP data was intensified to provide relevant data for the analysis. The third phase incorporated a large amount of quantitative data processing and calculation. Simulations of different lot sizing methods were conducted and safety stock calculations were performed. In order to make the calculations manageable some assumptions and simplifications were made. The third phase was finalised by analysing how the in-store inventory turnover rate would be affected by the proposed measures of improvement. This phase set the groundwork for further discussion and conclusions.

The final phase aimed to discuss and conclude the findings from the analysis while keeping a holistic view in relation to the purpose of the study. These findings were presented and discussed with the case study company, as well as within the thesis group.

4.4 Research quality

It is important that all research studies are open to critique and evaluation, as the absence of these elements may result in meaningless or even wrong findings (Long & Johnson, 2000). Evaluating research studies is therefore a prerequisite to be able to apply the findings. Commonly, research evaluation relies on the assessment of validity and reliability. Even though there have been some discussions about the application of validity and reliability in qualitative research they tend to be employed in the same way as in quantitative research (Bryman & Bell, 2003).

4.4.1 Validity

Validity describes whether a research measures what it was supposed to measure. As measurements often contain some kind of error, a true valid measure is hard to come by. Validity could be seen as an ideal, where the research rather is characterised by ensuring more valid measures than less valid measures. Validity has much to do with demonstrating that reported findings are solid through thorough descriptions and explanations (Ghauri & Grønhaug, 2005; Bryman & Bell, 2003).

It was a challenge to ensure the validity during the thesis due to the large amount of quantitative data available through Hemtex's ERP system. Thus, it was sometimes difficult to assess the appropriate data to extract in order to measure or analyse the intended phenomenon. By conducting interviews with representatives from Hemtex about the required data, units of measurements and the way that the data were collected and calculated, the validity of the research was enforced. The validity was also strengthened by simulating results with different approaches before performing deeper analyses. In this way it was possible to discover the feasibility of a given approach and whether that fulfilled the aim of the research.

Validity is also associated with generalisability, i.e. whether the result of the study can be generalised across settings (Bryman & Bell, 2003). LeCompte and Goetz (1982) claim that ensuring generalisability often is difficult in qualitative research due to the common usage of case studies in this kind of research. Yin (2009) confirms this view by stating that it is challenging to ensure validity when conducting a case study, as subjective assessments are made when collecting data. For this reason, the ability to generalise the result was a prime concern during the thesis and something that was discussed to a great extent. The generalisability was somewhat enforced by conducting the benchmark. This made it possible to create a better understanding of the retail industry and helped in identifying common conditions, problems and improvement potential that provided a basis when analysing the research problem. A wide and deep literature study also helped in improving the generalisability. As most of the research was done with the case company in focus, generalising the result to other context should be done with some caution.

4.4.2 Reliability

Reliability has to do with consistency or stability of a measure of a concept. Consequently, reliability refers to the confidence in data collection (Ghauri & Grønhaug, 2005; Bryman & Bell, 2003). One way of establishing stability in the research is to check whether asking identical questions to a respondent at different occasions produces consistent answers (Long & Johnson, 2000).

To ensure that the thesis fulfil a high level of reliability, as much information as possible were provided about relevant empirical data, methods used and decisions taken during the course of the work. It is important to clarify that most company names as well as specific information about Hemtex's items and stores was excluded and replaced with fictitious names. This is due to confidentiality reasons. The reliability was also strengthened by the fact that all interviews, data analyses and observations performed during the research were attended by at least two members of the thesis group. This ensured that any misinterpretation of gathered information was avoided. Also, the fact that the majority of the interviews conducted during the thesis were recorded has also enhanced the reliability. This made it possible for the thesis group to verify any gathered information and thus ensure the confidence of the research. It is however important to emphasise that quite a few assumptions preceded the data analyses, which possibly hurt the reliability as other researches might make other assumptions. Therefore, the assumptions are explained as thoroughly as possible in the thesis.

5 EMPIRICAL FINDINGS

This chapter presents all the relevant information about the case company that was gathered during the thesis. Also, the benchmarked companies are introduced in the final part of the chapter.

5.1 Hemtex AB

Hemtex describes its products as functional home textile of high quality to a competitive price, where every product is developed for a reason. The company has a total of 558 employees, including the headquarters and the stores, of which 481 are based in Sweden. According to the annual report of 2014, the turnover was 1041 MSEK generated from the 157 physical stores together with the online channel. Since 2009, the ICA Group is a main shareholder in Hemtex and today owns approximately 68.5 percent of the stocks.

Hemtex sales strategy is strongly characterised by different promotions, offers of the week and discounts. This has implications for all operational processes, not least the logistics. However, Hemtex is currently running improvement projects aiming to scale down the promotions, and thus reduce the price reduction. Instead the ambition is to strengthen the Hemtex brand and increase the amount of sales at full price.

5.1.1 Organisation

Hemtex has a functional organisational structure with traditional business units like finance, marketing, logistics, H&R etc. The organisational structure and the different business functions are shown in Figure 13. The company has a high degree of centralisation where the majority of the operational processes are controlled from the headquarters in Borås. The stores have some autonomy when it comes to store display, which is further discussed in section 5.1.3.

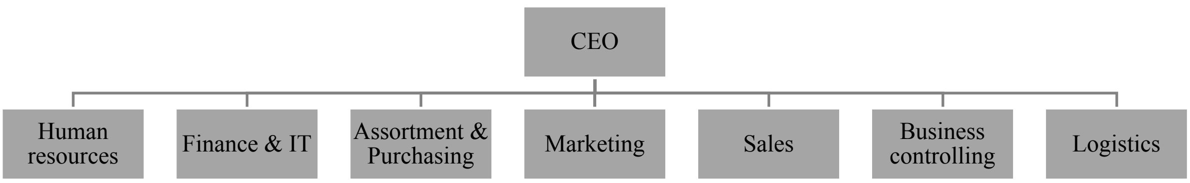

Figure 13 – An organisational chart of Hemtex's main functions

The logistics department is fairly small, only consisting of six employees; the logistics manager, three supply chain planners, one inbound coordinator and one outbound coordinator. The department is responsible for the procurement of NOOS articles, inbound expediting, coordinating with the 3PLs and ensuring that the right volumes are delivered to the stores. Regarding the latter, it involves allocating goods to the stores, monitoring the store replenishment, setting safety stock levels and planning goods allocation prior to promotions.

5.1.2 Products

Hemtex has about 1600 articles in the stores at a given point. The assortment is divided into NOOS articles and seasonal articles. There are roughly 300 NOOS articles, which contributed to around 40 percent of the turnover in SEK during 2014. A seasonal article can be turned into a NOOS article if it has sold successfully at least one year.

All articles are categorised according to a specific hierarchy that follow the sequence: 1. Department, 2. Main group, 3. Sub group, 4. Item, see Figure 14 below. Also, all articles are classified in A, B or C categories where A articles are supplied to all stores, B articles are supplied to a smaller number of stores and C articles are delivered to the least amount of stores.

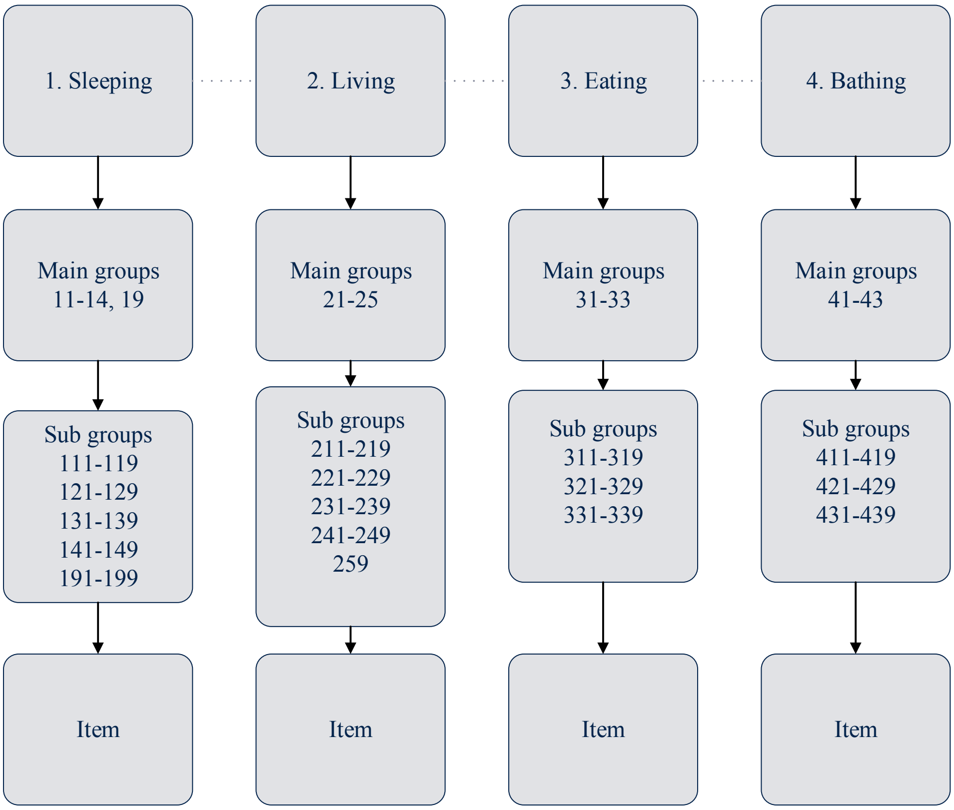

Figure 14 – The different tiers of Hemtex's product hierarchy

Like many other companies in the retailing industry, Hemtex has divided the fiscal year into four promotional seasons that corresponds to the calendar seasons, as seen in Table 3 below. Table 3 shows when each season starts, ends and the number of weeks for each season. During these seasons Hemtex has different promotions that include a varying number of products. This especially concerns the seasonal articles but NOOS articles can be included in the promotions as well. A seasonal promotion always has a certain focus, e.g. a certain design pattern, but there are normally articles from each product department in all promotions. In the end of the promotional seasons Hemtex has sales periods where they try to deplete the remaining quantity of articles that are intended to expire. The major sales periods occur after

Christmas, between week 52 and week 5 and during the summer, between week 25 and week 31.

Table 3 - The seasonal calendar of Hemtex

Quarter	Starting week	Ending week	Number of weeks
Spring	6	18	13
Summer	19	31	13
Autumn	32	44	13
Winter	45	5	13

All articles are delivered in packages according to a predetermined packaging hierarchy. The suppliers deliver the articles in export packages that only contain a specific article. An export package has the recommended measure of 60x40 centimetres which means that four packages fit on the bottom of a EU pallet. One export package contains a number of case-packs. A case-pack contains a certain amount of consumer units, which constitutes the minimum order quantity from the DC to the stores.

The case-pack size differs between different products in the assortment but the aim is that all products within a subgroup should have roughly the same case-pack size. The unit cost is also a determinant for the case-pack size, e.g. low value items generally have larger case-pack sizes. Today, the case-pack sizes come in all kinds of quantities, ranging from two to twelve for the majority of the items. Table 4 below shows an overview of the average case-pack size for the NOOS articles in each main group.

Table 4 - Average case-pack sizes for each main group

Main group	Case-pack size
11	3.2
12	4.1
13	4.0
14	2.8
19	3.4
21	5.3
22	6.7
23	4.7
24	8.7
31	7.3
32	7.2
33	9.0
41	4.7
42	2.1
43	5.5

5.1.3 Stores

Hemtex has stores in three markets, namely Sweden, Finland and Estonia. Sweden is the largest market with 133 stores. The Swedish stores are divided into five regions, North, West, Mid, Stockholm and South. Moreover, Hemtex has 19 stores in Finland and 5 stores are located in Estonia. Among all the stores, the Hemtex group owns 142 stores, whilst franchise companies own 15 stores.

All current stores are categorised in two different ways. Firstly, they are categorised in six sales categories (1-6) depending on the turnover, where category 6 represents the highest turnover. However, the sales categories are expressed on the main group level for each store and are not aggregated to the overall store level. This means that each store has one sales category for each main group. A categorisation example is illustrated in Table 5 below. The table shows the sales interval that provides a basis for assigning stores to a particular sales category as well as the share of store within each sales category.

Table 5 – An example of sales categorisation for a main group, illustrating the share of stores in each category and exemplifying sales intervals

Sales category	**Share of stores**	**Sales interval** (SEK)
1	28.0 %	7700 – 12600
2	30.6 %	12600 – 17800
3	21.7 %	17800 – 23100
4	11.5 %	23100 – 29000
5	4.5 %	29000 – 33700
6	3.8 %	33700 –

The sales categories are reviewed eight times a year by supply chain planners and store controllers and compared against the sales interval. During a review, a store's level of sales is determined by weighing historic and recent sales data to capture the sales trend. In addition, the sales categories are sometimes adjusted upon request by the store managers as the categories are the basis for the in-store minimum stock level. This will be described in more detail in section 5.3.1. The sales intervals are evenly distributed and automatically adjusted by the ERP system based on sales statistics.

All stores are also categorised according to three assortment categories (A, B and C) that express the share of the total assortment that a store receives in ascending order. Similar to the sales categories, the assortment categories are not expressed on overall store level, but for each department within a store. In other words, a store's Sleeping department can belong to category A while the Eating department may belong to category B. In order to reach sufficient order quantities from the suppliers, Hemtex has decided that it needs to be at least 50 stores that have the majority of the departments within the largest C category.

The store managers have accountability for the store's result. The costs are divided into affectable, e.g. personnel expenses, and non-affectable like rent, advertising and inventory. Each store, and each department belonging to a store, is followed up on result in relation to budget each week. A more thorough follow-up is conducted every month. The performance measures that are followed up are shown in Table 6, including an explanation of how they are measured.

Table 6 – Hemtex's performance measures for store follow-up

Performance measure	Explanation
Sales	SEK
Average purchase price	SEK
Conversion rate	Share of store visitors making a purchase (%)
Productivity	Sales (SEK) per worked hour

Also, store managers have some freedom regarding store display, as every store is unique in terms of size, shelves and tables. This is especially the case for large stores. However, the store managers receive directions from the headquarters and regional visual merchandisers. There are also standards governing the customer cycle and the location of departments within a store.

5.2 The supply chain of Hemtex

A mapping of Hemtex's supply chain is undertaken in order to get a general understanding of Hemtex's material and information flows and their included activities. Relevant representatives from different parts of the supply chain have been interviewed and this constitutes the foundation of the supply chain map illustrated in Figure 15. The supply chain map is described below.

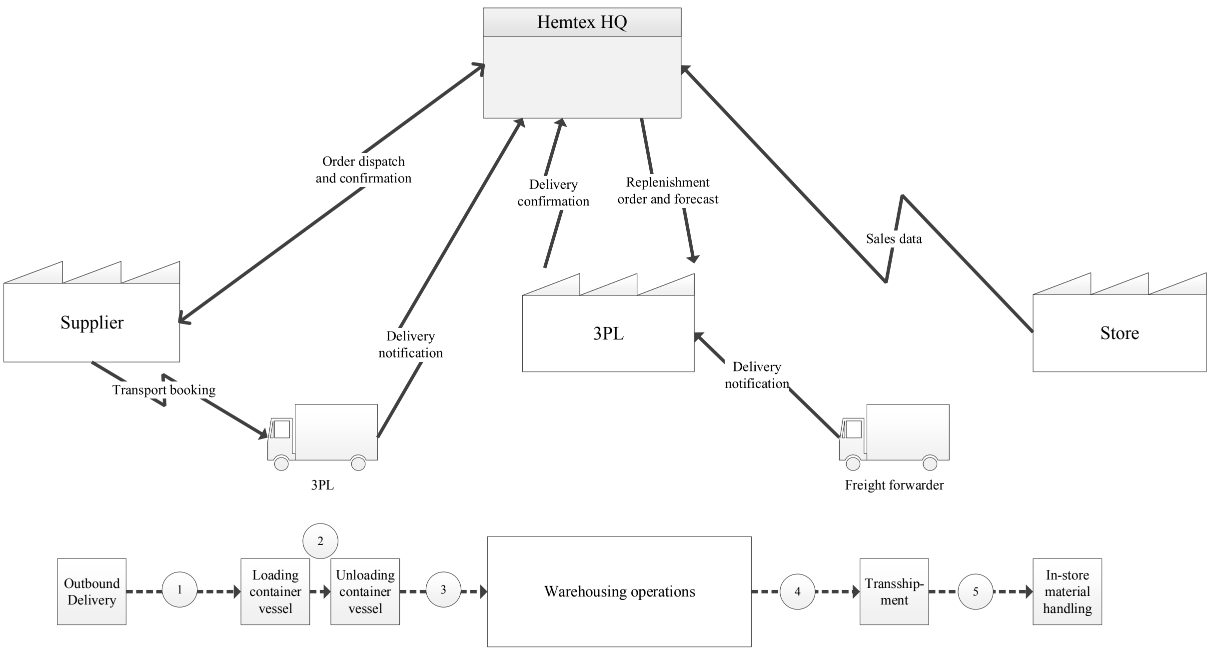

Figure 15 - A map illustrating Hemtex's supply chain from the suppliers in Asia to the stores in Sweden

1. Road transportation from supplier to sea port (E.g. in China)
2. Sea transportation from Asia to Gothenburg
3. Road or rail transportation from Gothenburg to DC in Jönköping

4. Road transportation from DC to one of the freight forwarder’s transhipment points
5. Road transportation from transhipment point to store

The majority of Hemtex’s products are sourced from Asia, especially from China and Bangladesh. All purchasing activities related to Asia are handled in close collaboration with ICA’s global sourcing department (IGS), which is not mentioned in the supply chain map. Hemtex is also working with a few European suppliers, mainly located in Turkey. Note that this is not illustrated in the supply chain map either. The goods coming from Asia is transported by sea, whilst goods delivered from European suppliers are transported by road.

