

Enhancing inventory management for primary and secondary warehouse

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Abstract <p>Valtra Oy Ab has faced operational challenges with controlling its inventory in the primary warehouse in Suolahti and in the secondary warehouse run by a third-party logistics operator in Säynätsalo. The need for storing items is growing steadily due to the recently released tractor models. Because of the new models, more items have been added to the stock than older items have reached their obsolete-status. The main objective of the thesis was to examine what kinds of actions would be required to reduce the inventories in Suolahti and in the third-party logistics operator's warehouse in Säynätsalo. The study was of great interest to the company because proper analyses of inventory management had not been conducted in the recent years. The empirical section was based on quantitative methods and logical deduction. Finally, the study included calculating the fixed storing area in the third-party logistics operator's warehouse in order to alleviate the transformation project of the upcoming warehouse management system (WMS).</p> <p>The theoretical background of the study was based on inventory management, warehousing and introducing various tools for analysis. The acquired data from the warehouse management system was compiled for various analyses that focused on finding possible solutions to the research problem by reflecting the data against the theoretical background.</p> <p>As a result, new solutions were found to enhance inventory management. Especially, the study found numerous items that already had a full write-off value in the bookkeeping but were still stored in the inventory. The study presented recommendations on either discarding the items or transferring them from Suolahti to Säynätsalo. Cost calculations of recommended actions were included in the results, but the execution was excluded from the content.</p>		
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1 Introduction

1.1 Background for the research

The title of the bachelor's thesis is "Enhancing inventory management for a primary and secondary warehouse". The thesis was implemented in cooperation with Valtra Spare Parts and, more specifically, with the warehousing and purchasing team. Recently released tractor models, such as the new 4th generation of the A-model caused a situation where more and more items were added to stock than older items reached their end of service life. The study was of great current interest for the company because number of items had been steadily increased through the years, and proper analyses of inventory management were missing from the recent years. It is challenging to store new items because their demand cannot be forecast precisely.

One of Valtra's core competencies is based on serving customers on the highest level. Thus, Valtra should anticipate investing considerable amounts of resources to provide the promised level of service. Especially, large amounts of capital tied-up to inventories cause naturally costs and increase the risk of non-marketable items. On the other hand, it ensures a high service level, but the processes can be optimized to run more efficiently.

Thus, the existing problem is related to inventory management, in other words, how inventories should be managed to reduce both irrelevant tied-up capital and storing space and simultaneously ensure that the current service level will be maintained to satisfy the customers. It should be considered carefully which items are have an impact on the service level and revenue. Only a portion of the items provides the majority of the revenue, the rest has been stored only to maintain a desirable service level.

1.2 Research objectives

The study focused primarily on examining the actions which would be required to reduce the inventories in Suolahti and in third-party logistics (3PL)-operator's warehouse in Säynätsalo. In practically, the highest benefit would be gained by discarding

the useless items because the expected income from these items would be minimal, but their storing is causing costs constantly. Additionally, it should be considered that items are stored in a suitable warehouse either in the primary one in Suolahti or in the secondary one in Säynätsalo. Ideally, the target is to store the most crucial items in Suolahti and the slow-moving or large items in the 3PL-operator's warehouse in Säynätsalo.

Thus, the main objective of the study was to present recommendations whether an item needs to be stored in Suolahti or Säynätsalo or whether it should be discarded. The study includes recommendations for item policy, and estimations of the costs caused by the recommended actions. The implementation of the required actions is highlighted in the thesis content. Finally, the study includes a pallet storage area calculation for the third-party logistics operator's warehouse in Säynätsalo.

The main objectives of research have been listed below. The theoretical background was selected according to these topics in order to provide a valid fundament for the research.

- **Providing a list of items that should be discarded**
- **Providing a list of items that should be transferred from Suolahti to Säynätsalo**
- **Calculating the needed storing area in the 3PL-operator's warehouse**

On the other hand, the research approach could be selected to cover the strategical mistakes in the management instead of enhancing the current state. That approach method would be concentrated to exploring the main reasons which have led to disorder and the growth of obsolete items. That approach is, of course, an important part of inventory management, but due to its complexity and limited resources, it should be investigated in the separate topic of discussion.

1.3 Theoretical background and research method

In order to achieve the above-mentioned objectives, the basics of inventories, warehousing and analysing tools had to be addressed. Moreover, the theoretical basis

was supported by the basics of bookkeeping, obsolescence and its management. The theoretical background was based on literature and internet sources.

The empirical section brings together some quintessential parts of both the *quantitative* and *qualitative research method*. Primarily, the research was based on numerical data transformed into statistics, which is typical for quantitative research. Quantitative research uses measurable data to constitute facts and reveal some repetitive patterns. On the other hand, some parts of this research consisted of exploratory research to gain an understanding of the underlying reasons or motivations. Finding results by using unstructured and semi-structured techniques allowed to develop ideas and solutions towards quantitative research. Thus, this research had partially common aspects with the qualitative research approach. (Qualitative research 2010)

The ABC-analysis, XYZ-analysis and Kraljic matrix were used as data analysing tools. These analyses were used to detect an item's importance, logistics costs and the item's current trend in its service life. However, due to incomplete data of the picking frequency, the XYZ-analysis and Kraljic matrix analyses could not be used for all the items. Thus, the analyses were primarily focused on the ABC-analysis.

The collected data from the warehouse management system Proteus were compared with the theory from the literature. Obviously, all the needed parameters should be assigned beforehand in order to find suitable information for research. By combining all analysed data into one table, it was possible to make justifications about an item's policy for discarding or transfers.

2 Company presentation

2.1 Valtra Oy Ab

Valtra is a leading manufacturer and service provider in the Nordic countries and it enjoys a growing reputation in South America. Valtra machines are sold in over 75 countries. Valtra has 2100 employees working around the world. Every year Valtra manufactures over 24 000 tractors which have been made-to-order so that each tractor has been manufactured according to customer desires. (About Valtra 2017)

In 2016, Valtra's revenue was 89,4 million euros and net revenue was 13,7 million euros. Valtra's customer base comprehends farmers and contractors who appreciate close customer relationship and solutions developed for challenging conditions. (About Valtra 2017)

History

Valtra has manufactured tractors since 1951 but its origin goes back to the 19th century. Valtra tractors represent two of the company's traditional turning points: Valmet from Finland and Volvo BM from Sweden. From its roots, Valtra has invested in comprehensive development and various changes, and its name has been changed from Valmet and ValtraValmet to Valtra. (About Valtra 2017)



Figure 1 Aerial photo of the Suolahti factory complex (About Valtra 2017)

2.2 AGCO Corporation

AGCO is one of the world's largest agricultural equipment manufacturers, which is based in the State of Georgia in the United States. AGCO Corporation was incorporated in 1990, and after multiple company fusions, AGCO grew to be the world's third biggest manufacturer and distributor of agricultural machinery. (About AGCO 2017)

From the 5th of January in 2004, Valtra has been part of the AGCO Corporation. Valtra belongs to AGCO's international brands, the other key brands are: (Our Brands – AGCO 2017)

- Fendt
- Massey Ferguson
- Challenger
- CSI



Figure 2 AGCO's brands and short description of each brand (Our Brands – AGCO 2017)

AGCO Parts

AGCO Parts are the only genuine parts that are designed and engineered for the AGCO machinery. The wide range of parts consist overall of over 3.5 million part numbers. Furthermore, AGCO offers services to AGCO's machinery, currently over 3500 models are supported globally. (About AGCO Parts 2017)

Valtra Parts are part of AGCO Parts EAME (Europe, Asia, Middle East) operations. The AGCO Parts EAME's main warehouse is currently located in Ennery, France. Valtra Parts has a promise that spare parts will be available for 15 years after the end of a specific tractor production.

2.3 Suolahti warehouse

Suolahti warehouse is located next to Valtra's tractor factory in Äänekoski. The warehouse provides spare parts for the Valtra tractors and for the AGCO Parts EAME (Europe, Asia and Middle East) network. At present, about 35 permanent employees are working in two shifts in the Suolahti warehouse. In addition, the warehouse uses 1-3 rental workers during high peak seasons to reduce order lines. On average, the warehouse handles 35 000 outbound lines and 7000 inbound lines monthly. The total area for the warehousing operations is about 4921 square meters. By using a narrow-aisle layout, the warehouse has a capacity of 15 kilometres of EUR-pallet shelves and 8 kilometres of small item shelves. (Huolto ja huolenpitoa 2014)

2.4 Logistikas Oy as a 3PL-operator

Logistikas Jyväskylä has been offering effective warehousing solutions for local workshops and assembly manufacturing companies and their suppliers in Säynätsalo since 2011. Closely integrated IT-systems with its customers make it possible that the daily operations can be planned and scheduled precisely. In addition to warehousing services, Logistikas has facilities for value added services in its 22 000 square meter premises, such as pre-packing, spare part kitting and consignment stock handling. (Logistikas Jyväskylä 2017)

Valtra has outsourced the storing of slow-moving and large items to Logistikas. As of October 2017, Logistikas has been storing about 13 000 items. In the recent years, the cooperation has broadened to include spare part kitting, pre-packing and controlling the storing and deliveries of the Valtra Collection e-commerce. (CT-Logistics ja Valtra tiivistävät yhteistyötä 2017)

2.5 Background of having 3PL-operator

Overall, the performance of the Suolahti warehouse is on an acceptable level, and the processes are efficient when the warehouse is handling the average number of

inbound and outbound lines. However, during peak seasons, the high volume causes a significant drop in the warehouse's performance. Extra workforce eases up the pressure slightly, but the lack of handling space causes bottlenecks in the operations. This is one of the main reasons why Valtra has partially outsourced its warehouse services to an outside service provider.

Originally, the plan was to move the slow-moving items under the 3PL-operator's control. Furthermore, the deal included the storing of large items (such as rims, gear-boxes and axles) due to the limited storing space in Suolahti. Outsourcing also allowed storing reserve batches under the 3PL-operator while the primary storing location was still in Suolahti. In need of quick replenishment, a warehouse transfer was made from Säynätsalo to Suolahti. Unusually, the key target of the outsourcing was a lack of space, not finding the most cost-efficient solution. The plan was to keep the main functions under control in Suolahti and outsource items that were irrelevant for the whole warehouse processes. The cooperation can be described as a Second Party Logistic Model (2PL).

However, during the recent years, the cooperation has become deeper and closer. Nowadays, the 3PL-operator is responsible for other operations that have been bottlenecks in the Suolahti operations. The 3PL-operator is partially responsible for the kits' construction and pre-packing. Moreover, order picking and dispatching have become more comprehensive during the progress of the co-operation. This deal reminds more and more of Third Party Logistic (3PL), which means closer co-operation between both parties. It can be said that the cooperation between the two parties has developed from a typical supplier stage to a strategic partnership.

3 Inventory management

Before describing inventory management, the general features of warehousing as well as stock and its purpose, importance and use need to be introduced.

3.1 Warehousing

Warehousing is closely related to the supply chain. Warehouses are needed in demand-driven supply chains, both in storing goods and in sorting activities. Both aspects are compulsory in feeding external customers. (Emmett 2005, 1.)

The fundamentals of warehousing are people, equipment and space. All these aspects are linked together, because when, for example, operating with limited space, more is needed from the people and equipment. On the other hand, saving on equipment often leads to demanding more from the people. (Ackerman, 1997, 20.) The variations of equipment and buildings are relatively small. Because of this, people are the most crucial component of warehouse operation. Usually, the personnel's performance makes the difference between high- and low-quality warehousing. (ibid, 20.)

Storing solutions

While choosing the most suitable storing solution, the warehousing trade-off is between speed, cost and capacity. Cheap solutions often lead to larger space requirement and these have a requisite for more labour while more automatized solutions are characteristically more expensive. Finding a balance between trade-offs is the key for success. (Richards 2011, 163.)