The transportation activities from Asia to the DC in Jönköping are outsourced to a 3PL. The suppliers in Asia have to book a slot on the vessel at least ten days before departure to ensure there is room for the goods. Normally, the goods are delivered seven days before the date of departure. There is also a shipping window enabling the shipper to depart five days before or after the agreed upon date.

Hemtex’s purchasing department is responsible for the contact with the 3PL that handles the inbound transportation. The purchasing orders are communicated through EDI and contain information about delivery date and shipping window etc. The 3PL is also supportive with some delivery monitoring as they send reminders to the suppliers regarding transport booking.

The products are shipped to the port of Gothenburg and the transportation lead time from Asia is approximately five to six weeks (port to port). The full container loads are transported by train to Jönköping train station and further transported to the DC by truck. Whenever it is not possible to fill an entire container, the cargo is transhipped to pallets and transported by truck to the DC. The DC is outsourced to another 3PL, which operates the warehouse and is responsible for outbound transportation. On average, the DC is supplied with products once a day from either the European or Asian suppliers.

Forecasts are sent to the DC in Jönköping so that the 3PL is able to provide enough manpower for the order-picking process. The forecasts are based on the past two years outgoing volumes from the DC, including seasonal trends as well as regular sales. Also replenishment orders are sent to the DC. Whenever the warehouse is understaffed, the 3PL prioritise picking orders that are related to stores geographically far away or to stores with high sales volumes.

As noted in Figure 15, the freight forwarder is responsible for transporting the products from the DC in Jönköping to all stores around Sweden. The 3PL owns the contract with the forwarder and is therefore responsible for all support concerning the transportation services. There are primarily two different flows of goods departing from the DC, one for full pallets and one for the remaining products. The latter is delivered to the freight forwarder’s transhipment terminal in Torsvik outside of Jönköping and further transported from there. Around 50-90 percent of the products are transported on pallets. Products going to Stockholm are generally delivered directly without any transhipment since fairly large volumes are going to this area. The majority of the goods are also transhipped at a distribution terminal closer to the stores, including the products going to Stockholm. It is naturally up to the freight forwarder to decide what terminal that will act as a transhipment point. The transportation lead time is one day to stores that are located south of Sundsvall, otherwise it is two days.

5.2.1 Warehouse operations

The 3PL is responsible for providing Hemtex with various warehousing activities. These activities are illustrated in Figure 16 below, and more thoroughly explained below. It should also be mentioned that three percent of all goods is controlled, which is not illustrated in the figure. This control mainly focuses on quantities and is usually not related to any quality assurance of the product. As mentioned previously, the 3PL also owns the contract with the freight forwarder, which implies that the 3PL is the party that is in contact with the carrier and handles price discussions as well as different kinds of complaints.

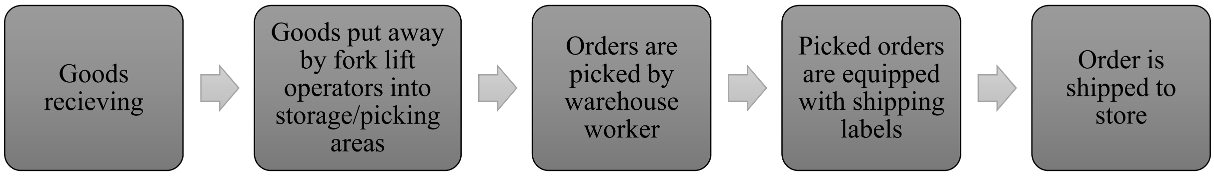

Figure 16 – The activities within the warehousing process

When the goods have arrived to the DC, a forklift operator starts unloading the goods and then puts it in a certain unloading area. Subsequently, every pallet gets a unique identification number and is assigned to a certain storage lot in the warehouse. Then the goods is put-away by forklift operators into storage/picking areas in accordance with the assignment in the previous step. The following step is triggered by a replenishment order coming from Hemtex, which in turn is based on sales statistics in the stores. An order picker picks one order at a time following a route up and down the aisles until the entire order is picked. The order picker uses a scanning device to register each product and then the product is put into a standardised shipping box. It is important to have in mind that the time taken for the order picking process differs greatly between different orders and the number of order lines is the ultimate determiner of the total time taken. Once the entire order is picked, it is subsequently delivered to the next step, where each shipping box is labelled for transportation purposes. After the labelling step, each order is placed in an outbound loading area, where the goods await the arrival of the freight forwarder.

As the contractual period ended, Hemtex recently renegotiated the contract with the 3PL. This caused some changes to the costs derived from the order-picking process. Whereas the cost structure of the old contract was based on a fixed fee per started order plus a variable part driven by the number of case-packs, the new cost model is solely based on volume. This means that there are no fixed fees for the orders picked by the 3PL. However, the contract includes a clause stating that the annual agreed-upon volume cannot exceed a certain level. If that should occur the contract has to be revaluated.

5.2.2 In-store handling

Once the freight forwarder arrives at the store with the goods, the in-store material handling process is initiated. The process and its included steps are illustrated in Figure 17 and further explained below.

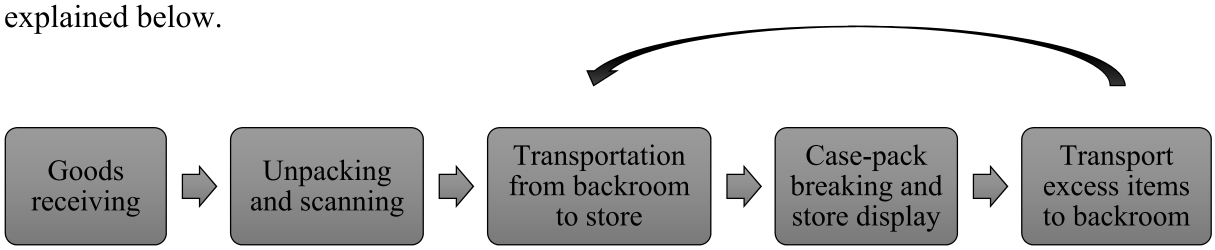

Figure 17 – The activities within the in-store material handling process

Upon arrival at the store, a staff member is responsible for the goods receiving, which includes transporting the goods, usually a pallet, from the drop-off zone to the backroom. The goods, delivered in an export package or a shipping box, are subsequently unpacked and scanned and then put in a trolley used for transportation from the backroom to the store. Once in the store, each case-pack is broken and the consumer units are then put on the shelf. Usually, too many items are brought out into the store, which means that several items have to be returned to the backroom for storing and thereafter be used for replenishment purposes. In other words, the last step of the process will not necessarily take place.

The case-pack size is strongly connected to the in-store material handling cost and has big implications for how time consuming the in-store material handling process will be. Observations have made it possible to conclude that the time consumption for scanning, case-pack breaking and in-store shelving is independent on the case-pack size. This means that a larger number of case-packs will increase the time spent on these activities linearly. To conclude, a smaller case-pack size results in more shelving occurrences and thus a higher shelving cost is developed.

According to store personnel, transporting excess items back to the backroom can sometimes be very time consuming. Consequently, it is rather frequent that items taken out to the store for shelving do not fit in the shelf. Items that are stored in the backroom are replenished eventually why almost the entire in-store material handling process has to be reassumed. The replenishment from the backroom is also generating a cost, which is indirectly dependent on the case-pack size.

5.3 Current store replenishment

Hemtex uses an ERP system to manage the store replenishment of NOOS articles. More precisely, the logistics department uses a module in the ERP system called Forecasting and Replenishment (F&R) that automatically generates daily replenishment orders that are sent to the DC. The system is updated with store transactions every 15 minutes.

5.3.1 Minimum stock and service level

The minimum stock expresses the quantity that is needed to ensure an attractive store display and is set jointly by central visual merchandisers and supply chain planners. The main goal of the inventory levels is to stimulate demand and fill the shelf in the store. The minimum stock plays a considerable role in the material planning; more about this in the following section. Hemtex does not carry out any calculations to determine appropriate minimum stock from what is needed to cover any unexpected demand. Similarly, no consideration is taken to the effects on tied-up capital or the probability of stockouts. This means that Hemtex does not separate the minimum stock into a traditional safety stock used to cover variations in demand and a display quantity to create an appealing shopping experience. Conversely, these quantities are expressed together as the minimum stock. The minimum stock is set by primarily considering qualitative aspects like plausibility, feeling and experience.

The majority of the minimum stocks are expressed on the subgroup level, which means that all items within the subgroup have the same minimum stock. It is not seldom that the minimum stocks are expressed on the item level, especially with regards to the NOOS articles. When the minimum stock is set on item level, it is only valid for that specific item and other items within the same subgroup may have minimum stock set on the subgroup level. It is up to the supply chain planners to determine whether an item should have a minimum stock on item- or subgroup level. The behaviour for making this decision differs quite a lot between the supply chain planners, as someone almost exclusively set item specific minimum inventory levels whereas someone else expresses most of them on subgroup level.

The minimum stocks are based on the six sales categories described in section 5.1.3. Consequently, there are six different minimum stocks for each subgroup, i.e. one stock level for each sales category. The same goes for items with minimum stock expressed on item level. Figure 18 shows the relation between sales categories and minimum stocks and how these can be set on subgroup level or item level.

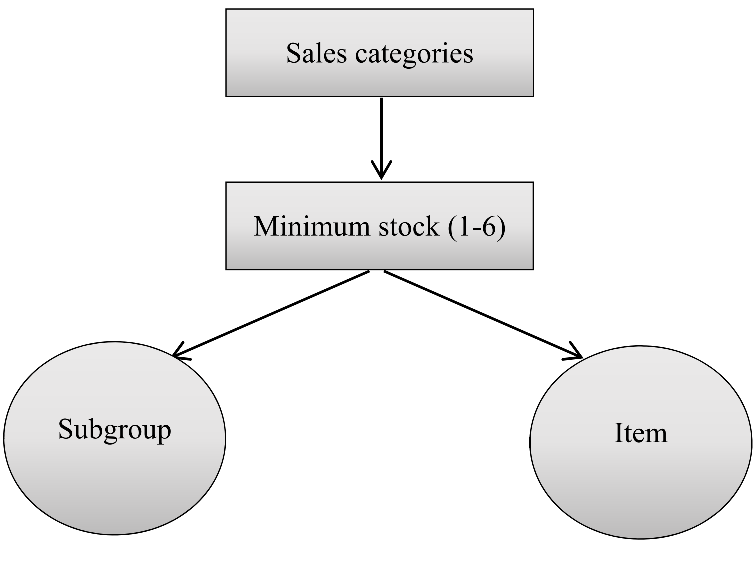

Figure 18 – The relation between sales categories and minimum stocks and how these can be set on subgroup level or item level

It would be preferable to have item specific minimum stocks for all articles as this would enable to manage them in more detail. The main reason that Hemtex does not work in this way is that the minimum stocks are manually adjusted in the ERP system whenever the demand is expected to change drastically. For instance, before Christmas or during promotions and sales offerings, the minimum stocks are qualitatively raised. Before Christmas it is common to increase the minimum stocks by 20 percent. Offers of the week are also causing an adjustment to the minimum stocks in the beginning of the week before the promotion. Subsequently, the levels are readjusted around Thursday in the week of the offering.

From the reasoning above it is also clear that Hemtex does not measure the service level offered to the customers in the stores. This means that there are no structured ways of ensuring a higher service level for items that are more important than others. Instead this is done by qualitatively setting a higher minimum stock for articles that deem to be important. Despite the lack of knowledge about the actual service levels the Logistics Manager states that: '*I believe that we have a service level of 100 % for many of our products in the stores*'. Figure 19 illustrates the relation between the average minimum stocks in all stores on subgroup tier with the average weekly demand per item and store for the same subgroups. Noticeably, there is a large difference between them.

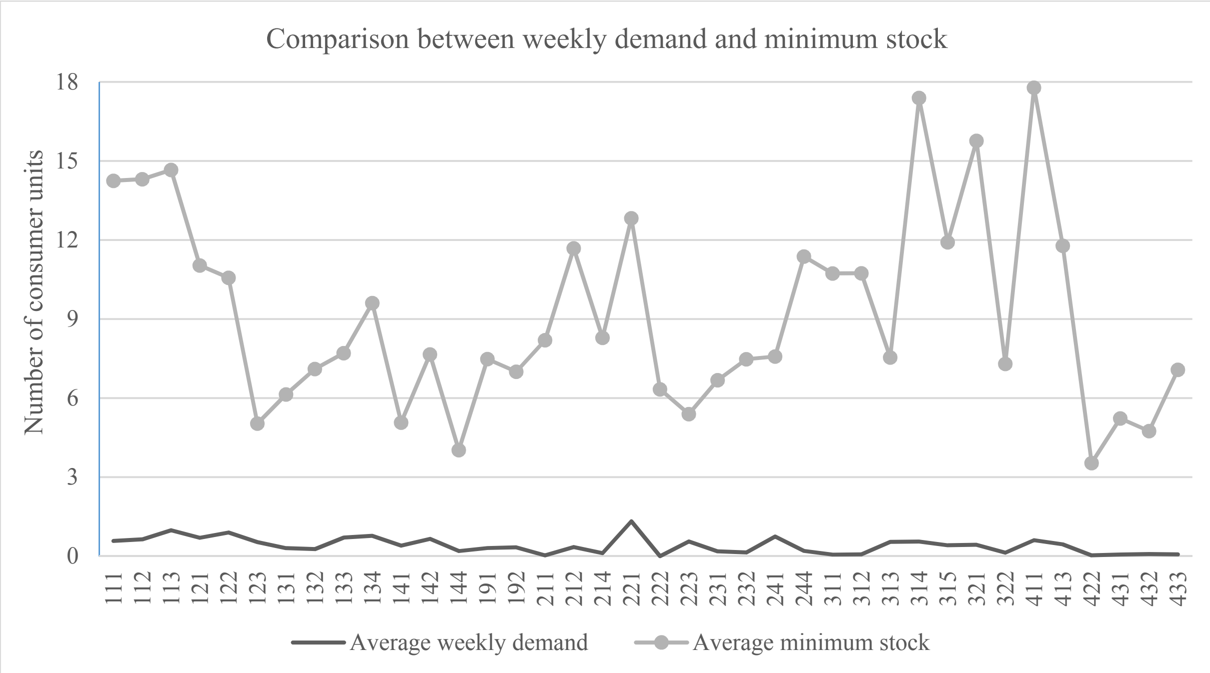

Figure 19 – A comparison between average weekly demand per item and store and average minimum stock per subgroup

From interpreting Figure 19 it is not surprising that there is a common view at Hemtex that the minimum stocks are too high and should be lowered consistently. The main reasons why this work is progressing slowly is that there is a feeling that this will result in reduced sales. Still, Hemtex claims that there are evidences suggesting it would be feasible to reduce the minimum stocks with maintained sales. For example, Hemtex reports that store number 3 and store number 4 have lower minimum stocks than what the sales categories would suggest due to limited backroom storage. Despite this, these stores are among the seven best-selling stores in Sweden and there is no significant difference when it comes to stockouts. Figure 20 displays the relationship between average inventory and net sales for a selected number of top-selling stores. As seen in the figure, store 3 and 4 has less average inventory than many stores that has considerably lower net sales.

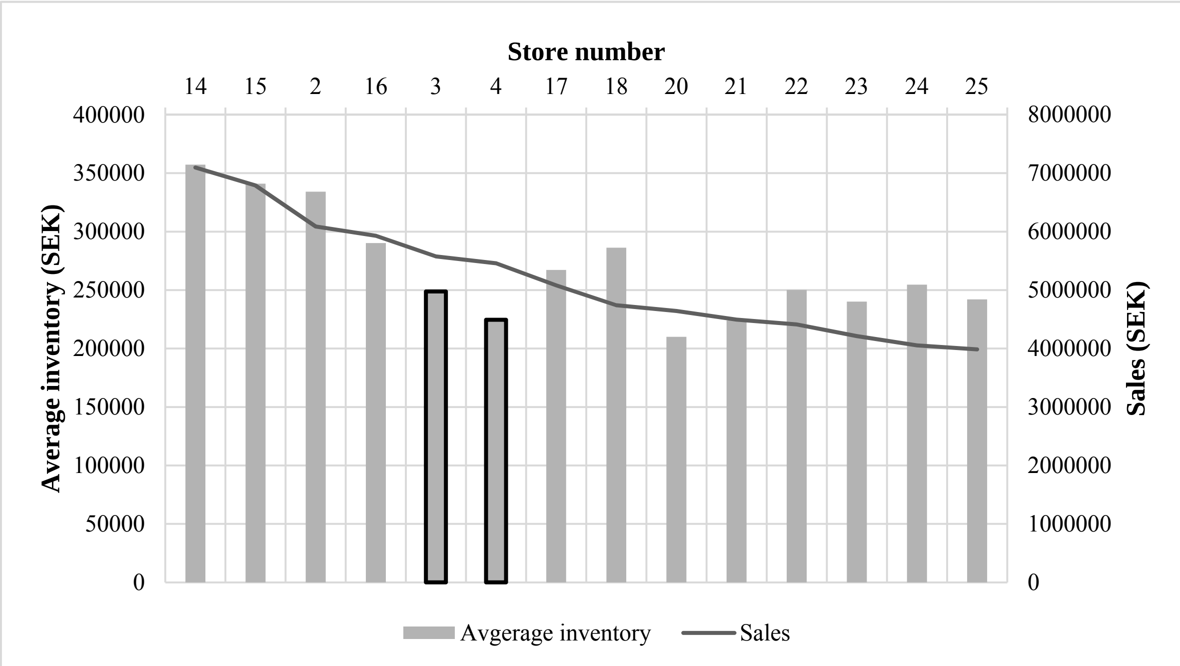

Figure 20 – An illustration of the relationship between average inventory and net sales for a selected amount of top-selling stores - Store number 3 and number 4 are highlighted

According to Hemtex, another identified problem with the current way of determining minimum stocks and allocation of goods to the stores is the store categorisation. This results in continuous supply of excess items to some of to the smallest stores. Simultaneously, it results in continuous supply shortage to some of the largest stores. The reasons are twofold. Firstly, it is because some stores match poorly with the assigned sales categories, which means that they have a higher or lower minimum stock than what would be preferable. This occurs when a store belongs to the lower scale in the lowest sales interval (sales category 1) or vice versa. Secondly, some stores matches poorly with the assortment categories which means that they either receive larger parts of the assortment than needed or that the assortment is not big enough to fill up the largest stores.