The most common alternatives for storing pallets consist of wide-aisle racking, double-deep racking, narrow-aisle racking, drive-in racking, push-back racking and mobile racking (see. Table 1). Each solution suits for a different role and often there is not a one right answer while choosing a storing method. Moreover, the type of storage depends on the building configuration, currently used equipment and available budget. (ibid.163-164.)

Table 1 Characteristics of storing solutions (Richards 2011, 175.)

Performance of racking system	Adjustable pallet racking	Double deep	Narrow aisle	Drive-in/ Drive-through	Live storage	Push back	Mobile	Satellite
Use of floor space	50 %	70 %	60 %	80 %	80 %	70 %	80 %	85 %
Use of height	70 %	70 %	80 %	70 %	70 %	70 %	70 %	80 %
Speed of access and throughput	80 %	60 %	70 %	50 %	80 %	70 %	60 %	70 %
Access to individual pallets	100 %	50 %	100 %	40 %	40 %	60 %	90 %	60 %
Occupancy rates	90 %	70 %	90 %	60 %	80 %	80 %	90 %	80 %
Stock rotation	70 %	50 %	90 %	60 %	100 %	60 %	60 %	90 %
Ease of mgmt and control	60 %	60 %	60 %	60 %	80 %	60 %	60 %	60 %
Specialist handling equipment required	No	Yes	Yes	No but restricted	No	Possibly	No	Yes
Ease of relocation	100%	100 %	100 %	70 %	70 %	80 %	80 %	100 %
System adjustability	100 %	100 %	80 %	100 %	40 %	100 %	100 %	70 %

In the recent years, the most popular solution for storing has been wide-aisle racking because it requires the least capital and maintenance costs and because no special kinds of forklifts are needed. However, wide-aisle racking provides the poorest aisle to storage ratio. Thus, by narrowing the aisles to a minimum rate would significantly provide more capacity for the warehouse which, is illustrated in Figure 3. On the other hand, narrow-aisle racking requires special types of forklifts and some additional accessories, such as guide rails or wire-guiding systems. Moreover, this method requires a very flat floor, especially if the storing height exceeds 10 meters. (ibid. 167-168.)

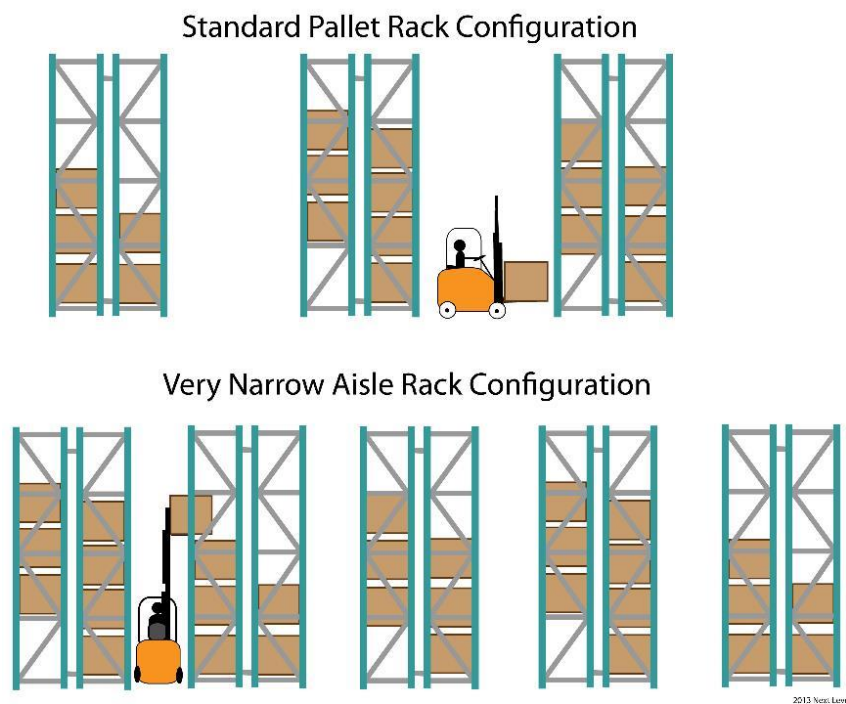


Figure 3 Comparison between wide-aisle and narrow-aisle racking (Very narrow aisle pallet racking 2013)

Warehouse administration and management

Plenty of management decisions concern warehouses. Some decisions are caused by business needs and some are decisions from the operative point of view. Both ways are fulfilling the basic functions of a warehouse. The main motives of warehouse management are efficiency, accuracy, cleanliness, cost controlling, safety and security. The management of a warehouse is dealing with a constant pressure of providing greater availability of items with precise accuracy and reduced lead times and at the same time minimizing costs and striving towards flexibility in operations.

The administration of the warehouse might vary due to the ownership model, business model, complexity and culture of the company. There might be multiple levels of leadership. For instance, the warehouse manager could have multiple team leaders who, in turn, might have warehouse operators responsible for each segment.

(Richards 2011, 232-234.)

Outsourcing has become as an alternative for running warehousing operations. Outsourcing means generally moving some of a company's functions from its own control under another participant's control. It enables the company to focus on its own core business. Additionally, the lack of resources could be a reason for outsourcing. If the company does not have enough resources to run its functions, it can share responsibility with another participant. (Kiiha 2002, 1.)

Companies have recently moved their logistics functions to chosen service providers. This is called Third-Party Logistics (3PL). In the third phase, the service provider's and company's cooperation is closer, and their operative processes are usually integrated to boost the collaboration. Outsourced service providers commonly take care of warehousing or deliveries, and they are responsible for supervising and controlling the operations. Thus, the service providers are working as intermediaries between production and the customers, but they do not own the products at any point of the process. (Pastinen, Mäntynen, Koskinen, 2003, 131-132.)

3.2 Stock and inventory

"Stock consists of all the goods and materials that are stored by an organization." (Waters 2003, 4.) Stocks are everywhere in everyday life. For example, shops purchase goods from a wholesaler and keep them in stock until selling them to the customers or factories keep raw materials stored for item production. It can be simplified that whenever a company has goods or materials that are not used immediately, it puts them into stock. In some cases, the stock is not very easy to notice, such as reserving water in reservoirs from which the water will be used gradually by water companies. (Waters 2003, 4-7.) Stocks are usually replenished by supplier deliveries and consumed by customer demands, as it is shown below in Figure 4.

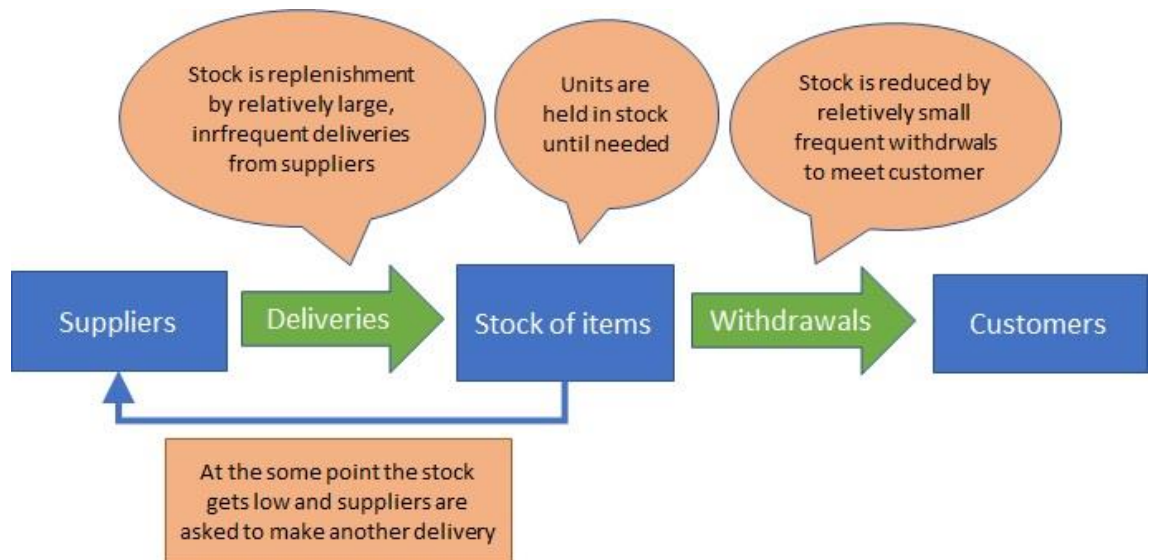


Figure 4 A typical use of stock (Waters 2003, 5.)

Deliveries from suppliers are generally larger batches and then based on customers' orders the stock gradually reduces. It can be noticed that inbound batches are not so frequent whereas the customer's orders are made constantly. (See Figure 5.)

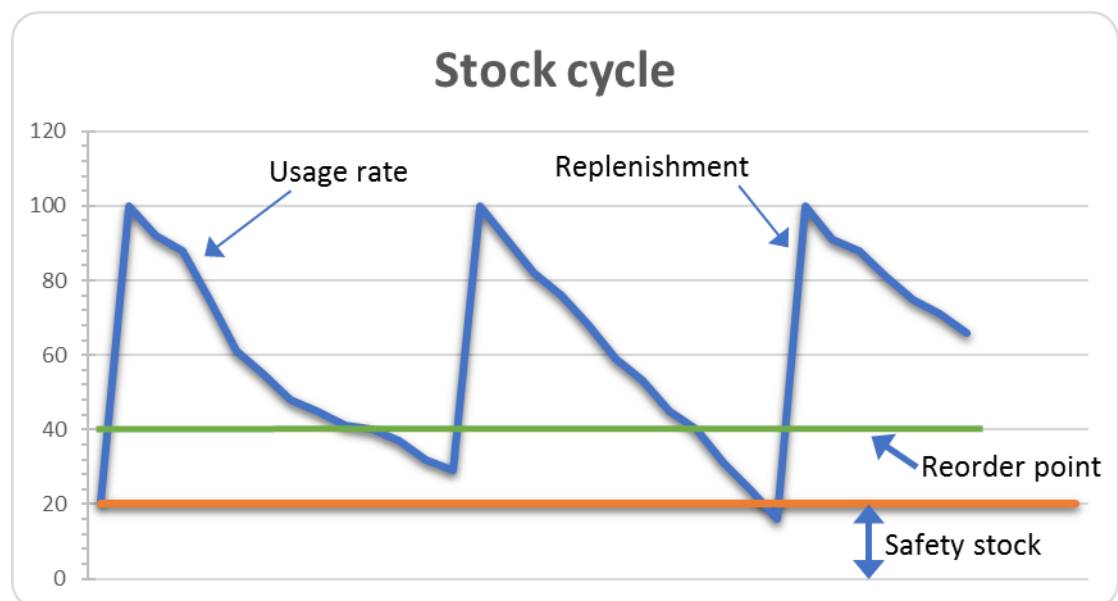


Figure 5 An example of a typical stock cycle

Reasons for stocks

Holding stocks is natural nowadays due to fact that companies cannot guarantee instant availability. Without stocks, most operations are impossible. Warehouses are

having stocks as buffer which lowers uncertainty in supply and ensures that customers demand will be served as soon as possible. However, it must have a balance with service level and costs, holding excessive stocks leads additional costs and complicates material management significantly. (Sakki 2003, 71.)

According to Sakki (2003), in the ideal situation company wouldn't have any stocks. Therefore, all the assets can be allocated towards productive functions. However, monitoring, supervising and shortage related costs would be significantly higher than storing costs. Additionally, service level would dramatically decrease because none items are instantly ready for the delivery.

In certain circumstances, increasing the stock might be beneficial. If company manages to bargain supply price discounts by bulk purchasing, gained benefits could exceed storing and handling costs. In some cases, additional stock can be temporary, such as anticipation of demand during promotional or seasonal peak times. (Emmett 2005, 36.)

On the other hand, excessive stock would ensure availability even in the extraordinary cases but it causes redundant costs, expensive insurances and difficulties with the storage management. Finding a suitable balance between service level and storing costs would be a goal to achieve. (Waters 2003, 7-8.)

Value of stock

Stock shows as a current asset on the company's account. Therefore, it is necessary to have correct values for stock because it has influence on the total value and key performance indicators.