For many of the items, the minimum stocks are changed a couple of times a year, which means that there are nothing that can be expressed as ordinary levels. Sometimes the supply chain planners and central visual merchandisers discuss the feasibility of current minimum stocks, although this occurs rather infrequent. Chiefly, it is the responsibility of the supply chain planners to continuously ensure that the minimum stocks are appropriate and are adjusted when needed. Also, store managers sometimes ask the supply chain planners to adjust the minimum stocks in their store. This is normally not questioned by the supply chain planners, which means that they adjust the levels accordingly.

5.3.2 Replenishment planning and lot sizing

During ordinary sales Hemtex uses F&R for the automated store replenishment. The automated store replenishment is based on a re-order point system with periodic review, where the delivery frequency for each store governs the length of the review interval. The re-order point is calculated as the sum of the minimum stock and a forecast of the demand during the distribution lead time, as seen in Equation 10. The average demand during the replenishment lead-time is based on smoothing average for the last twelve weeks. However, in most cases the minimum stock constitutes the major quantity of the re-order point.

$$ROP = MS + (D \times L)$$

Equation 10

Notations for Equation 10:

ROP = Re-order point
MS = Minimum stock
D = Demand
LT = Lead time

Consequently, an order is triggered when the stock on hand plus items in transit falls below the re-order point. The ERP system calculates the order requirement based on current stock on hand, products in transit, sales forecast, the minimum order quantity and the delivery frequency for the store in question, see Equation 11.

$$OR = MS + (D \times L) - SH - IT$$

Equation 11

Notations for Equation 11:

OR = Order requirement
MS = Minimum stock
D = Demand
LT = Lead time
SH = Stock on hand
IT = Items in transit

To illustrate the order requirement calculation more in detail, an example of how lot sizes are calculated is provided in

Table 7 below. The calculation in the table is built on the same components as in Equation 11.

Table 7 – A calculation example of Hemtex's current re-order point and lot-sizing system

Stock on hand (SH)	5
Items in transit (IT)	2
Forecasted demand per day	0.85
Lead in time in days	2
Minimum stock (MS)	6
Minimum stock + demand during lead time (MS + DDLT)	6 + 2 × 0.85 = 7.7
Order requirement = (MS + DDLT) - (SH + IT)	7.7 - (5 + 2) = 0.7 > 0 => an order is generated

In the calculation example in

Table 7 above, the order requirement would be 0.7 consumer units. However, the order quantity must be in multiples of case-packs. This means that a store is replenished with a whole case-pack even if the requirement is less than one consumer unit. This may result in large deviations if the item requirement is small and the case-pack size is large. There is no minimum trigger point in terms of a multiple or number of consumer units needed for an order to be triggered. The case-pack size and the lack of a minimum trigger point cause the stores to always receive higher quantities than the calculated requirements.

Hemtex does not take any consideration to what is most economically feasible when determining the order quantity. In other words, the ERP system does not provide any optimal cost reasoning when calculating the order quantities. One reason for this is that Hemtex lacks an inventory carrying factor to follow up the capital tied up in inventory. However, the Group Controller mentions components of the ordering cost. For example, the weighted cost of capital (WACC) is 9 percent. Also, the obsolescence sums up to 1.1 percent of the annual cost of goods sold.

The requirements of all items in a store are summed and sent as a store order for picking at the DC. This procedure is repeated each weekday at 6 AM, given that the store has daily deliveries. The stores are offered to receive deliveries every weekday. Regarding the delivery frequency, the store managers are able to decide themselves which days and what time of the day they prefer deliveries. Most of the stores have deliveries every weekday between 9 and 10 AM. Hemtex has ERP support for two ways to hedge against the absence of weekend deliveries. The first method is to aggregate demand and deliver larger order quantities on Thursdays and Fridays and the other one smoothens out demand, which means that the order quantities are more evenly spread on all delivery days of the week.

Hemtex deviates from the automated store replenishment in a few situations. Prior to larger promotions or holidays such as Christmas, additional quantities need to be allocated. Since Hemtex automated replenishment forecasting ignores deviations and does not take promotions into account, it must be handled by manual intervention. Hemtex has two ways of accomplishing this. The first method, described in section 5.3.1, is by increasing the minimum inventory levels, thereby generating larger order quantities. The second way to allocate larger quantities is to do it manually, i.e. by generating a manual push order. Occasionally these push orders are initiated by store personnel when they believe that shortages may occur.

5.4 Inventory turnover rate

As described in section 2.4, the inventory turnover rate expresses the number of times, on average, that the value of inventory is consumed during a period of time. This was illustrated in Equation 1.

$$Inventory\ turnover\ rate = \frac{Cost\ of\ goods\ sold}{Average\ inventory}$$

Equation 1

Hemtex follows up the inventory turnover rate as one of the most important logistical performance measurements. For instance, according to the Group Controller *'it has been a goal for long to increase the inventory turnover'*. The inventory turnover is followed up in each store as well for the company in total. Hemtex measures the inventory turnover differently from a business controlling perspective and from a logistics perspective. Whereas business controlling measures inventory turnover by considering the sales price, the logistics department focuses on the unit cost. As this thesis focuses on how to better manage the inventory from a cost and service perspective the latter variant is used in this case.

When it comes to the inventory turnover on a store level, Hemtex puts the cost of goods sold during the last 52 weeks in relation to the average inventory. The basis for both the denominator and the numerator is the unit cost in the store as Hemtex follows the cost of an item throughout the supply chain. Consequently, in comparison with the unit cost at the DC, the unit cost increases by the value of the refinement once the item are put on the store shelf. In this context, the refinement concerns the cost of warehouse handling, distribution and in-store handling. Calculating the average inventory in each store is done by considering the average ending inventory during the last 52 weeks. The in-store inventory turnover is aggregated and expressed as an average for each sales region. Table 8 shows what the average inventory turnover rate was in each region during 2014 as well as the total average inventory turnover rate.

Table 8 – Inventory turnover rate during 2014 expressed per region

Region	Inventory turnover rate
North	3,96
Mid	4,27
Stockholm	5,58
West	4,51
South	4,22
Average	**4,51**

5.5 Benchmarking

A benchmarking is conducted in order to achieve a more holistic understanding of relevant logistical aspects in the industry, with a prime focus on how retailers manages inventory in the distribution channel. Three companies are benchmarked against Hemtex and for confidentiality reasons they are named company X, company Y and company Z.

5.5.1 Company X

Company X is a fashion retailer with approximately 480 stores operating mainly in Europe. Among all these stores, 210 are located in Sweden. Apart from the physical stores, company X also has an online channel for customers in the European Union as well as Norway. The assortment consists of women's fashion, lingerie and kids wear.

Purchasers are planning incoming quantities on SKU level, i.e. how many of each colour and size that are going to be purchased. The purchasing quantities for new items are based, to a large extent, on experience, whereas the quantities for rebuys are generally based on historic data. The purchasers are also responsible for determining what quantity of a certain item each store should have. For the products with the shortest life-cycles, a case-pack optimisation is done for every order. This optimisation generates four different case-pack sizes, where each case-pack contains different quantities as well as a range of different sizes, e.g. two small, three medium, one large and so on. In addition, every order is also made up of a quantity that is destined for replenishment, and this quantity is purchased piecewise. Generally, 70 percent of the purchased quantity is pushed out to the stores, whilst the remaining 30 percent is left at the distribution centre for replenishment purposes. The percentage fragmentation is based on store display quantities as well as in-store turnover rate.

The more slow-moving part of the assortment is bought solely for replenishment purposes. This regular store replenishment is managed by a system that is more or less fully automatic. The replenishment system controls all the stores from a central level, but occasionally the supply chain planners need to initiate a manual push, which is usually based on previous experience of sales patterns. In general, the replenishment quantity is based on past sales, i.e. sell one, and get one. The in-store inventory levels are called demo-stocks and are based on a qualitative assessment of what minimum quantity should be displayed in order to generate sales. This is done for each individual item. Also, the inventory turnover is a determinant when deciding these demo-stocks. Company X has an overall inventory turnover goal and plans according to this.

To cope with the complex planning environment company X relies on forecasting to handle fluctuations during "normal" sales periods. Historic sales data are used to plan for seasonal variations such as summer and Christmas. Also, various promotions are offered to the customers and these are planned in close collaboration between the logistics and purchasing department.

The distribution centre serving the Swedish, as well as the Norwegian and Finnish market, is located in Partille and owned by company X itself. In addition, there is a separate distribution centre handling the products transported on hangers, which constitutes around one percent of sold goods. This operation is outsourced to a 3PL. All stores are centrally controlled and replenished on a daily basis, but there are no deliveries during weekends. However, the country manager states that '*if there were any transport providers that offered weekend deliveries, which there are not, we would have had that'*. The lead time is one day except from north of Östersund, where it is two days. Regarding the distribution, company X states that Norway is the most challenging country, and the lead time to the north of Norway is 5 days.

5.5.2 Company Y

Company Y is a sports equipment retailer with 150 stores located all over Sweden. The ownership structure is quite complex, where the many of the stores are independent companies, which in turn own shares in the parent company. However, company Y has directly operated stores in the largest cities. Similar to company X, company Y also has an online channel. The assortment primarily focuses on sports apparel and outdoor equipment.

Company Y's replenishment system is intended to be based on EOQ principles on item/store level. However, the Supply Chain Manager states that '*EOQ often generate high order quantities why we usually deviate from this quantity'*. EOQ is therefore mostly used for low-value items like underwear and socks. The costs that are incorporated in the EOQ are handling cost at the DC, delivery cost and in-store handling costs.

Contrasting the above, the order quantity is normally based on forecasting by estimating the demand during two order cycles. The replenishment system is centred around material requirements planning reasoning, which is a backward-scheduling system. The idea of the system is to project what quantity is required and when. In this case, the projection is based on the past six to eight weeks' consumption, and the forecasted quantities are expressed on item level. The case-pack size also has implications for the order quantity but in order to limit this constraint, company Y has set a minimum quantity in order to trigger a replenishment order, which is half the case-pack size. The case-pack size of a certain item is based on the value of the item and handling costs, where the objective is to minimise the handling costs at the distribution centre as well as in the stores.

To determine inventory levels in the stores company Y works both with safety stocks and store display quantities. The former is based on a forecast that expresses the probable sales volume during the replenishment lead time. However, the safety stock is subordinated the store display quantity, which means that once a store display quantity is set the safety stock cease to apply unless the safety stock exceeds the store display quantity. The store display quantity is based on a qualitative assessment of what is likely to generate most sales. The display quantity is set by each individual store and is not controlled from a central level. The supply chain department sets a maximum display quantity that the stores are not allowed to exceed. This way of working is mainly due to the ownership structure previously described.

All stores are followed up on service level and inventory turnover rate, which are the most important logistical performance measures at the company. The service level is measured by analysing the number of stores that has an item available at a given time. Company Y has a total service level goal of 94 percent but does not differentiate it for different products.

Company Y has outsourced its distribution activities to a 3PL who is responsible for warehousing and transportation. The lead time is two days north of Sundsvall and to Visby, otherwise one day. In general, the stores have deliveries 1-3 times per week and it is up to each individual store to decide on what day a delivery shall arrive. Company Y does not have any deliveries during the weekends. The delivery days are fixed and cannot be changed from week to week.

5.5.3 Company Z

Company Z is a fashion retailer solely focusing on clothes for women. The company has a total of 180 stores in the Nordic countries as well as in Germany, and around 90 of these are located in Sweden. Just as the above-mentioned companies, company Z is also offering the opportunity to buy clothes online. The assortment is mainly centred around fast fashion products, i.e. products with extremely short life cycles. The firm is strongly influenced by its focus on short lead times and high turnover rate. Currently, company Z has a total turnover rate of approximately 8 times a year.

The main part of the assortment is items with very short life cycles, i.e. 4, 8 or 12 weeks. For items with a four week life cycle, the purchased quantity is delivered to the stores without any storing at the distribution centre. However, for items with a life cycle of 8 or 12 weeks a replenishment quantity is sometimes kept at the distribution centre. For the majority of the assortment, the replenishment is based on a pure push strategy and a dedicated replenishment department is responsible for handling this system.

Regarding the basic assortment, which consists of around 40 items, an automatic re-order point system is used. As the system is incapable of handling any major fluctuations in demand manual adjustments are done in order to cope with these variations. It should also be mentioned that basic items are going to all stores, whereas seasonal items are allocated based on the stores' performance in terms of sales. The store display quantities have no connection to what is optimal in terms of costs, but is instead solely based on visual merchandising reasoning about what quantity that generates most sales. Moreover, it has to be taken into account that, for example, a certain piece of underwear needs to have a store display quantity of at least 3 pieces, and in a range of different colours, since company Z often has promotions like ‘3 for 2’, especially for underwear and similar products.

The order quantity is based on an item’s sales potential during the coming 4-12 weeks. In addition, the order quantity must be in multiples of the case-pack quantity. The case-pack size depends on the size of the item (XS-XL) and are determined by considering what is most optimal for the smallest stores (in terms of turnover). For example, if it is optimal for the smallest stores to have case-packs with one consumer unit for a XS item and three consumer units for S-L items, these will be the quantities replenished to the largest stores as well.

When it comes to price reductions and promotions, a basic item is only, in general, on promotion if the purpose is to phase out the item in question. However, the items with the shortest life-cycles are marked down on a weekly basis (only a few items at a time). Company Z does not wish to be seen as a “discount-store”, so it usually sticks to having bigger discounts during the normal sales periods, which is one week during spring and one week during autumn.

Similar to company X, company Z also has its own distribution centre and is outsourcing the transportation activities to a forwarder. The lead time is one day within the Nordic countries, except for the north of Sweden, which has a lead time of two days. Since a part of company Z’s business idea is to have news every weekday, all the stores need to have daily deliveries from Monday to Friday.

6 ANALYSIS

The analysis chapter is structured according to the analytical framework that was developed by combining theory from the frame of reference. The first part assesses retail distribution by focusing on the balance between cost and service, while the remainder of the chapter analyses how minimum stocks and lot sizing can increase the in-store inventory turnover rate.

6.1 Balancing cost and service in retail distribution

Although there are differences between all the retail companies in the study, they are naturally facing many similar problems when it comes to logistics management. A lot of the problems are related to the ambition of balancing cost and service as illustrated in the logistics mix.

The location and the number of storage facilities is an important component in the logistics mix that has implications for the service the retailer is able to offer. The benchmarking shows that all companies in the study believe that it is sufficient to have one central distribution centre to serve the Swedish market. Company X may very well have two distribution centres but the second one is only to be able to handle products transported on hangers. It is interesting to note that Hemtex and company Y has outsourced the warehouse operations to a 3PL, whereas company X and company Z own the warehouses themselves. Operating the warehouse themselves means that company X and company Z can be more flexible when it comes to handling replenishment orders, sequencing deliveries and reacting to volatile customer demands. As noted in section 2.2, these are the key issues of this logistics component. Operating the warehouse in-house naturally brings a lot of fixed costs, which can be troublesome in times of declining customer demands. Only having one central DC, located at the same latitude, means that all of the companies have similar lead times to their stores, i.e. one day within the south parts of Sweden and two days to the north parts.

All companies in the study have outsourced the outbound transportation to different forwarders. They all have limited possibilities of managing this logistics component when it comes to resource utilisation, mode of transport, points for transhipment etc. This is certainly the case for Hemtex that negotiates the contract with its forwarder through the 3PL. It is not possible to control the service level to the same extent when the transport assignments are outsourced through another service provider.

Gattorna et al. (1991) mention the delivery frequency as another important consideration for managing the transportation component. The delivery frequency to the stores differ somewhat between the companies but the general pattern is to have frequent deliveries. Since the delivery frequency governs the periodicity of store replenishment in the industry it is an important aspect to manage. It is noteworthy that Hemtex and company Y let the stores determine the delivery days themselves. In the case of company Y, it is however understandable considering the ownership structure where the stores own shares in the parent company. Company X and Z have delivery every weekday. It is costly to have deliveries that frequent but judging from the trend in the industry it is worth to take that cost to be able to offer the corresponding service. According to the companies, the ambition of having a high delivery frequency has primarily to do with volatile demand that makes it hard to predict future requirements. As mentioned in section 5.5.1, company X would even prefer to have weekend deliveries if it was possible.

All the companies in the study have rather automatic systems for replenishing NOOS articles. This means that all companies frequently gather POS data about for instance stock on hand, sales and other types of movements. As a consequence, it is sufficient to say that all the companies are concerned with managing the communication component in the logistics mix. It is noticeable that the industry relies on manual adjustments when it comes to determining the minimum stocks. The companies are not gathering any data to establish the relationship between inventory and sales but primarily rely on qualitative assessment and experience when making choices on minimum stocks. These quantities have major implications for the costs and service level in the distribution channel. This is confirmed by Gattorna et al. (1991) who emphasise the importance of the inventory component as it directly affects the ability to offer a certain level of service to the customers. As noted in section 2.7.3 there is however strong evidence for the positive relationship between retail stock and sales. Therefore it is difficult to completely disregard the need for qualitative elements in the determination of in-store inventory levels, more about this in section 6.2.

The industry is strongly influenced by the stock-sales relationship when managing inventory in the logistics chain. This is the main determinant for setting minimum stocks in all the four companies. The motives for determining suitable inventory levels differ somewhat between the companies. Whereas Hemtex sets appropriate levels solely from what looks appealing to the customers, company X and company Z puts a lot of emphasis on the inventory turnover rate when making the decision. Keeping the store inventory to a minimum is obviously the primary objective for these companies. Company Y on the other hand, both bases the inventory levels on safety stock calculation and qualitative assessment, as mentioned in section 5.5.

The lot sizing methods used also differ somewhat between the companies. For instance, company Y partly bases the order quantities on EOQ principles, even though they usually deviate from these quantities. This is described more thoroughly in section 6.3.3. On the other end, there is company X that has more of a one piece flow in the form of sell one, get one. What is common for the lot sizing methods in the companies though, is that they all are based on some kind of forecast.

The reason why it is only company X that accomplishes more of a pull based replenishment systems that the industry in general is limited by case-pack sizes for its store replenishment. This ties to the next component in the logistics mix, namely unitisation and packaging. As understood by the companies, this is a critical component since the case-pack size has major implications for the order quantity. Fernie and Sparks (2014) emphasise that the type of packages is a big driver of logistics cost. Determining the size of a case-pack is normally a trade-off between handling costs in the logistics chain and flexibility, i.e. being able to replenish quantities that match the actual customer demand. As the literature refer to all kind of handling costs, including handling costs in the stores, the companies primarily consider handling costs at the warehouse when making adjustments to the case-pack sizes. As mentioned in section 2.8.5, 75 percent of the material handling in a retail supply chain occurs in the store why the opposite ought to hold true. For instance, none of the companies mention the backroom logistics effect as an important determinant, which is strongly emphasised by researched theory. Company Z dimension the case-packs by considering the sales in the smallest stores. In this way company Z is able to diminish the replenishment deviations from the actual customer demand as the product requirements are bound to deviate most from the case-pack size in these stores.

Table 9 summarises how the studied retail companies manage the components in the logistics mix, and in the extension how they balance the cost and service requirements in the distribution channel.

Table 9 – A summary of how the studied companies manage the components in the logistics mix

Component	Factor	Hemtex	Company X	Company Y	Company Z
Storage	# of warehouses	1	1 (2)	1	1
	Type of contract	3PL	Ownership	3PL	Ownership
Inventory	Minimum stock determination	Qualitative assessment	Qualitative assessment & inventory turnover	Qualitative assessment & safety stock calculation	Qualitative assessment
	Lot sizing method	Forecast	Kanban & forecast	EOQ & forecast	Forecast
Transportation	Type of contract	Forwarder	Forwarder	3PL	Forwarder
	Delivery frequency	3-5 days	5 days	1-3 days	5 days
	Lead time	1-2 days	1-2 days	1-2 days	1-2 days
Unitisation and packaging	Case-pack determination	Item value & product hierarchy	One-piece flow	Item value & handling cost	Handling cost, turnover (smallest stores) & item size
Communication	Type of order system	Automatic	Automatic	Automatic	Automatic

As noted in the table, the retailers have rather similar approaches to balance the cost and service requirements in the distribution channel. For instance, the retailers put a lot of emphasis on high delivery frequency and short lead times to ensure a high service level. All the retailers use qualitative assessment as the main method for determining minimum stock and are thus strongly driven by the inventory-sales relationship. This means that there is generally a strong focus on service when determining suitable levels. However, the majority of the retailers seem to advocate taking into account some other factor when making the decision, for instance inventory turnover or safety stock calculation. In this way they increase the cost focus when making the decision. Another common characteristic is that all companies rely on forecasting to determine order quantities for store replenishment.

One of the main differences between the companies is how they manage the packaging and unitisation component. The retailers emphasise rather different considerations for determining appropriate case-pack sizes. It is noticed that the majority of them have a strong cost focus when making the decision. According to the retailers this means that they have rather large case-pack sizes for parts of the assortment. The exception is company X that has a one-piece flow for the majority of the NOOS items. This enables company X to better match the order quantities to the actual customer requirement. As mentioned above, little consideration to in-store handling might be a reason that the other companies have concluded on larger case-pack sizes.

As noted in section 2.2 it is also important to recognise that all components are inter-linked why making changes to one component cannot be done without considering the impact on others. It is therefore necessary to have all the factors in mind when making adjustments to the inventory component by analysing how minimum stocks and lot sizing can increase the in-store inventory turnover rate.

6.2 Potential for reducing minimum stocks

Hemtex's way of determining minimum stocks today is made qualitatively and is changed manually in the ERP system. This way of determining minimum stocks is easy for the employees to understand and does not require extensive calculations. As explained in the empirical chapter, there is no consistent way of working regarding the determination of minimum stocks, e.g. the minimum stocks are sometimes set on subgroup level and other times on the item tier. The manual adjustments of minimum inventory levels at Hemtex are very dependent on the expertise and experience of the employees performing the adjustments. As described in section 2.7.2, many different aspects can be considered when manually revising safety stock levels. Manual evaluations of tied-up capital and the possibility of shortages are usually taken into account. This is however not the case at Hemtex. Furthermore, manually revising stock levels is a resource consuming method and it is not possible to continuously follow up quantities and tied up capital for single items. Handling thousands of items this way cannot generate optimal inventory levels for the majority of items concerned.

As stated in the theoretical framework, determination of safety stocks based on a desired service level is the most widely used method. The empirical findings show that Hemtex does not have a safety stock policy defined by service levels and does not measure the actual service level. Still, the assumption is that the service level is high, as there are considerable differences between average minimum stocks and average weekly demand as shown in Figure 19. It is therefore interesting to examine what service levels Hemtex offers its customers. By examining the number of stores that has a certain item in stock at a particular moment, an approximation of the in-store service level is calculated. The procedure is repeated on six occasions with eight weeks intervals to reduce the impact of deviation, as seen in **Fel! Hittar inte referenskälla.**. **Fel! Hittar inte referenskälla.** shows that Hemtex's average in-store service levels are significantly high with 98.76 percent in average. Company Y for example, has a service level target of 94 percent.

Table 10 – A snapshot of Hemtex's in-store service level at eight different weeks during 2014

Week	Service level
10	99.71 %
19	99.83 %
27	99.31 %
35	99.57 %
43	99.57 %
51	94.54 %
Average	98.76 %

As stated in the theoretical review, the prime consideration when managing retail logistics is to balance cost and service requirements. When comparing the companies' ways of determining minimum stock in Table 9, Hemtex is the only one not considering any other measure apart from the qualitative assessment. This indicates that Hemtex has a lesser amount of cost-focus compared to the other companies. Also, the high service levels of Hemtex imply that the company has a large focus on customer demands and leans towards the service side of the scale. This is illustrated in **Fel! Hittar inte referenskälla.**. The consequence of a service focused approach is most likely a costly distribution set-up. As mentioned in section 2.2, logistics cost is a large share of a retailer's total cost, sometimes up to 30 percent. Consequently, there should be a potential for cost savings at Hemtex if it is feasible to reduce the offered service levels. The service level is the main driver of the inventory holding cost that a retailing company has to bear, thereby also affecting the inventory turnover rate. However, it is important not to be too cost-oriented as failing to meet consumer demand results in lost sales.

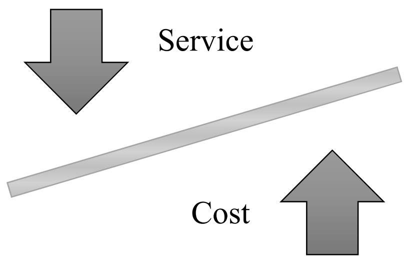

Figure 21 – An illustration of the balance between cost and service, where Hemtex's focus is on the service side of the scale

There are some empirical evidence suggesting that it would be feasible to reduce the in-store inventory levels while maintaining sales, as mentioned in section 5.3.1. This was illustrated in Figure 20, which shows that the stores number 3 and 4 accomplish a high turnover with less average inventory than comparable stores. These examples illustrate that a high level of sales can be kept while reducing the stock levels somewhat and consequently indicates the potential for in-store inventory reduction.

It is not only the balance between cost and service that is of importance when it comes to determination of minimum stocks. It is also a trade-off between the level of detail and the resources consumed. One extreme is to treat all items the same and the other end of the spectrum is to handle each item after its unique characteristics. A compromise of these two extremes is to classify all items into categories and thereafter handle each category individually, as suggested by Axsäter (2006).

By performing an ABC classification, the compromise mentioned above is achieved. In this case a multi-criteria (double) ABC classification is conducted for all NOOS articles. The two criteria that the classification is based on are one volume based and one frequency based criterion as suggested by Rudberg (2007). More precisely, this ABC analysis concerns the gross profit and the number of items sold (sales volume). Each criterion is divided into three categories. The categories A, B and C correspond to the gross profit criterion and the categories 1, 2 and 3 relate to the sales volume criterion. Consequently, the result of the classification is nine categories, as can be seen in **Fel! Hittar inte referenskälla.**. The input data for the ABC classification comprises sales data for all NOOS items sold in corporately owned stores in Sweden during 2014.

According to researched literature, the Pareto principle usually applies when performing an ABC classification and it is also recommended to follow this principle when setting the categories. However, this is not the case for the NOOS items at Hemtex, where instead 20 percent of the items only account for 56 percent of the gross profit. Hadad & Keren (2013) mention another common way of subdividing articles into categories. In this approach, the categories are more variable, where category A usually incorporates 15-20 percent of the articles that make up between 45 to 80 percent of the business value. The division is made in line with this approach and the relationship between the share of items, share of gross profit and share of sales volume for the different categories is illustrated in **Fel! Hittar inte referenskälla.**.

Table 11 - Allocation of articles, gross profit and sales volume between categories from the ABC classification of Hemtex NOOS articles

A1	**A2**	**A3**	**Sum**
Share of articles: 13%	Share of articles: 8%	Share of articles: 2%	23%
Share of gross profit: 43%	Share of gross profit: 15%	Share of gross profit: 4%	62%
Share of sales volume 37.5 %	Share of sales volume: 7.5 %	Share of sales volume: 1%	46%
B1	**B2**	**B3**	**Sum**
Share of articles: 8%	Share of articles: 16%	Share of articles: 11%	35%
Share of gross profit: 6%	Share of gross profit: 12%	Share of gross profit: 8%	26%
Share of sales volume: 13 %	Share of sales volume: 12 %	Share of sales volume: 3.5 %	28.5 %
C1	**C2**	**C3**	**Sum**
Share of articles: 3%	Share of articles: 11%	Share of articles: 26%	40%
Share of gross profit: 1%	Share of gross profit: 3%	Share of gross profit: 6%	10%
Share of sales volume:	Share of sales volume:	Share of sales volume:	20%

0,05	0,08	7%	

Next, suitable service levels for the nine categories are assigned. Category A1, for example, contributes to 43 percent of the gross profit as well as 37 percent of the sales volume. Category A1 is seen as the most important one, and is assigned a service level of 99 percent. The category C3 items, on the other hand, adds up to only six per cent of the annual gross profit and are sold in low numbers, which imply that a lower service level is possible. Therefore the C3 items are assigned a service level of 85 percent. The assigned service levels are based on lowering the service for articles that either contribute less to the profit or have low sales volumes, or of course a combination of both these aspects. Articles not contributing to gross profit nor selling in great numbers are not as important to keep in stock. For a full view of the assigned service levels for each category, see **Fel! Hittar inte referenskälla.** below.

Table 12 – Assigned service levels for each category

Assigned service level per category		
A1: 99 %	A2: 98 %	A3: 95 %
B1: 98 %	B2: 95 %	B3: 95 %
C1: 95 %	C2: 90 %	C3: 85 %

To limit the scope of the analysis it is necessary make a selection of a certain number of stores to include in the study. A thorough classification of the stores is made with the aim to end up with a representative selection of stores. First, the stores are divided into four equally large categories based on the annual sales as the current sales categories are expressed on main group level. The categories are named 1-4, where category 1 consists of the 25 percent top-selling stores and category 4 includes the bottom 25 percent of stores in terms of net sales. Second, aspects as assortment category and geographical aspects as location and size of city are considered in the selection process to achieve a representative sample of stores. Finally, stores that Hemtex considers to have problems with excess or shortage in supply, due to reasons mentioned in section 5.3.1, are also included. The outcome of the store selection is 13 stores geographically spread over Sweden, ranging from large to small in terms of net sales with a factor of six for the smallest compared with largest store. **Fel! Hittar inte referenskälla.** provides a list of different selection criteria, namely net sales category, assortment category and geographical region, as well as a compilation of the selected stores. Approximately, the 13 selected stores represent ten percent of the corporately owned stores in Sweden.

Table 13 – Store included in the minimum stock analysis, including sales and assortment categories as well as geographical location

Store	Net sales category	Assortment category	Geographical region
1	1	C	Stockholm
2	1	C	West
3	1	C	West
4	1	B	Stockholm
5	1	C	Mid
6	2	B	North
7	2	C	West
8	3	A	South
9	3	B	Mid
10	3	B	South
11	4	A	North
12	4	A	Stockholm
13	4	A	West

The second part of the analysis examines how to determine safety stocks for all the NOOS items in the selected stores, calculated by using Equation 4. The input includes data for all NOOS items in terms of average weekly demand during 2014, safety factors based on the assigned service levels, lead times, standard deviation of demand per week and standard deviation of lead time derived from delivery precision data, see **Fel! Hittar inte referenskälla.**. As shown in **Fel! Hittar inte referenskälla.**, the results of the calculations are item specific safety stocks. For a table of the calculated safety stocks for a selected number of articles, see appendix 5.

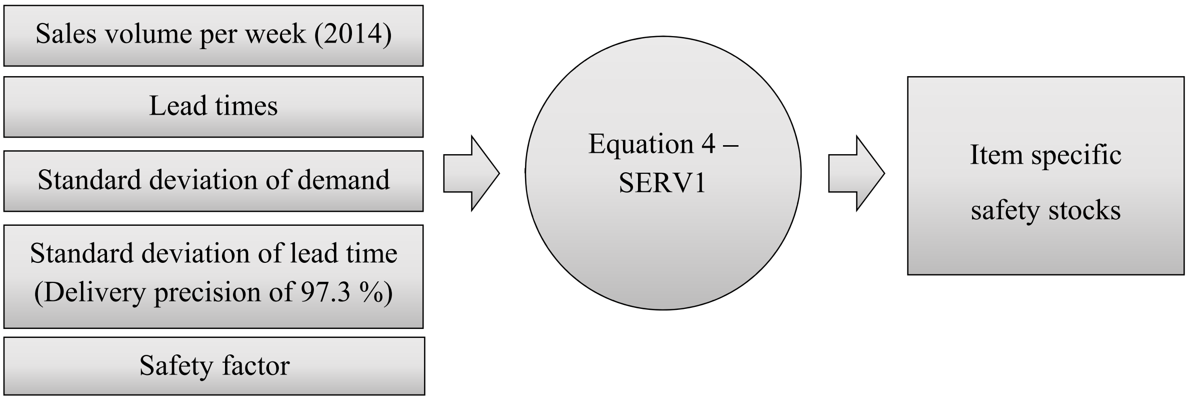

Figure 22 - Illustration of how to calculate item specific safety stocks, including needed input

The calculated in-store safety stocks are lower than Hemtex current minimum stock for all NOOS items. However, the calculated safety stocks are not viable in-store inventory levels, as the demand is inventory-dependent the retail industry. By only displaying the calculated safety stocks, the shelves would probably look empty and the overall store display unappealing to the customers, resulting in lost sales. As described in the theoretical framework, the inventory-sales relationship builds on the assumption that more stock increases the likelihood a product is seen and subsequently sold. This is achieved by introducing a physic stock.