Value of stock can be computed simply by multiplying number of items by item cost. However, stock level can vary a lot so usually average value over sufficient period is needed. Eventually, item cost changes due to discounts, variation of quality, inflation, suppliers or by changes in the trade terms. To get acceptable evaluation of stock value, following methods have been used: (Waters 2003, 48-49.)

1. *Actual cost:*

Setting value by actual cost method is used if there are only couple items in the stock. This method is the most accurate and reacts to changes precisely. However, this method requires that each item value must be evaluated individually. Under some circumstances, this method is replaced by the average cost method because items turnover rate is too high for precise valuating.

2. *First-in, First-out (FIFO):*

As the title says, FIFO assumes that firstly arrived items are used at first. The value of stock is determined by unit which has made first its way to inventory. It gives acceptable value for replenishment costs but there is risk that this method overestimates value of the stock. Moreover, it cannot be guaranteed that customers are willing to pay item which price has been increased.

3. *Last-in-last-out (LIFO):*

Instead of FIFO, LIFO assumes that latest bought units are sold first. Nowadays LIFO is less used because this method assumes that stock always contains units which have bought in the beginning. If price would rise over time, LIFO under-estimates the value of stock.

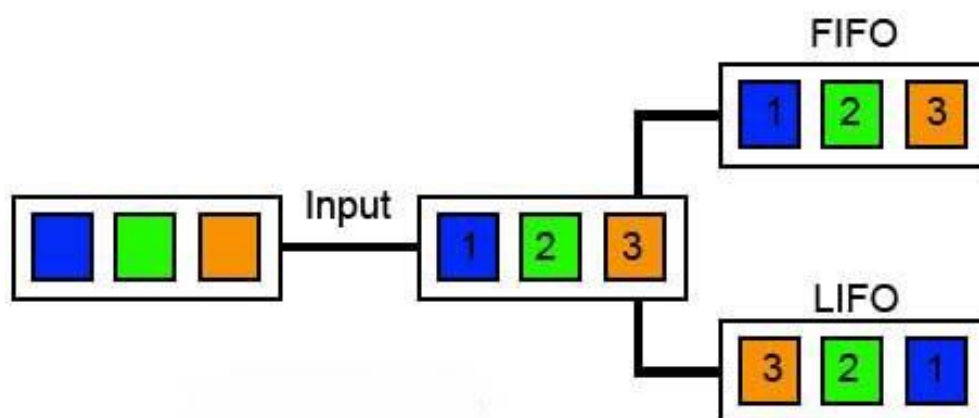


Figure 6 Difference between FIFO and LIFO (FIFO and LIFO meaning 2017)

4. **Weighted average costs:**

Weighted average method is used to find average unit cost over the all purchasing history data and set up value for remaining stock. Weighted unit cost can be calculated by dividing the total costs of all purchases with the number of units bought. This is commonly used because of its simplicity, only one calculation is needed to get acceptable value of the stock. (ibid, 48-49.)

3.3 Supply chain

Supply chain is used to describe as a process which integrates, coordinates and controls the material and goods movement from supplier to customer destination. Supply chain links all activities between supplier and consumer in the right place and right time. Consequently, it contains all activities of sourcing, buying, manufacturing, transferring and selling. Therefore, it can be said that the supply chain is taking care of business from initial customer demand. Without order, nothing happens, it is the order which starts and steers whole process. (Emmett 2005, 1.)

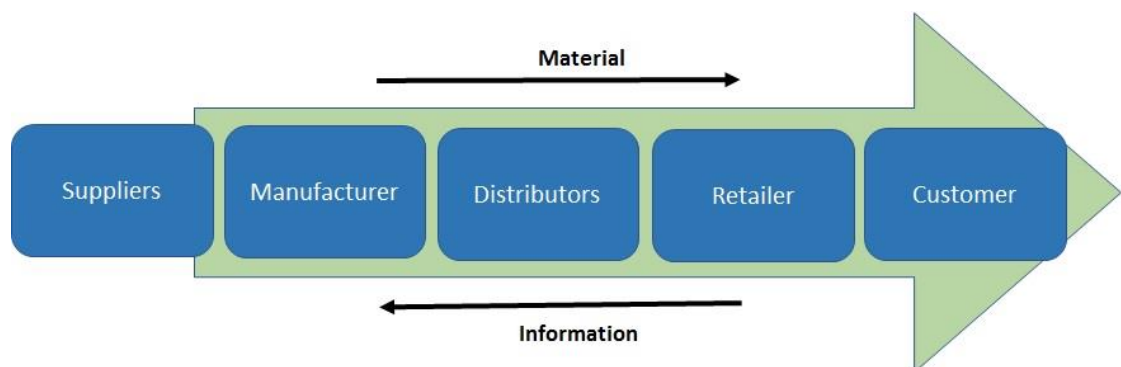


Figure 7 Simplified supply chain steps (Transforming Supply Chain 2012)

Supply chain management

Supply chain management can be defined as managing activities in the chain to make the most of the added value to the product. Supply chain management is all about flow of goods and information. Without information flow, supply chain partners cannot coordinate day-to-day flow of goods and materials or make long-term plans to develop processes. (What is Supply Chain Management? 2017)

With help of the efficient supply chain management, it can be gained larger added value for customer with small total costs. A significant part of product's value composes from supply chain participants, such as raw material producer, vendors or distributors. Each participant affects to costs and by way to end price. Manufacturer's part of the end price is usually only 10-50% so by focusing on chain participant's, reduced costs could lead to sustainable competitive advantage. (Lehtonen 2004, 105.)

3.4 Inventory management

Inventory management can be described as controlling product flow in the supply chain and at the same time providing required service level at an acceptable cost.

As it has been mentioned in Chapter 3.2., stock is an asset in financial point of view. Nevertheless, holding stock carries costs which will cut down profit and competitiveness. The turnover of inventory means sales, therefore, the quicker the inventory turns, the better will the profitability. Hence, controlling inventory management consist of the following main actions: (Emmett 2005, 35-37.)