To limit the scope further and to be able study some items in more detail, a selection of articles is also made. The selection of articles is made to attain a spread of items throughout the product hierarchy and achieve a representative sample of different service levels. Regarding the latter, a proportional share of each category in the ABC classification is chosen for the selection, e.g. 13 percent of the NOOS items are in category A1, thereby approximately 13 percent of the items for selection are chosen from category A1. The final selection includes 26 items, representing roughly ten percent of the NOOS items.

For the selected articles the psychic stocks are determined in order to attain more realistic minimum stocks. According to van Donselaar et al. (2007) determining the psychic stock is done by considering requested service level and impact on marketing, primarily taking into account the minimum number of items required to create an appealing shopping experience. The determination of the psychic stock levels for the selected articles is performed in two steps. Firstly, appropriate psychic stocks are estimated for the articles in question by observing typical in-store display options. Secondly, with these estimated psychic stocks in mind, discussions with central visual merchandisers take place to make a final decision on suitable levels. It is then possible to calculate the new minimum stocks using **Fel! Hittar inte referenskälla.**. In general, the suggested minimum stocks are lower than Hemtex’s current minimum stock.

$$Minimum\ stock = Safety\ stock + Psychic\ stock$$

Equation 12

As the minimum stocks are the main contributors to in-store tied up capital, it is interesting to compare the current minimum stocks to the suggested minimum stocks, and the average inventory costs they give rise to. This is done by multiplying the minimum stocks with the unit cost for the selected articles respectively. There is a significant difference in terms of average inventory held, where the suggested minimum stocks imply an overall reduction in average inventory with 28 percent for the selected items in the selected stores. **Fel! Hittar inte referenskälla.** illustrates a compilation of the average inventory for the current and suggested minimum stocks in the 13 studied stores. Noticeably, the lowest reduction is calculated for store number 3 followed by store number 4. As described in section 5.3.1, the sales categories for these stores are downgraded by Hemtex, and consequently these two stores already has lower minimum stocks compared to number 1 and 2, which are equal in terms of net sales.

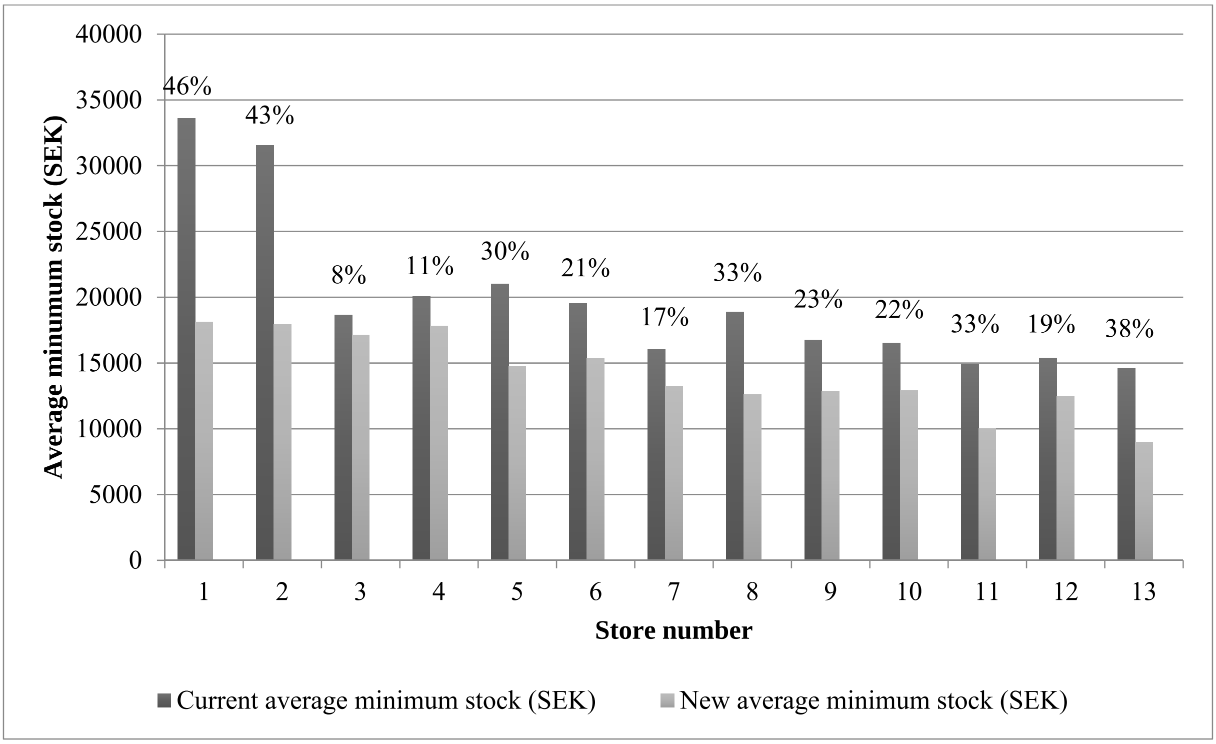

Figure 23 – Comparison of average minimum stock for the current and the suggested stage in the selected stores, where the percentages on top of the bars represent the difference

6.3 Potential for improving lot sizing

The following section focuses on how to improve lot sizing procedures at Hemtex. The current lot sizing method is criticised, the feasibility of using EOQ or Silver Meal in retail store replenishment is assessed and an analysis of the potential for case-pack size reduction is provided.

6.3.1 Problems with the current lot sizing method

Considering the current lot sizing method used in Hemtex's replenishment system, an order from the distribution centre is triggered when the stock on hand (i.e. backroom storage plus store display quantity) plus items in transit falls below the minimum stock plus the forecasted demand during the distribution lead time. However, as mentioned in the empirical chapter the case-pack size will be the ultimate determinant of what the actual order quantity will be. A more pedagogic illustration of the current lot sizing method and the difference between the order requirement and the actual order quantity is presented in **Fel! Hittar inte referenskälla.** below.

Table 14 – An example of the difference between the order requirement and the actual order quantity

Stock on hand	12
Forecasted demand per day	0.53
Lead time in days	2
Minimum stock	11
Minimum stock + demand during lead time	12.06
Order requirement	0.06
Case-pack size	6
Actual order quantity	6

This way of determining the order quantity usually creates a problem, especially when the case-pack size is large in relation to the order requirement. As in the example above, where the case-pack size is hundred times larger than the order requirement, the actual order quantity is almost one case-pack (5.94 consumer units) larger than what is actually needed in order to satisfy the customer need. This will most likely lead to an average inventory that is higher than what could be achieved with a smaller case-pack size and, in turn, also lead to an increased amount of tied up capital in inventory. The reasoning behind this is that the smaller the case-pack size is, the easier it is to match supply with demand, i.e. the order quantity will be more in line with the requirements of the customer.

A conclusion after having analysed these numbers is that a case-pack size of one is often more appropriate. Note that this is without consideration to how a smaller case-pack size is likely to affect, for example, the material handling in the store and tied up capital in inventory. For example, a low-value item that has a large case-pack size might not be suitable to deliver in a case-pack size of one when looking at material handling costs, given that the sales volumes are similar to the current ones. In order to understand whether it is feasible to order in accordance with the current system cost aspects need to be considered. That is why economic order quantities are calculated, where the trade-off between ordering cost and inventory carrying cost is examined.

6.3.2 Defining lot sizing components

To be able to conduct analyses of the economically based lot sizing methods it is first necessary to calculate the included components. As mentioned in the theoretical study, both EOQ and Silver meal are based on finding the optimal balance between the inventory carrying cost and the ordering cost. Also, the inventory carrying factor is used in the analysis of suitable case-pack sizes. Considering that Hemtex does not dimension the order quantities on economical calculations today the components are constructed from scratch.

Inventory carrying factor

The inventory carrying factor is defined as the sum of all costs related to having stock on hand in relation to the average inventory. First, it should be noted that calculated inventory carrying factor only is valid for NOOS articles. Since the seasonal articles have far shorter product life-cycle they are exposed to more risk and should therefore be associated with a higher inventory carrying factor. As stated by Mattson (2003b) in section 2.8.4, it is not uncommon for companies to use different inventory carrying factors for different kind of products.

Identifying all the relevant costs used for the calculation should be done by only considering the ones that are dependent on the inventory levels. When doing so, it is fruitful to divide the costs into capital costs, inventory carrying costs and risk costs. The capital cost is relevant in this case as it expresses the costs of having capital tied up in inventory. In this case Hemtex's weighted average cost of capital (WACC) is used, which is 9 percent as mentioned in the empirical chapter.

According to researched literature, there are few inventory carrying costs that are relevant when conducting the calculations. Insurance cost is one of the few costs that have been emphasised, and is therefore the only inventory carrying cost that is used in this case. Furthermore, obsolescence is the only risk cost included in the calculation. According to the Group controller the obsolescence is 1.1 percent of the cost of goods sold annually.

The inventory carrying factor is calculated using **Fel! Hittar inte referenskälla.** below. The average inventory used in the denominator is the value of the average inventory in all stores during 2014.

$$Inventory\ carrying\ factor = WACC\ (9\ \%) + \frac{Risk\ cost + Inventory\ carrying\ cost}{Average\ inventory} = 15\ \%$$

Equation 13

Ordering cost

As mentioned in section 2.8.4, the ordering cost is the sum of all incremental costs that derive from preparing and processing a purchasing order. In this particular case the order concerns call-off based procurement from Hemtex's DC. Consequently, the costs for request for quotation, supplier negotiations, and selection of suppliers can be disregarded in the calculation. Moreover, as the replenishment system is automatic the administrative personnel costs are irrelevant in this case. Remaining ordering costs that deem to be important are handling costs and transportation costs. This is supported by company Y, which states these costs as the one considered when calculating the ordering cost at the company. Further, company Y takes into account both handling cost at the DC and at the stores. **Fel! Hittar inte referenskälla.** shows the included cost components for calculating the ordering cost and the ordering cost resulting from the calculations. The three different cost components contribute to the ordering cost by roughly one third each. The cost components are described below.

As the calculations of economically optimal order quantities regard each item individually as opposed to the total store order that includes all required items, the above costs are expressed per order line. As was previously elaborated upon, the contract between Hemtex and the 3PL regards a cost model based on volume with no fixed fees. The same goes for the transportation cost between the DC and the stores. As a consequence, the handling cost at the DC and the transportation cost will depend on the procured quantities. This is not generally the case as described in section 2.8.4, but due to the structure of the cost drivers in Hemtex distribution channel this is the basis for the calculations here. The final cost component is the handling costs in the stores. The in-store handling process is described in section 5.2.2 and the determination of handling costs is done by performing interviews with store personnel, making observations in two stores and estimating the time for conducting goods reception activities for an order line.

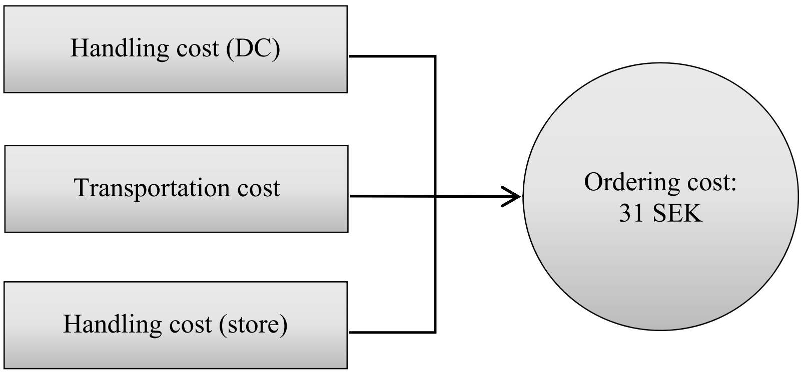

Figure 24 – Illustration of the generated ordering cost and components for calculating it

6.3.3 Feasibility of EOQ in store replenishment

Even though it is widely acknowledged that the economic order quantity model is operating most satisfactorily in an environment where the demand is relatively stable, it is still useful to consider it. As stated by Piasecki (pp 31, 2001), ‘anytime there is repetitive purchasing or planning of an item, economic order quantity should be considered’. In addition, retail inventory management is commonly based on EOQ principles according to researched theory. Also, the benchmarking has shown that company Y uses EOQ as support when determining replenishment order quantities.

It is possible to calculate an EOQ for an item with variable demand in terms of seasonality by looking at a shorter time period. In this particular case, EOQ is used to get an understanding of whether the current lot sizing method generates economically viable order quantities. Also, an EOQ calculation can possibly indicate if it is reasonable to lower the case-pack size.

As described in section 2.8.1, EOQ is based on balancing ordering costs and inventory carrying costs and further includes the demand per time unit and unit cost. The basis for the calculation is the Wilson formula, expressed in Equation 6 below.

$$EOQ = \sqrt{\frac{(2 \times D \times S)}{(I \times C)}}$$

Equation 6

The inventory carrying factor and the ordering cost were calculated in the previous section. The remaining components, i.e. the demand per time unit and the unit cost, are taken from Hemtex's ERP system. As mentioned in the empirical chapter, Hemtex tracks the unit cost throughout the supply chain and the value that is used in the calculations concerns the unit cost on store level. The demand per time unit expresses sales per week in a store and the data are taken from 2014. However, in order to get reasonably smooth demand when calculating the EOQ, the demand during normal sales periods is considered. In this case, demand during Christmas in addition to other demand peaks is excluded from the calculation. As mentioned in section 2.8.1, EOQ is a stable model when it comes to misevaluation of its parameters why this assumes to affect the result marginally.

To limit the scope of the analysis, and for sake of coherence, the calculation is performed for the same 13 stores that were the basis when calculating safety stocks (see **Fel! Hittar inte referenskälla.**). Similarly, the analysis is conducted for the same 26 NOOS items as in the safety stock calculations. Economic order quantities are calculated for each item in each store by considering the demand per time unit, unit cost, ordering cost and inventory carrying factor in accordance with **Fel! Hittar inte referenskälla.** below. The result is item specific economic order quantities.

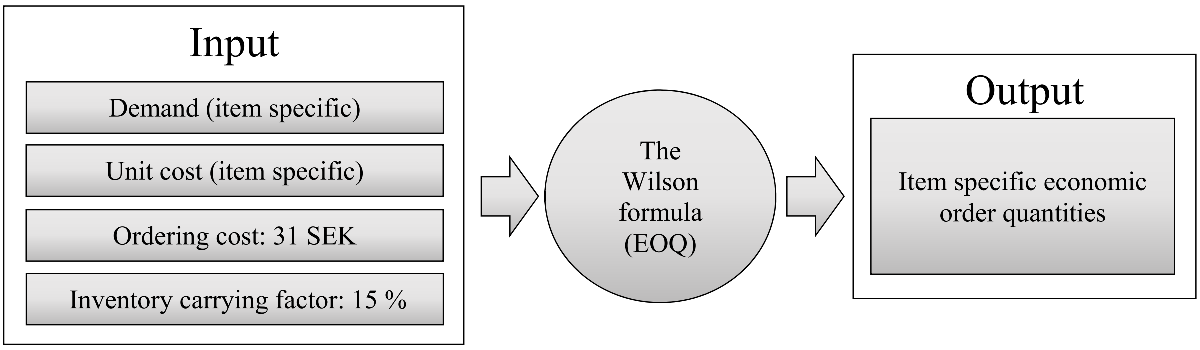

Figure 25 – Illustration of input and output of the Wilson formula

The calculations show that the economic order quantities are considerably larger compared to the present average order quantities for the majority of the items. By calculating the average order quantity (AOQ) delivered to three different stores during 2014 it is possible to highlight the substantial differences. **Fel! Hittar inte referenskälla.** illustrates the difference between AOQ and EOQ for five items in the three stores. These stores and items is enough for representing the outcome, however a more detailed table can be found in appendix 6. Although considerably larger than current order quantities it is important to keep in mind that EOQ constitute the most economically viable order quantities. However, there are several other aspects that have to be taken into account when evaluating the method. These will be elaborated on below.

Table 15 - Comparison between current average order quantity (AOQ) and EOQ for five items in three different stores

	Store 13		Store 2		Store 8	
Item number	**AOQ**	**EOQ**	**AOQ**	**EOQ**	**AOQ**	**EOQ**
1	10	12	10	26	10	10
2	10	22	10	69	10	30
3	100	290	100	519	100	337
4	8	19	8	58	8	41
5	4	5	4	15	4	7

When assessing the feasibility of EOQ as a method for determining order quantities in the retail industry it is also interesting to calculate the economic run-out time. As described in section 2.8.2 the economic runt-out time puts EOQ in relation to the average demand per period. Hence, the method provides a more pedagogical illustration of the feasibility of the calculated order quantities. An example is provided by calculating the economic run-out time for article 1, as seen in Equation 7.

$$ERT = \frac{EOQ}{Average\ demand\ per\ period} = 15.8 \text{ weeks}$$

Equation 7

The economic order quantity covers almost 16 weeks demand. This does not only apply to item 1, but is more or less general for all the 26 studied NOOS items. This gives an indication that EOQ might not be appropriate in this context.

It should also be emphasised that order quantities of this size most likely will cause problems in the stores. One obvious limitation is the physical space in the shelves as well as in the backroom. If all NOOS articles should have been replenished with EOQ principles, the store's inventory capacity would be exceeded, especially in the small stores. Also, a large order quantity means that only a small proportion of the ordered quantity fits on the shelf and the rest has to be kept in the backroom. According to Waller et al. (2008), this will increase the number of exposures to stockouts due to poor replenishment from the backroom. In turn, stockouts can cause lost customers and employee time, which may hamper the productivity and conversion rate in the stores. As earlier shown in Table 6, these are important performance measures for following up the stores.