- Deciding which items are stored and the location of the stock
- Sustain sufficient level of inventory to lower uncertainty in the supply and ensure demand availability
- Maintaining the supply, determining optimal timing and quantity for the orders

As a summary, fully functional inventory management leads to following benefits:

- Reduced costs which leads to larger profit
- Saved assets can be allocated for other processes
- Improved service level
- Improved customer satisfactory
- Better ability to react changes in the supply or demand
- Unnecessary actions can be cut down
- Easier monitoring

3.5 Controlling the flow

Through the entire order process, companies have a responsibility to maintain optimal warehouse efficiency by controlling inventory flow. The main targets are reduc-

ing throughput times, improving effectiveness and maintaining customer-based service strategy. Implementing controlled flow is a part of the company's day-to-day functions and considered in the company's strategy. (Sakki 1994, 25-26.)

In practically, the main principle of controlling the flow is quite simple. The most ordinary failing is lack of sufficient collaboration. Controlling inbound lines to fit forecasted demand is another practical example of challenge to have suitable balance for the flow. (ibid, 26.)

Need for controlling

Item availability, consumption and attributes specifies requirements for warehouse controlling. Some items are easy to procure and for some items are needed a lot of work to acquire them. Some items can be stored many years and some items could get spoiled in couple days. Some items are ordered daily and some items have been bought irregularly. All these factors should be considered while determining correct parameters for warehouse controlling. Moreover, company's business model is affecting to flow controlling. Warehouse controlling is totally different if company is focused on manufacturing, storing or working as a retailer.

3.5.1 Re-ordering

According to (Sakki 2009), there are two common reordering methodologies. The first methodology is called as a *reorder point method*. This method is based on assumption that the order is placed in specific time so items are received at the same time while level of inventory falls on the safety stock. In a theory, by this method safety stock is never reached. In addition, order batches would always contain the same amount but ordering frequency occurs irregularly. In order to avoid risk of out of stock, safety stock must be held considerably high level while using this method. (120.)

The second methodology is called as *time phased order point method*. According to this method, inventories are filled regularly but the size of order batch is varying. This

allows for planners to make amendments according to seasonality or customer requirements. Whichever method is used, three main principles are related for reordering: (ibid. 120.)

- **Lead time:** Period between placing and order and receiving the items
- **Safety stock:** It's based on an estimate of minimum inventory level which cannot be fall below. Lead time, demand variation, criticality and supplier precision are effecting for this value
- **Estimate for upcoming demand**

3.5.2 Economic order quantity

Inventory management costs can be divided to two classes: holding costs and ordering costs. While company has a small inventory, order batches are also small. Thus, inventory value can be reduced but correspondingly transportation costs have been increased due to several deliveries. The most suitable solution for batch size can be defined if it is known purchasing and storing costs. This method has been described as a Wilson's formula. (Sakki 2009, 116.)

EOQ (Economic Order Quantity) is known nowadays as a Wilson's formula which is based on ordering costs and storing costs by single unit. However, this formula assumes that demand is constant and costs are invariable. Moreover, this method does not recognize service level at all. (Ritvanen & Koivisto 2007, 34., Karrus 2003, 38.)

The formula is expressed in below:

$$EOQ = \sqrt{\frac{2 \times D \times O}{C \times I}}$$

D = estimate for annual consumption (pcs)

O = the cost to place an order (€)

C = the unit cost of the item (€)

I = the annual holding cost (€)

The result of EOQ-formula is always an estimate but it guides to the correct answer.

EOQ-chart has been illustrated below in Figure 8:

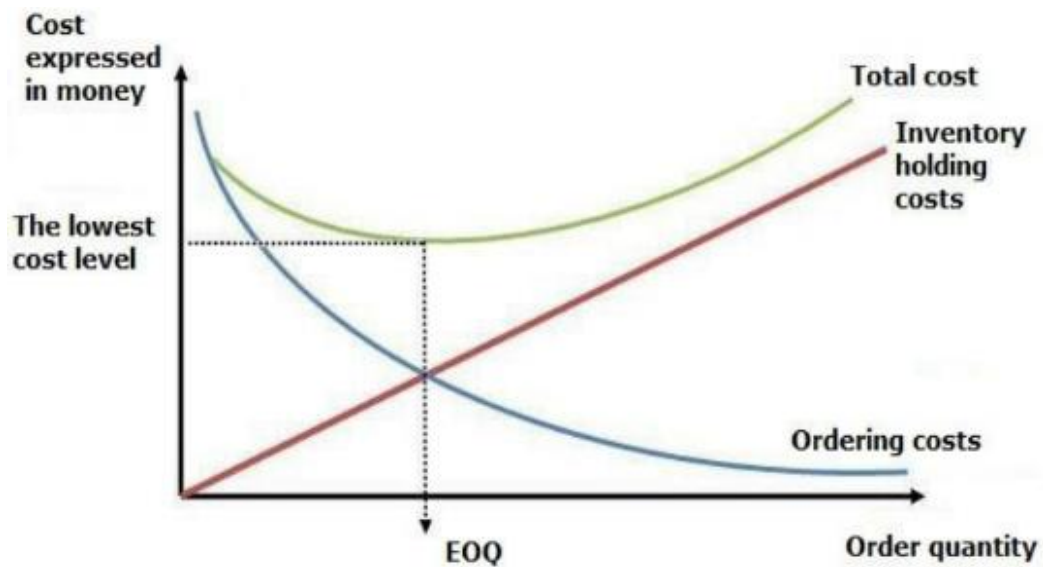


Figure 8 The chart illustrating the concept of EOQ (Boron, J. 2014)

Naturally, while EOQ grows, inventory holding cost are simultaneously increasing. However, ordering costs are reducing due to larger and fewer orders. Optimal batch size can be found from the intersection of costs. (Sakki 2009, 117.)

The most problematic part would be to evaluate the ordering costs because these have the largest variation. Therefore, these costs must be evaluated precisely because these are related to multiple functions, for example, in ordering, monitoring, goods receiving, unloading, inspections and binning. (ibid, 117-118.)