Another consequence of large order quantities is that in-store personnel will spend too much time on material handling activities. This is particularly evident for small stores with few staff members. As emphasised in section 2.8.5, 75 percent of the material handling in the retail chain occurs in the store, which means that in-store handling costs have to be accounted for in any decision model that aims to improve the store replenishment process.

Even though the Wilson formula generate unsatisfactorily large quantities it can be used as an indication and a reminder of what is economically optimal. For instance, it can be beneficial to order items with low value and high demand according to EOQ principles. Low-value items do not add any substantial amounts of tied-up capital and together with high sales it is reasonable to have larger quantities of these items in the store. Also, as the benchmarking indicates, company Y uses the EOQ model in this way.

To conclude, given that the EOQ calculation is generating the optimal order quantity considering inventory carrying costs and ordering cost, it is always interesting to evaluate the feasibility of the model. Although, in this case it cannot be the optimal lot sizing method since volume is a major cost driver and the retail environment is generally too volatile for the EOQ model to operate satisfactory.

6.3.4 Feasibility of Silver Meal in store replenishment

The use of a dynamic lot sizing method in a retailing environment can have many potential advantages compared to a classical lot sizing method like EOQ. As described by Jonsson and Mattsson (2009), a dynamic lot sizing method is likely to generate more optimal order quantities since both order quantity and order frequency vary between consecutive orders. It is however reasonable to assume that the Silver-meal heuristic will generate similar order quantities to EOQ since it build on the same equilibrium condition, i.e. the one between inventory carrying cost and ordering cost. The calculations are based on the same inventory carrying factor and ordering cost as the ones used in the previous section. Similarly, the weekly demand and unit cost is taken from Hemtex's ERP system as for the EOQ calculations.

As described in section 2.8.3, the Silver Meal heuristic is an iterative method, which is repeated once the number of periods that generates the lowest total cost per period has been identified. Consequently, Silver Meal can be compared to a cycle. This analysis is only conducted for two consecutive cycles because of the large order quantities generated from the method, as will be shown below. **Fel! Hittar inte referenskälla.** illustrates the input and the basis for the calculations as well as the cycle that shows how the procedure is repeated when the lowest total cost per period is found.

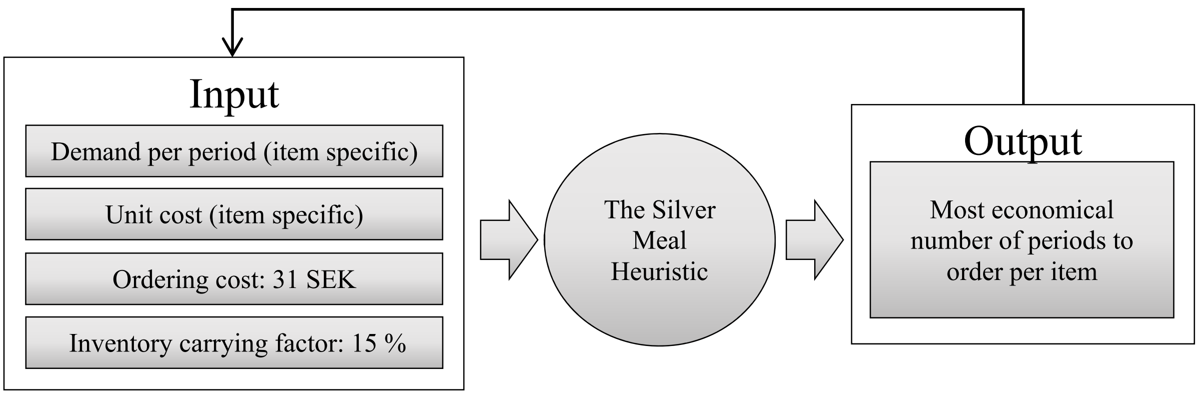

Figure 26 – Illustration of input and output of the Silver Meal heuristic and the cycle showing how the calculations start over once the lowest total cost per period has been identified

By comparing the economic order quantity with the average order quantity generated from the silver-meal heuristic, it is easy to draw the conclusion that order quantities based on the silver-meal heuristic will cause the same problems as those for EOQ. A simple comparison between the order quantities generated by the two lot sizing methods is presented in **Fel!**

Hittar inte referenskälla. below. The table exemplifies the generated order quantities for two items in three stores.

Table 16 – Comparison of order quantities generated by EOQ and Silver Meal methods for two items in three stores

Order quantity with Silver Meal and EOQ			
Item	Store	EOQ	Silver Meal
6	1	17	21
6	13	8	3
8	1	12	12
8	13	3	4
2	1	77	72
2	13	22	8

It is clear that the silver-meal heuristic, in general, is generating similar order quantities as the EOQ calculations. Accordingly, this will lead to the same problems as stated in the previous section. It may not reasonable to base the size of the store replenishment orders on these lot sizing methods for two major reasons. First, the in-store personnel will not have enough time to handle these quantities since only a small portion of the ordered quantity will be displayed whereas the remaining items will be stored in the backroom. As most of the stores have daily deliveries, the quantity going to the backroom could just as well be stored at the DC and then be supplied when needed. Secondly, the economic run-out time for an order quantity generated from the silver-meal heuristic is naturally similar to the one generated from the EOQ, and it is not reasonable to order a quantity that is covering several months of demand.

6.3.5 Feasibility of reducing the case-pack sizes

Even though both EOQ and Silver Meal indicate that it would be economically advantageous to replenish considerably large order quantities it is still interesting to analyse the potential for reducing the case-pack sizes. As illustrated in section 6.3.1, the case-pack size will constitute a constraint no matter what lot sizing method that is applied. This means that it will never be possible to supply the actual order requirements. Also, the case-pack analysis builds on somewhat different cost parameters than EOQ and Silver Meal as will be shown further on.

As previously described, researched literature has highlighted many potential benefits of reducing the case-pack size. The hypothesised winnings by reducing the case-pack size are not surprising as the sheer idea of replenishing larger quantities than needed at a given point in time reveals the improvement potential. However, it is not feasible to reduce the case-pack sizes solely based on the realisation that it will result in lower inventory levels and consequently lower inventory costs. Examined theory mention many other costs that need to be considered when conducting the analysis. Other costs that need to be taken into account are picking costs at the distribution centre, shelving costs at the stores and differences in labour costs caused by the backroom logistics effect as mentioned in section 2.8.5. The literature has also emphasised that smaller case-pack sizes can result in lesser stockouts due to the backroom logistics effect. However, due to the difficulty of measuring the amount of stockouts caused by changes in the case-pack size this was excluded from the analysis.

For the sake of coherence the analysis is conducted for the same NOOS articles as in the safety stock analysis described in section 6.2. For each item, the sales volume, unit cost and case-pack size provides a basis to perform the analysis. Furthermore, the analysis is conducted for all Hemtex's corporately owned stores in Sweden. All data are taken from 2014.

The basis for the analysis is that smaller case-pack sizes will result in less capital tied up in in-store inventory. This is because a smaller case-pack will guarantee a replenishment quantity that better correlates with the store requirement at a given point in time. Another cost advantage with smaller case-packs is the backroom logistics effect. In other words, a smaller case-pack increases the probability that all units can fit on the shelf, which results in fewer replenishment occurrences from the backroom. The cost reduction caused by *less tied-up capital* and *the backroom logistics effect* are put in relation to the *extra time for shelving activities* caused by smaller case-packs. These activities are independent on the case-pack size and will thus be carried out more times with smaller case-packs. Consequently, by comparing these costs for different case-pack sizes it is possible to calculate the new case-pack size, using **Fel! Hittar inte referenskälla.**. The three cost components (highlighted in italics above) are further elaborated below.

$$\Delta Cost = \Delta Shelving\ cost + \Delta Inventory\ carrying\ cost + \Delta Backroom\ replenishment\ cost$$

Equation 14

Researched literature emphasises the potential increase of shelving cost at the store by reducing the case-pack size. Section 5.2.2 explains how observations made it possible to identify the in-store handling activities whose time consumption is independent on the case-pack size: scanning, case-pack breaking and in-store shelving. Subsequently, it is necessary to measure the average amount of time spent on these activities for each case-pack. By conducting interviews with store managers, making time measurements and observing store personnel in two different stores of varying sizes it is possible to estimate the time spent on these activities. The shelving cost per case-pack is calculated according to **Fel! Hittar inte referenskälla.** below and is independent on the case-pack size. As seen in the figure the basis for the result is the time for shelving and the average wage for the store personnel. Comparing the number of shelving occurrences per year enables to compare the shelving cost for different case-packs. Smaller case-pack sizes result in more shelving occurrences and subsequently a higher shelving cost.

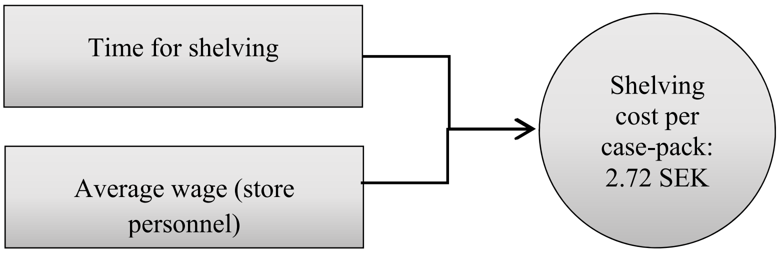

Figure 27 –Illustration of the input data generating the material handling cost for shelving

The truly interesting aspects of the analysis are the potential cost savings. As previously described, the inventory carrying is one potential for cost savings. The calculation is done by using the same inventory carrying factor as in the calculation of EOQ, see **Fel! Hittar inte referenskälla.**. The assumption preceding the calculation is that the order quantity always corresponds to one case-pack (OQ). Calculating the change in inventory carrying cost deriving from the change in case-pack size thus becomes the same as calculating the change in cycle stock. As described in section 2.7.1, the cycle stock varies from zero units to a full order quantity, which means that, in average, the cycle stock is half the amount of an order quantity. However, as described in the same section, this builds on another assumption, i.e. that the inventory depletion is constant. Having these assumptions in mind, the inventory carrying cost for a case-pack is calculated using **Fel! Hittar inte referenskälla.** below.

$$Inventory\ carrying\ cost\ = \frac{OQ}{2} \times Inventory\ carrying\ factor\ \times Unit\ cost\ \times \#\ of\ stores$$

Equation 15

The last cost component in the analysis is the change in replenishment occurrences from the backroom caused by the case-pack size. Thus, the basis for this cost component is that a larger case-pack will increase the probability that all items will not fit on the shelf. As noted in the empirical chapter it is rather frequent that items have to be returned to the backroom. It is necessary to estimate the average time spent on replenishing one case-pack from the backroom and how frequent this occurs. Similar to the shelving cost calculation, conducting interviews with store managers, making time measurements and observing store personnel in the same two stores make it possible to estimate this cost. Subsequently, an average cost per case-pack is calculated in accordance with **Fel! Hittar inte referenskälla.** and relies on the time for backroom replenishment, the frequency of occurrence and the average wage for the store personnel. Larger case-packs will result in more replenishment occurrences and consequently a higher backroom replenishment cost.

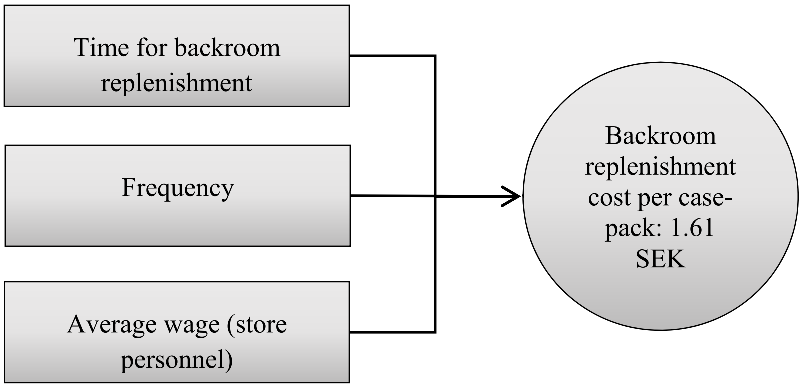

Figure 28 – Illustration of the input data generating the average material handling cost for backroom replenishment

Following this methodology for all selected items makes it possible to conclude the new case-pack size using **Fel! Hittar inte referenskälla.** described before. **Fel! Hittar inte referenskälla.** below shows the result with an illustration of the previous case-pack size, the new one and the difference. The table also shows the sales volume and unit cost for each item. To avoid presenting too much information that makes it difficult to interpret the result, only ten of the selected items are shown in the table. Also, these items illustrate the most interesting aspects of the result. A complete table with all the selected items can be found in appendix 7.

Table 17 - An illustration comparing old case-pack sizes with new case-pack sizes

Item number	Sales volume (# of pieces)	Unit cost (SEK)	Old case-pack size	New case-pack size	Difference
1	3 873	34	10	4	6
6	9 348	111	6	3	3
10	38 506	43	3	11	-8
11	11 382	508	2	2	0
12	3 858	409	4	1	3
13	47 236	66	4	9	-5
18	2 438	74	6	2	4
23	4 759	45	2	4	-2
24	5 555	59	5	3	2
26	2 503	11	12	5	7

As seen in the table the result is somewhat contradictory as it argues to increase the case-pack size for some items and decrease it for others. The contradiction primarily depends on the sales volume and the unit cost. The analysis indicates that it is preferable to increase the case-pack size for items with high sales volume and fairly low unit cost. It shows the opposite for items with high unit cost and low sales volume. Also, the result indicates that it is economically viable to reduce the case-pack size for the majority of the studied items.

As described in researched theory it is important to take all potential costs into consideration when optimising the case-pack size to ensure a cost optimisation in the entire chain. Two costs that are emphasised by the literature when optimising the case-pack size are material handling costs at the DC and packaging costs. These costs are not considered in the initial analysis of the new case-pack size. The reasons are twofold. Firstly, as mentioned in section 5.2.1, the picking cost at the DC is now driven by volume as opposed to the number of case-packs like before. Due to the need of revaluating the contract if Hemtex exceeds a certain level, it is uncertain what will happen with the picking cost in such a scenario. Secondly, Hemtex does not disaggregate the purchasing cost for a product into smaller constituents why calculating the changes in packaging cost is clouded with uncertainty.

Besides the calculated cost benefits of reducing the case-pack size there are other advantages as well. Researched theory stresses the occurrence of deviations from the ASO system caused by store managers. As noted in the empirical chapter this goes for Hemtex as well. According to van Donselaar (2007) et al. one of the most efficient measures for reducing the workload imbalance and deviations from the ASO system is to reduce the case-pack size. Reducing the frequency of manual replenishment orders placed by Hemtex's store personnel will thus enable them to concentrate on sales activities as opposed to spending time trying to outsmart the ASO system. It will also reduce the time that supply chain planners spend on manually adjusting replenishment orders and stock levels.

6.4 Impact on in-store inventory turnover

The purpose of this section is to present what implications the findings of the earlier analyses sections will have on the in-store inventory turnover rate.

As described in the frame of reference, the inventory turnover rate has big implications for a company's cash flow, therefore it is an important measurement. Since it is a relative measure that can be used for comparability, the inventory turnover rate is interesting to study. All of the benchmarking companies emphasise the inventory turnover rate as one of the most important performance measurements for the material planning. Company Z for example, uses inventory turnover rate as the primary steering parameter when it comes to the material planning and store replenishment. Increasing the inventory turnover rate is often superordinate other factors at company Z.

As described in section 5.4, Hemtex has for a long time had the goal to increase the inventory turnover rate. The success of achieving this has however been limited. Zentes et al (2011) state that one way to increase the inventory turnover rate is to reduce the inventory of slow moving items. The aim of the ABC classification is to classify items accordance with their moving pace (sales volume) and contribution to gross profit. Articles with low sales volume and low contribution to gross profit are assigned lower service levels aiming to reduce the average inventory, and thus increase the inventory turnover rate. Also, the analysis of the new case-pack size intends to reduce the average inventory. Consequently, the calculated minimum stock (**Fel! Hittar inte referenskälla.**) and the new case-pack sizes (**Fel! Hittar inte referenskälla.**) provide an input to the calculations of the new in-store inventory turnover rate.

The calculations are based on the selected stores and articles, described in section 6.2. According to Muller (2011) there are different methods of valuing the cost of inventory, where the specific cost method allows for calculations based on the actual cost of an item at the point of consumption. As Hemtex uses this method of calculating in-store inventory turnover rate and data for the actual cost of items is available in the ERP system, this method is applied for the calculations.

The inventory turnover calculations are based on putting the calculated minimum stock and new case-pack sizes in relation to the current ones. Also, the calculations build upon the assumption that the cost of goods sold (COGS) will be unchanged when comparing the new inventory rate with the current. This is likely the case as the calculated minimum stock will not have any implications on COGS, and the impact on COGS caused by the change in case-pack size is assumed to be negligible.