As the title says, EOQ optimize order batches only from the economic point of view. However, practical restrictions might prevent utilizing this method whereupon batch sizes must be evaluated individually for each item. If EOQ-formula solution passes all the practical restrictions, it can be enacted to the real-life. (ibid, 119.)

3.5.3 Limits for minimum and maximum inventory

Occasionally it is worthwhile to set minimum and maximum limits for the inventory. By that way inventory levels can be kept between desired parameters. Replenishment order is made when minimum level of the inventory has been reached. Inventory level would be back to its maximum level when the replenishment order arrives

to the stock. If inventory level is between the limits, there is no need for replenishment order. (Sakki 2009, 125.)

3.5.4 Obsolete items management

As it has mentioned in chapter 3.1, holding stock carries costs which will reduce profit and competitiveness. Especially storing obsolete items is harmful for the company because expected profit from obsolete item is minimal. Accordingly, it must be regularly monitored to avoid storing worthless items.

Item becomes obsolete if its value is partly or entirely lost. Additionally, item with slow turnover rate could become as obsolete due to weakening demand and rising storing costs. Obsolete items are never procured, these have become obsolete during storing. (Hakonen, Pöhö, Summa 1992, 10.) From the economic point of view, item can be described as an obsolete when item's scrapping value exceeds the market price. When item reaches the mentioned status, it should be preferably scrapped.

The reasons which might lead to reduced turnover rate:

1. Insufficient inventory management

Lack of sufficient inventory management could lead to holding excessive inventory level.

2. Demand

Inventory level might be adjusted according to the demand from the history, not according to the actual situation. Actual sales are not matching with forecasted sales and especially forecasts for new items are commonly too optimistic. Products which have a short life-cycle, sudden demand falling is natural.

3. Batch size

While company is achieving for the most economical batch size, company might order excessive batches from the inventory management point of view. Thus, fixed

costs might be reduced but the advantage is lost due to storing costs and the rising risk of that item would turn into worthless. (Hakonen, Pöhö, Summa 1992, 13.)

In some cases, bounded assets might be stuck in the slow-moving and obsolete items. It causes that profits cannot be expected anymore. Thus, inventory value cannot be restored even with additional investment. Moreover, obsolete items occupy storing space and thereby restricts operating possibilities. Because storing costs are dependent to storing time, disposing obsolete items must be considered as a high priority.

According (Slater, 2010), the main reason for the excessive stock is caused due to misaligned responsibilities. Generally, one person has an authority to add an item to inventory but the same person is not responsible for the economic impact to the inventory. Thus, eventually inventory will be overstocked. It is based on human nature that looks for possibilities to maximize revenue even if it is not profitable in the longer run. By aligning both authorities and responsibilities of inventory management would lead to inventory optimizations. (91.)

Obsolete item management cannot be executed once but it should be a continuous process. Company should develop organization which is corresponding of regular monitoring and executing actions when needed.

3.6 Bookkeeping

Bookkeeping is a central part of a company's main functions. Companies must constantly record and monitor all the business transactions, such as the amounts, dates and data of its revenue, as well as gains, expenses and loss transactions. Bookkeeping is necessary for the company itself but in addition, various external parties such as owners, the government and creditors are interested in the company's economic success. (Tomperi 2017, 7-8.)

The main objective of bookkeeping is to express a company's financial result. According to the bookkeeping reports, companies' taxation and other payments are determined. Moreover, bookkeeping shares data on operative accounting and reports and analyses the information to the management. According to the bookkeeping law, all

companies, societies, joint-stock companies, limited partnerships and foundations are obliged to do *double entry bookkeeping* regardless of their type of business. (ibid. 11)

3.6.1 Inventory write-downs and write-offs

Inventory write-down is a process to reduce inventory value. Write-downs might be needed if some items have not been sold for some time or when the next generation of the product has recently been launched. The items are not totally worthless, but a write-down is needed to meet more accurately the item's value in the current demand. (Tomperi 2017, 38.)

Nowadays, item value has been defined according to specified bookkeeping write-down rules and recommendations. The remaining value can be calculated monthly or annually depending on reporting frequency. As the definitive parameters of value, the following aspects are commonly used: (Lahti 2015)

- Item sales and its trend recently
- The item's stage in its service life (proximity to the end of the service life)
- The possibility for substituting the item with another one
- Condition of the item
- The item's depreciation rate

Inventory write-offs are executed to reduce an item's value entirely so that it is no longer valuable in any form. An item's write-off can occur because of various reasons, due to reaching the end of its service life, a loss from theft, misplacement or deterioration.

However, even if an item has been entirely written-off from the bookkeeping value, scrapping these items is never free. It should be considered that scrapping process requires labour and in some cases transportation which always causes additional costs.

3.6.2 Inventory counting

According to law, inventory counting must be executed at least once in a year. Incorrect inventory level data can cause excessive stock levels, unexpected stock outs or excessive purchasing due to improper values. (Emmett 2005, 75-76.) The irregularity of inventory levels can incur for several reasons, for example for wrong identification, mistakes in picking, goods movement without any records or poor inspecting of receipts. Proceeding according to the given procedure would significantly reduce mistakes in each step. This method is commonly described as the *proactive approach*. Hence, if several irregularities have been noticed in the inventory levels, it commonly points out that mistakes have been made during the process. Nevertheless, the best result can be gained by combining the proactive and reactive method. The main target is that the system and personnel would continuously prevent mistakes before they happen and regular counting of the inventory level is executed alongside. (ibid. 76.)

Inventory counting consist of two basic models; *periodic* and *continuous checking*. Periodic counting means that the entire inventory is inspected at once at specified time intervals. Periodic counting means that warehouse operations must be halted entirely or at least partly during the counting process. This method suits better for small inventories with simple items. Continuous checking allocates permanently some resources to inventory counting. Continuous checking allows warehouse operations to be performed normally during the counting. In a theory, counting mistakes would be reduced due to the knowledge and better ability of the personnel in continuous checking. On the other hand, this method requires more responsibility from the personnel and some warehouse management systems might face challenges in the counting process while an item has simultaneously been allocated for sales. (ibid, 77-78.)