As expressed in Equation 5, total inventory consist of psychic stock (PS) plus safety stock (SS) and cycle stock (CS). By combining Equation 1 and Equation 5, **Fel! Hittar inte referenskälla.** is obtained. This implies that potential changes in inventory turnover rate will derive from changes in the minimum stock, i.e. psychic stock plus safety stock, or the cycle stock.

$$Inventory\ turnover = \frac{Cost\ of\ goods\ sold}{Average\ (PS + SS + CS)}$$

Equation 16

The next step is to calculate the change in cycle stock deriving from the change in case-pack size. To make the calculations more manageable it is assumed that the order quantity is one case-pack and consequently the cycle stock corresponds to half a case-pack. This leads to an expression of change in cycle stock, shown in **Fel! Hittar inte referenskälla.**.

$$Change\ in\ CS = \left(\frac{Current\ casepack\ size}{2} - \frac{New\ casepack\ size}{2}\right) * Unit\ cost$$

Equation 17

By combining **Fel! Hittar inte referenskälla.** and **Fel! Hittar inte referenskälla.** it is possible to calculate the new inventory turnover rate for the selected stores in accordance with **Fel! Hittar inte referenskälla.**. Thus, the input data for making the calculations are COGS, in-store average inventory, unit cost, change in minimum stock, the current case-pack size and the new case-pack size.

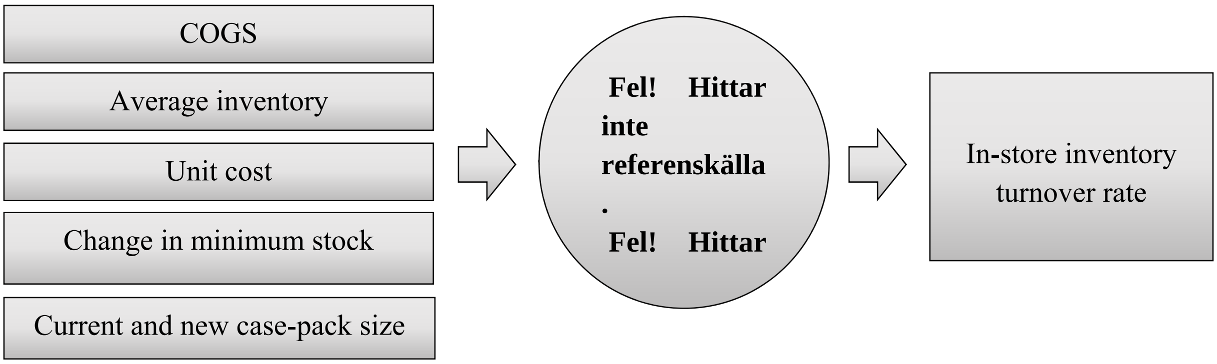

Figure 29 - An illustration of the input and equation used for calculating the inventory turnover rate

Following this procedure makes it possible to calculate the new inventory turnover for all the selected stores. The current inventory turnover rate, the new inventory turnover rate and the increase in percentage for the 13 selected stores are shown in **Fel! Hittar inte referenskälla.** below. The table shows that the average increase in in-store inventory turnover rate sums up to roughly three percent.

Table 18 – A comparison between the current and new in-store inventory turnover rate in the 13 selected stores

Store	Current inventory turnover rate	New inventory turnover rate	Increase
1	7.69	8.08	5.12 %
2	6.28	6.56	4.55 %
3	7.67	7.75	0.99 %
4	8.50	8.63	1.43 %
5	5.83	6.03	3.41 %
6	4.00	4.09	2.26 %
7	3.86	3.93	1.86 %
8	4.05	4.21	3.92 %
9	3.64	3.73	2.62 %
10	3.12	3.19	2.40 %
11	2.58	2.68	4.00 %
12	3.20	3.28	2.44 %
13	1.97	2.06	4.65 %
Average	**4.80**	**4.94**	**3.05 %**

It is important to note that the increase in in-store inventory turnover rate only expresses the 26 selected articles' contribution to the overall inventory turnover rate for all NOOS articles. As seen in **Fel! Hittar inte referenskälla.**, the increase in inventory turnover rate spans from approximately 1 percent to 5 percent amongst the different stores, with an average increase of 3 percent.

6.5 Summarising the analytical findings

This is a rough summary of the analysis chapter and its different parts. For more specific information the reader is referred to each individual part.

The starting point for the analysis chapter was to examine how retailers balance the cost and service requirements in the distribution channel. Basing the analysis on the logistics mix and the conducted benchmarking it was shown that retailers have rather similar approaches to achieving an appropriate cost/service balance. Primarily, all retailers emphasise the importance of high delivery frequency and short lead times in order to offer a high service. The main difference lies in the amount of cost focus the retailers have when determining minimum stocks and case-pack sizes.

Analysing the feasibility of current minimum stocks, and the potential for lowering them, showed that Hemtex offers very high service levels in the stores. This illustrated the potential for lowering the service level and subsequently the current minimum stocks. By doing a multi-criteria ABC classification based on gross profit and sales volume a structured way of reducing the service levels was accomplished. Service levels were assigned to the nine different categories prior to calculating new safety stocks using SERV 1 (see Equation 4) in 13 selected stores. Due to the demand stimulating function of inventory in the retail industry, a psychic stock was added on top of the calculated safety stocks for a selection of items in accordance with researched theory. The result showed a consistent inventory reduction for the selected items in the focal stores, ranging from 8 to 46 percent.

The next part of the analysis focused on how to improve the lot sizing procedures used at Hemtex. It was established that the problems with the current lot sizes chiefly are related to the case-pack constraint, i.e. that the order quantity always has to be in multiples of a case-pack. This motivated an analysis of the case-pack sizes. However, first it was necessary to assess whether the current order quantities are economically feasible by calculating economic order quantities. After having retrieved and calculated the included components, economic order quantities were calculated both according to EOQ and Silver Meal principles. Both these lot sizing methods indicated that it is most economically viable to order considerably large order quantities compared to ordinary ones. For instance, calculating the economic run-out time for an item's EOQ indicated that the order covers almost 16 weeks demand.

As mentioned above, the analysis chapter continued by analysing the feasibility of current case-pack sizes. The basis for the analysis was to put inventory carrying cost and backroom replenishment cost in relation to the shelving cost. In other words, smaller case-packs result in lower inventory carrying cost and lower probability that all items will not fit on the store shelf. Conversely, a smaller case-pack will result in more shelving occurrences. By comparing these costs for different case-pack sizes it was possible to conclude the new case-pack size. The result showed a case-pack reduction for the majority of the studied items. However, it also indicated a rather drastic increase for some other items. By analysing the results it became clear that the contradiction primarily depends on the unit cost and sales volume. The analysis pointed towards increasing the case-pack size for items with low value and high sales volume and vice versa.

The final part of the analysis chapter aimed to calculate the impact on in-store inventory turnover from the changes in minimum stocks and case-pack sizes. Consequently, the minimum stocks and case-pack sizes generated in previous sections were put in relation to the current ones to derive at new inventory turnover rates. The calculations were conducted for the same stores and items that were studied in the previous sections. The analysis showed that the overall reduction of minimum stocks and case-pack sizes for the focal items resulted in a consistent increase of the total in-store inventory turnover rate, ranging from 0.99 to 5.12 percent.

7 DISCUSSION

The discussion chapter elaborates and discusses on the findings and results generated in the analysis from a theoretical and practical perspective. Also, the results are criticised by reconsidering the choices made and methods used for reaching the results.

7.1 Minimum stocks: reasoning about the result

During the thesis it has become obvious that retail companies lack data and information about the nature of the stock-sales relationship mentioned in section 2.7.3. Conversely, minimum stock levels are set purely based on qualitative assessment and without basing the decision on any hard facts. Following from this, some kind of qualitative assessment is hard to completely disregard when determining the minimum stocks. This is why it was necessary to add a quantity on top of the calculated safety stocks. However, this quantity only expresses the minimum quantity that is required to create a sufficiently high shopping experience, i.e. the psychic stock, instead of the full minimum stock. This means that the impact of the qualitative assessment is diminished. It might be possible to completely erase the impact of qualitative assessment after the initial assignment of psychic stock. With a continuous revision of the safety stock calculations it would then be possible to avoid the recurring adjustments of the minimum stocks in situations of rising demand.

The safety stock calculations also intended to provide a pedagogical illustration of what it actually takes to cover the random variations in demand. Thus, realising the mathematically “correct” safety stock might cause visual merchandisers to think more cost consciously when determining suitable psychic stocks. Apart from the more cost-focused mind-set, it would also be beneficial if supply chain planners and visual merchandisers were interacting on a more frequent basis to discuss the feasibility of minimum stocks.

As the purpose of the psychic stock is to stimulate demand by creating a good shopping experience, the actual quantity of the psychic stock is naturally dependent on the interior design of the store, e.g. the size of shelves and racks. For example, if the shelf is designed to fit a large quantity, the psychic stock has to be large in order to create a good shopping experience. The opposite holds true for a shelf that fits a relatively small quantity. In other words, a lot can be done with the store layout and interior design when it comes to reducing the in-store inventory levels while still maintaining an attractive store display. Conversely, the store layout may be an obstacle for introducing the suggested minimum stocks as the stores are tied to the existing store fittings. Changing the interior design of the stores may require extensive investments, but there are many techniques for making a store look more appealing, e.g. by making use of ‘bookends’ when stacking products in shelves.

It should be noted that the new minimum stocks might be too low in some instances. This is because the analysis does not consider the possibility of multiple shelving locations in the stores. In contrast, the analysis assumes that the examined items only are displayed at one location in the store. Although this might be true for the small stores it is probably not the case in the largest stores. It is also hard to make an estimation of the share of products that would be exposed in multiple locations as the store display changes on weekly basis. However, it is certain that it does not hold true for all items. As a consequence, the potential for inventory reduction may be somewhat overestimated in these stores.

Some reflection on the ABC analysis is also provided. For instance, it is important to note that the selection of categories was of arbitrary nature, for instance, by adding one more class or change the size of the categories the outcome may have been different. The same goes for determining suitable service levels. As mentioned in section 5.3.1, there are no particular guidelines for selecting the service level, other than the essence of having the customer expectations in mind. As a result, determining the service levels in the thesis was done simply by considering what seemed reasonable for the different classes. Assigning different service levels might have changed the safety stocks quite drastically as it is related to the service factor in equation x. Therefore it is advisable for retailers to continuously revaluate the selection of service levels.

Due to the limited possibility of managing different items in detail it is also possible that some items in the lower classes (e.g. category C3) are important even though they are 'unimportant' both from a gross profit and sales volume perspective. For instance, there might be products that are important to keep in stock as a service even though it contributes little to the gross profit and sales volume. One example might be table napkins that the customers expect to find in the stores. It is however possible to solve this problem by defining segments of the assortment that is important from a qualitative perspective and treat them separately. Within the lower rated categories there are also articles that deem to be unnecessary to keep as they contribute very marginally to the gross profit and sales volume. Consequently, the ABC classification can provide a basis for an overhaul of the NOOS assortment, with the aim of investigating the possibility to reduce the assortment width.

Another interesting aspect related to this thinking is complementary products. The sales of an item can be related to the sales of another item, e.g. the sales relationship between a pillow and a pillowcase. The demand for one of these items is likely to increase when the price of a complementary item is decreased. Even though there is no movement in price the demand of these items can be assumed relate.

7.2 EOQ and Silver Meal: reasoning about the result

As mentioned in previous sections, it is always interesting to consider the EOQ model whenever there is a repetitive purchasing behaviour. The method is also rather insensitive to any potential misevaluations of its parameters because of the flat cost curve. It is generally known that EOQ is operating most satisfactorily in a stable environment with small demand fluctuations, which is generally not the case in the retailing industry. Consequently, when considering the very basic form of EOQ, the theoretical conclusion is that it should not be an appropriate lot sizing method and this was confirmed in the thesis.

The main reason that the order quantity generated by EOQ is not feasible is the increased need of in-store material handling, which may steal focus from the customers. As mentioned in section 5.3.2, the goods are normally arriving at the store between 9 and 10 AM, and since the stores open at 10 AM, there is usually very little time that can be spent on material handling before the first customer arrives. Consequently, the staff members in small stores often have to replenish shelves when the store has opened, which means that the main focus is not on the customer as it should be. This problem would increase with order quantities suggested by EOQ.

Similar problems would occur with order quantities generated by Silver Meal. Even though this was suspected beforehand, as the method is based on the same parameters as EOQ, the characteristics of the model made it interesting to study. For instance, the Silver Meal heuristic is incorporating future demand in a better way than EOQ. Also, as silver meal is considering the demand for each time period, it is likely to be more responsive towards demand changes compared to EOQ. The methodology and thinking that provide the basis for Silver Meal may therefore be suitable for the retail environment even though the calculated order quantities are too large in this case.

One part of the explanation to why these lot sizing methods generate unreasonably large order quantities is that the ordering cost, which has a large impact in the calculations, may be misevaluated. The handling costs at DC and the transportation costs are based on volume and by the number of orders. For example, the cost of transportation is charged per shipping box that may contain different articles packed together. This implies that it is hard to directly relate these costs to an order. As the material handling cost at DC and the transportation cost are volume-based they would have arisen regardless of the number of orders as long as similar quantities are shipped over time, which in turn may suggest that the ordering cost are too highly calculated. With a differently valued ordering cost EOQ and Silver Meal might have generated more viable order quantities.

One aspect that could be interesting to incorporate in the lot sizing method, regardless of lot sizing method used, is a forecast. This will affect the demand parameter of the formula and make the model more flexible, given that the forecast is accurate and able to take promotions and sales peaks into account. Of course this also requires that the lot size is re-calculated continuously.

7.3 Case-pack reduction: reasoning about the result

The analysis of possible case-pack reduction intended to incorporate all the most relevant factors and costs. It is however important to emphasise that there are several other costs that is may be affected by a smaller case-pack size. Reducing the case-pack size will certainly affect the operations at the DC since more case-packs have to be picked and processed given that there is no significant drop in demand. However, the increased cost of the 3PL warehousing activities, which a smaller case-pack results in, will not affect Hemtex's costs due to the nature of the contract. As mentioned in section 5.2.1, the contract is solely based on volume and not on a cost per picked case-pack. In theory, this is a great opportunity for Hemtex that can elaborate with different case-pack sizes without any extra costs for the warehousing process. As long as the agreed-upon volume and number of order lines are not exceeded the case-pack size can be changed without any further implications. However, if this limit is exceeded the contract may need to be revaluated.

Considering that the case-pack size already is set at the supply level it is inevitable to provide some reasoning about the retailer's ability to influence the suppliers. A retailer's ability to change the case-pack size is naturally highly dependent on the retailer's purchasing volumes. It is hard to assess Hemtex's importance as customer in relation to other retail companies. It is however likely that Hemtex's bargaining power might be enhanced by the fact that all purchasing activities are handled in close collaboration with IGS, as described in section 5.2. It is fair to assume that a smaller case-pack size is likely to cause a slightly higher unit price since the supplier has to handle more case-packs in its manufacturing operations, i.e. there might be increased packaging costs. This, in turn, can affect the sales price, but it is fully up to Hemtex to decide if an increased unit price should be transmitted to the customer.

If it turns out to be economically disadvantageous to reduce the case-pack size another possibility is to introduce a minimum trigger quantity, similar to company Y. For instance, by determining that the order requirement should correspond to half a case-pack before the order is released, there should be potential for inventory reduction. Naturally, this is a minor change compared to changing the case-pack sizes. In line of this thinking, it is also interesting to consider whether it is actually necessary to reduce the case-pack size for all items. For example, a low-value item with high demand that can be displayed in large quantities can have a larger case-pack size without causing any substantial amounts of tied up capital or affect the backroom logistics effect. This is because the whole replenishment quantity can be displayed in the store without any storing in the backroom

Another positive aspect of reducing the case-pack size is that manual orders placed by store managers will not cause as big problems as with a large case-pack size. For example, if the store manager manually orders an additional number of consumer units and the case-pack size is large in relation to this requirement, the store will receive large quantity than needed. A smaller case-pack size is likely to limit the errors caused by the store managers. This also relates to misaligned incentives where store managers primarily have responsibility for result. As noted in section 5.1.3, the store costs are divided into affectable and non-affectable, where the latter includes inventory. This means that store managers have limited incentives to lower the inventory levels. In contrast, store managers may sometimes forget the cost aspect of the business, which can make them place manual orders that are not in line with what the system suggests.

7.4 Impact on in-store inventory turnover: reasoning about the result

As seen in **Fel! Hittar inte referenskälla.**, the analyses indicate a consistent increase of the inventory turnover in all studied stores. The percentage increase ranges from 0.99 percent for store number 3 to 5.12 percent for the store number 1. Expressed in absolute number it might sound insignificant to increase the inventory turnover rate from 7.69 to 8.08 (store number 1). However, this only expresses how much the 26 selected articles increase the total in-store inventory turnover. As described in section 6.2, the aim was to achieve a representative sample of articles when selecting the 26 focal ones. As a consequence, the hypothesis is that similar inventory reductions are possible for the rest of the assortment. If it would be possible to achieve similar inventory reductions for all other NOOS articles it might be possible to increase the inventory turnover tenfold from the current result. This is because the 26 selected items roughly constitute ten percent of the total number of items. As a matter of fact, when examining the calculated safety stocks for all NOOS articles in the 13 selected stores it is evident that the safety stocks are consistently low (see appendix 5). However, as noted before, this quantity excludes the psychic stock and cannot be viewed as a realistic minimum stock. The psychic stock has to be determined qualitatively for each item and therefore it is impossible to say for sure what can be done for the entire assortment. Consequently, the results should be interpreted as a tendency of what possibilities there are to achieve inventory turnover enhancement.

As mentioned in section 6.4, the calculation of the new inventory turnover is based on the assumption that the order quantity corresponds to one case-pack. When calculating the change in average inventory deriving from the new case-pack sizes it is then possible to calculate the change in cycle stock. Assumptions like these are always associated with some level of uncertainty and it is hard to foresee how much this affects the result. However, this was a necessary assumption to make the calculations more manageable. Otherwise it would have been necessary to track the actual order quantities during a given period and compare this to predicted new order quantities with the new case-pack sizes. Also, for most of the stores the change in cycle stock constitutes a rather small part of the total change in inventory why this assumption is believed to have limited impact on the result.

7.5 Implications for the balance between cost and service

Understandably, increasing the inventory turnover through reducing inventory levels in the stores enhances the cost focus in the distribution channel. As noted in the background chapter, a large part of the retailer's supply chain cost can be attributed to the distribution channel. For this reason it should be a prime concern for any retailer to increase the focus on cost savings in the downstream part of the supply chain. Furthermore, reducing the in-store inventory levels should be facilitated by the strong emphasis on short lead times and high delivery frequency in the industry. By ensuring this high sense of availability it should then be possible to lower the in-store inventory levels without causing stockouts.

In the end, the retailers' business idea builds on offering attractive products in convenient locations at affordable prices and through high product availability. Ultimately, the retailers' purpose is to maximise the sales potential to the end consumers. As a consequence, increasing the cost focus in the distribution channel cannot be done without considering the impact on the revenue stream. This is especially important when considering that two-thirds of out-of-stocks happens in the store, as noted in the background chapter. With this in mind, it stands without question that a consistent inventory reduction in the stores reduces the service level, which subsequently increases the risk of stockouts. This is the price of increasing the cost focus through enhancing the in-store inventory turnover rate. However, it is very difficult to say exactly what impact the changes will have on sales. This is because the sales-inventory relationship, even though greatly emphasised and established by the literature, is hard to scrutinise. Due to the highly psychological and qualitative nature of assessing the impact that a certain stock level has on sales, it is impossible to say what the new minimum stocks will mean for the revenues. However, it would be interesting to examine the sales-inventory relationship further. Retailers could perform pilot projects on this by experimenting with inventory levels and follow up their impact on sales.

Solely considering Hemtex, the hypothesis is that the new minimum stocks will have marginal effect on potential revenue losses. This is because the current service level is considerably high as shown in section 6.2. Having a service level of 98.76 percent is likely to drive costs more than it drive sales. Also, conducting the ABC analysis ensures that the service level is lowered particularly for those articles that contribute to a small part of Hemtex's gross profit and sales volume. This means that incidental stockouts is likely to happen for these "unimportant" items, which will have little effect on the final result. However, it is important to emphasise that stockouts is bad no matter what items that are attributed to it. It is therefore advisable to continuously measure what impact the new minimum stocks will have on the revenues and on potential stockouts.

As stated above, the lead times are short and the delivery frequency high within the industry and for the case of Hemtex as well. Moreover, this combined with the fact that Hemtex uses the specific cost method when valuing its products imply that it would be better, from an accounting perspective, to keep stock at the DC instead of in the stores as the unit cost increases downstream the chain.

As mentioned in section 2.2 it is important to recognise that all of the components in the logistics mix are inter-linked. Consequently, it is not possible to increase the cost focus in the distribution channel through reducing the in-store inventory levels without ensuring that the other components in the logistics mix are maintained. For instance, when considering that the inventory levels become slightly more vulnerable to stockouts it is necessary to keep a high delivery frequency and ensure that the lead times are held. Thus, making sure that the forwarders are able to keep a high delivery precision is also an important factor. If the warehouse operations are outsourced it is also necessary to maintain a close collaboration between the retailer and the 3PL regarding order prioritisation and sequencing. Ultimately, maintaining the service focus in the other logistics mix components is a key when increasing the cost focus through inventory reduction.

8 CONCLUSIONS

The conclusions aim to conclude the most important findings that were identified during the course of the work and that fulfil the purpose of the thesis. As the intention of the first research question was to map a retailer's supply chain it was answered in the empirical chapter and will not be dealt with here. However, findings that aim to answer the second and third research question are presented below.

The store replenishment framework was developed to ensure appropriate input and structure to the analysis. This model focuses on the retail industry, which is also the intended area of application.

Firstly, the analysis shows that retailers have rather similar ways of balancing cost and service requirements in the distribution channel. The main difference lies in the retailers' amount of cost focus when determining minimum stocks and case-pack sizes.

Secondly, the analysis shows that by disaggregating the minimum stocks into a safety stock part and a psychic stock part it is possible to lower the in-store inventory levels. Thus, it is also confirmed that solely basing the minimum stocks on what is needed to cover random variations in demand during the lead time is not possible in the retail industry. This is because the demand stimulating function of inventory.

Thirdly, it is evident during the thesis that EOQ and Silver meal are not feasible methods to determine the store replenishment orders in the retail industry. Primarily, this is because they generate unreasonably high order quantities that are not possible to physically handle in the stores.

Fourthly, the case-pack size has big implications for the retail store replenishment as it determines the minimum order quantity. The analysis of new case-pack sizes shows that cost benefits can be achieved by lowering the case-pack sizes for items with high value and low sales volume.

Finally, the thesis shows that by reducing the minimum stocks and case-pack sizes it is possible to increase the in-store inventory turnover.

9 FUTURE RESEARCH

The chapter provides possible areas for future research that were identified during the thesis.

The method of determining minimum stock by dividing it into a safety stock and a psychic stock rely on both qualitative and quantitative assessments. Qualitative assessment is always attributed to human factors why analysing whether it is possible and to determine suitable psychic stock levels quantitatively is a recommended area for future research. Inventory stimulates demand and to further examine the relationship between in-store inventory levels and sales is an area of high interest.

Further research should also focus on investigating what implications a smaller case-packs will have in a larger supply chain perspective, especially on the supply side of a retail company as changes in case-pack size may give rise to increasing costs upstream.

Another recommended area for future research is the incitement structure for store personnel, and how to better align the incentives with the objectives of inventory management. It would be interesting to see what effects a proper alignment would have on the in-store inventory levels and the inventory turnover rate.

It would also be interesting to see if similar studies are applicable to other branches of the retail industry, for example the grocery industry, as it should have similar problems to the one studied in the thesis.

10 RECOMMENDATIONS TO THE COMPANY

This chapter presents the recommendations to Hemtex for improving its store replenishment. The recommendations are divided into short-, mid- and long-term.

Short-term

- Start differentiating the NOOS items depending on their importance in terms of the suggested criteria or others, and update the classes continuously
- Experiment with the minimum stocks in a number of stores and try to analyse the nature of the stock-sales relationship
- Investigate the possibility of introducing a minimum trigger point for orders, e.g. half the amount of a case-pack
- Conduct more regular meetings between supply chain planners and central visual merchandisers to discuss the feasibility of the current minimum stocks
- Document and standardise the work descriptions of the supply chain planners, e.g. on how to adjust minimum stocks and decide quantities for push replenishment

Mid-term

- Analyse the possibility of reducing the number of NOOS items
- Investigate ERP system support for calculating safety stocks in accordance with the methods used in this thesis
- Pilot project of reducing the case-pack size for items with high value and low sales volume
- Investigate whether to change the incentive system for store personnel to make them more responsible for costs

Long-term

- Instil a cost focused culture in the organisation where different departments work cooperatively to best manage inventory

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APPENDIX 1 – INTERVIEW LIST

Respondents at Hemtex

- Mona Adawi – Head of CRM
- Ena Beblein – Interim Store Manager, Kungsgatan Göteborg
- Ann Bernlert – Logistics Manager
- Andreas Berntsson – Group Controller
- Johanna Engberg – Store Manager, Borås City
- Matilda Falkheim – Business Controller
- Malin Holm – Central Visual Merchandiser
- Jenny Johansson – Purchase Developer
- Åsa Karlsson – Sales Coordinator
- Pernilla Krantz-Pinori – Business Developer
- Anna Malmer – Product Controller
- Anna Pantzar – Supply Chain Planner

Other respondents

- Country Manager – Company X
- Store Replenisher and Supply Chain Manager – Company Y
- System Owner Logistics and Analytics – Company Z
- Client Manager – 3PL operating the DC

APPENDIX 2 – INTERVIEW GUIDE IN THE BENCHMARKING STUDY

General

Briefly explain your store replenishment system.

What is the lead time from the DC to stores?

What is the delivery frequency to the stores? Does it differ between stores?

Do you have weekend deliveries?

Stores

What does your store categorisation look like?

What parameters did you consider when conducting the categorisation?

How is this categorisation affecting the store replenishment system?

Products

Briefly explain the product hierarchy.

What implications does the product hierarchy have on the store replenishment system? For example regarding safety stocks, order quantities etc.

Do you have any classification of articles/products? If so, what parameters are considered in the classification? For example, gross profit or sales volume.

How is the basic assortment handled from a store replenishment perspective?

Store replenishment in detail

Which material planning method is used? Have you considered any other methods?

Have you done any case-pack optimisation? If so, what parameters were considered when determining the case-pack size?

When does the replenishment system trigger an order?

Do you have any minimum trigger point?

What parameters are determining the order quantity for an article? What determines the minimum possible order quantity for an article?

What is considered when planning a first allocation of a new article?

How do you determine safety/minimum stock for an article in a specific store? What parameters are considered? How is store display affecting the safety stocks?

The complex planning environment

How do you adapt the store replenishment system in relation to the volatile customer demand? For example, do you adjust safety stocks and replenishment quantities manually?

What would you say is the biggest challenge when it comes to store replenishment in this kind of environment?

Key performance indicators

Are you measuring tied-up capital on store level? If so, what numbers are considered?

Are you measuring service level in the stores? If so, how is the service level expressed?

Are you measuring the inventory turnover rate? If so, how is it calculated? Do you measure the inventory turnover rate on lower levels as well, e.g. for each store or part of the assortment?

APPENDIX 3 – THE STANDARD NORMAL DISTRIBUTION TABLE

Normal Distribution Table							
Safety factor	**Service level %**	**Safety factor**	**Service level %**	**Safety factor**	**Service level %**	**Safety factor**	**Service level %**
0,00	50,0	0,72	76,4	1,44	92,5	2,16	98,5
0,02	50,8	0,74	77,0	1,46	92,8	2,18	98,5
0,04	51,6	0,76	77,6	1,48	93,1	2,20	98,6
0,06	52,4	0,78	78,2	1,50	93,3	2,22	98,7
0,08	53,2	0,80	78,8	1,52	93,6	2,24	98,7
0,10	54,0	0,82	79,4	1,54	93,8	2,26	98,8
0,12	54,8	0,84	80,0	1,56	94,1	2,28	98,9
0,14	55,6	0,86	80,5	1,58	94,3	2,30	98,9
0,16	56,4	0,88	81,1	1,60	94,5	2,32	99,0
0,18	57,1	0,90	81,6	1,62	94,7	2,34	99,0
0,20	57,9	0,92	82,1	1,64	94,9	2,36	99,1
0,22	58,7	0,94	82,6	1,66	95,2	2,38	99,1
0,24	59,5	0,96	83,1	1,68	95,4	2,40	99,2
0,26	60,3	0,98	83,6	1,70	95,5	2,42	99,2
0,28	61,0	1,00	84,1	1,72	95,7	2,44	99,3
0,30	61,8	1,02	84,6	1,74	95,9	2,46	99,3
0,32	62,6	1,04	85,1	1,76	96,1	2,48	99,3
0,34	63,3	1,06	85,5	1,78	96,2	2,50	99,4
0,36	64,1	1,08	86,0	1,80	96,4	2,52	99,4
0,38	64,8	1,10	86,4	1,82	96,6	2,54	99,4
0,40	65,5	1,12	86,9	1,84	96,7	2,56	99,5
0,42	66,3	1,14	87,3	1,86	96,9	2,58	99,5
0,44	67,0	1,16	87,7	1,88	97,0	2,60	99,5
0,46	67,7	1,18	88,1	1,90	97,1	2,62	99,6
0,48	68,4	1,20	88,5	1,92	97,3	2,64	99,6
0,50	69,1	1,22	88,9	1,94	97,4	2,66	99,6
0,52	69,8	1,24	89,3	1,96	97,5	2,68	99,6
0,54	70,5	1,26	89,6	1,98	97,6	2,70	99,7
0,56	71,2	1,28	90,0	2,00	97,7	2,72	99,7
0,58	71,9	1,30	90,3	2,02	97,8	2,74	99,7
0,60	72,6	1,32	90,7	2,04	97,9	2,76	99,7
0,62	73,2	1,34	91,0	2,06	98,0	2,78	99,7
0,64	73,9	1,36	91,3	2,08	98,1	2,80	99,7
0,66	74,5	1,38	91,6	2,10	98,2	2,82	99,8
0,68	75,2	1,40	91,9	2,12	98,3	2,84	99,8
0,70	75,8	1,42	92,2	2,14	98,4	2,86	99,8

APPENDIX 4 – COMPONENTS OF THE ORDERING COST

Components of the ordering cost	
Request for quotation	Goods reception
Supplier negotiations	Inspection
Selection of supplier	Put away in stock
Purchase order/order proposal	Delivery reporting
Purchase order processing	Internal transportation
Delivery monitoring	Invoice check
Other supplier contacts	Payment
External transportation	

APPENDIX 5 – CALCULATED SAFETY STOCKS FOR A SELECTION OF NOOS ITEMS

Item number/ Store number	1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	1	2	2	1	2	1	1	1	1	1	1	1
2	3	2	2	2	1	1	1	1	1	1	2	1	1
3	25	24	37	13	15	50	20	13	9	19	24	11	9
4	2	3	3	3	2	1	2	2	2	1	1	2	1
5	2	1	2	2	1	1	1	1	1	1	1	1	1
6	9	10	11	6	7	6	5	2	5	4	4	4	2
7	1	1	1	1	1	1	1	1	1	1	1	1	1
8	3	2	2	3	2	3	1	2	2	2	1	2	1
9	4	3	3	4	2	3	2	2	2	2	2	2	1
10	16	15	15	14	15	10	10	12	7	10	10	6	7
11	7	7	5	7	4	4	3	2	3	3	2	3	1
12	3	3	3	4	2	4	2	2	2	2	-	1	-
13	15	15	16	13	9	9	7	9	6	5	7	6	5
14	2	2	1	2	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1
16	5	5	4	2	4	4	2	2	2	3	2	2	2
17	2	2	2	2	2	2	1	1	1	1	1	1	1
18	2	1	1	1	1	1	1	1	1	1	1	1	1
19	2	2	3	1	2	2	2	2	2	1	2	2	1
20	1	1	1	1	1	1	1	-	0	1	1	1	-
21	2	1	2	2	1	2	1	1	1	1	1	2	1
22	5	4	6	3	3	2	2	2	2	1	1	2	3
23	2	2	2	3	2	2	1	2	1	1	1	2	1
24	3	5	3	6	3	4	2	3	1	2	1	1	1
25	1	1	1	2	2	2	1	1	1	1	1	1	1
26	1	3	3	1	0	-	2	-	-	2	2	1	1

APPENDIX 6 – COMPARISON BETWEEN AVERAGE ORDER QUANTITY (AOQ) AND EOQ

	Store 13		Store 2		Store 8	
Item number	**AOQ**	**EOQ**	**AOQ**	**EOQ**	**AOQ**	**EOQ**
1	10	12	10	26	10	10
2	10	22	10	69	10	30
3	100	290	100	519	100	337
4	8	19	8	58	8	41
5	4	5	4	15	4	7
6	6	8	8	20	6	9
7	3	5	3	18	3	15
8	5	9	5	37	5	23
9	3	8	4	22	3	13
10	5	33	6	54	7	48
11	2	3	4	11	3	4
13	5	26	7	61	6	44
14	3	4	3	11	3	5
16	6	15	6	29	6	19
17	3	6	3	16	3	8
18	6	7	6	12	6	7
19	6	17	6	31	6	29
21	3	7	3	18	3	14
22	5	9	6	17	5	11
23	2	9	2	26	2	14
24	5	10	7	15	7	13
25	6	6	7	17	5	17
27	8	21	9	30	8	18

APPENDIX 7 – COMPARISON BETWEEN NEW AND OLD CASE-PACK SIZES FOR A SELECTION OF NOOS ITEMS

Item number	Sales volume (# of pieces)	Unit cost (SEK)	Old case-pack size	New case-pack size	Difference
1	3873	34	10	4	6
2	5461	8	10	9	1
3	128208	2	100	90	10
4	9388	14	8	9	-1
5	2463	58	4	2	2
6	9348	111	6	3	3
7	2103	29	3	3	0
8	6707	20	5	6	-1
9	9318	85	3	4	-1
10	38506	43	3	11	-8
11	11382	508	2	2	0
12	3858	409	4	1	3
13	47236	66	4	9	-5
14	3169	160	3	2	1
15	1674	47	3	2	1
16	9397	45	6	5	1
17	4135	90	3	2	1
18	2438	74	6	2	4
19	6605	23	6	6	0
20	1233	8	5	4	1
21	3414	46	3	3	0
22	7106	92	3	3	0
23	4759	45	2	4	-2
24	5555	59	5	3	2
25	3664	52	3	3	0
26	2503	11	12	5	7