3.7 Service level

Service level is one of the core indicators for monitoring company's effectiveness. Service level can be described as availability. Often companies hold more stock than

they expect to use. It leads to a higher service level which is defined as the probability that there are no shortages in the stock. Thus, the higher the service level, the higher safety stock is needed to meet the requirement. (Waters 2003, 170-173.)

If a company can deliver each line of the customer's orders, its service level is on the highest level. However, if a company falls into several backorders, there is room to improve the service level. In conclusion, a good service level brings new customers and maintains durable and close relationship with the existing customers. (Karrus 2003, 183.)



Figure 9 Alternatives if customer demand cannot be met (Waters 2003, 121.)

Relation to inventory management

Warehouse throughput times have recently been considered more vital than large stocks. Since it has been more common to reduce inventories, the customers must be served with short delivery times instead of each item is being stored in the warehouse. According to this rationale, the service level can be enhanced by quick deliveries. (Sakki 2003, 76.)

Service level can be contrasted to warehouse and inventory management. To guarantee a sufficient service level, a company must have relatively high safety stock to avoid uncertainty in supply and demand. Close cooperation and communication with the customers and suppliers allows to improve the service level. When suppliers have

access to precisely estimated demand, availability increases and the required stocks can be reduced in the supply chain. Thus, cooperation with the customers and suppliers is the key area when optimizing inventory management and service level. (ibid, 74.)

3.8 Cost structure

This chapter discusses briefly the most common types of costs related to warehousing and transportation. In most cases, the cost components are similar to each other but the proportion might vary.

3.8.1 Warehousing and logistics costs

Sakki (2003) classifies the warehousing costs under two classes: Tied-up inventory costs and goods storing costs. Warehousing forms roughly 20 – 40% of the logistics costs because storing materials or goods is never free.

Firstly, the basic costs, such as labour as those for rent and utilities should be considered. In addition, shelves, boxes, pallets and all the needed equipment should be taken into account. Moreover, the costs of the premises' cleaning, lighting, heating, cooling, indemnification and other equivalent types of costs should be noted. The common inventory holding costs are discussed below: (Inventory holding costs 2009)

Insurance costs

Companies protect themselves against theft, destruction and losses by using insurances. Depending on the business type and location, these costs might be a significant part of the whole costs.

Spoilage losses

Physically invalid items fall below a company's quality standards. These items must be written-off from the inventory value if the items are non-marketable. Thus, in

case of spoilage, the value of the item has been lost entirely. However, in some cases it might be possible to refurbish items so that their value could be restored back to their original value. Nevertheless, refurbishment should be critically considered if the item's refurbishment cost is close to its original value.

Obsolete inventory write-offs

As already stated in Chapter 3.6.1, obsolete items' write-offs are happening regularly. They are happening due to the quickly developing industry, or because an item might already be out-dated in less than a year. If items cannot be sold, they might need to be written-off entirely.

Depreciation costs

Over time, equipment, items, premises and machines will lose their value, which is called depreciation. Depreciation is a model of allocating the remaining cost of assets to their useful service life. Depreciation does not directly affect the cash flow but it should be taken under consideration in the cost calculations.

Opportunity cost of tied-up capital

Already tied-up capital to the inventory cannot be used for profitable operations, and, thus, a company's profitability is directly affected by it. Therefore, it is crucial to allocate scarce capital to the most efficient use where it would return the best expected value to the business. If there are better alternatives to allocate tied-up capital, it should be invested elsewhere, which would generate a better return.

3.8.2 Freight pricing

Transportation constitutes one of the largest partition of the logistical cost and it has an impact on item's market price depending on its character. Transportation costs are affected due to following reasons: (Bowersox D, Closs D. 1996, 365-367.)

- Transported distance
- Amount of transported goods
- Size and dimension of transported goods
- Item's complexity for handling or loading
- Item's vulnerability
- Market situation
- Additional services and service level

Freight costing could be complicated in the real-life due to abnormal item dimension and weight. However, in this research is used only pallets so pricing theory can be simplified by using only pallet pricing.

Pricing according to actual weight

Pallet weight is used as a freight pricing when it is not possible stack pallets on top of delivery. Pricing is defined for EUR-pallets 740 kg and for FIN-pallets 925 kg. For the entire freight weight can be calculated by multiplying number of pallets by pallet weight. (Maantiekuljetusten hinnoittelu 2017)

Pricing according to volumetric weight

Volumetric weight is used when actual weight is lower than calculated weight according to volume or when transported unit is stackable. Delivery's total volume can be calculated by multiplying length, width and height. Volumetric weight in the road transport can be then calculated by multiplying actual volume by 333kg. (ibid.)

Pricing according to loading meter

A loading meter corresponds to 1 metre of loading space in a truck. It is used when transported unit cannot be stacked. Usually one loading meter corresponds to 1850 kg. Delivery freight weight can be calculated by multiplying used loading meters by 1850 kg. (ibid.)

4 Tools for analysing

In this chapter familiarized topics are connected to basics of measuring performance and various tools for analysis. The purpose of this chapter is to find suitable type of analysis method and how tools are utilized for various types of items.

4.1 Measuring and KPIs

Measuring performance and efficiency is natural part of controlling operations. The key performance indicator (KPI) is a tool which indicates how well objectives have been achieved. Indicators should contain essential and compressed information in format of easy to read. KPIs are essential part of goal-directed management. (Pastinen I, Mäntynen J, Koskinen L. 2003, 153.)

KPIs should be chosen precisely to get accurate and unbiased results. Above all, a good KPI should measure correct attributes and give a reliable result. A good KPI should meet the following features: (ibid. 154-155.)

- **Competence:** KPI is representing the actual performance
- **Coverage:** KPI is focusing on entirely to the target process
- **Comparability:** Measures can be compared with different volumes, organizations and periods
- **Accuracy:** KPI's accuracy is on the sufficient level and values can be trusted
- **Profitability:** Measuring costs won't exceed gained benefit

Turnover rate

Inventory turnover rate is one the most common indicator to measure inventory management efficiency. Inventory turnover measures the number of times inventory has been sold in the specific period. The higher turnover rate, more effectively company produces profit with assets of the inventory. However, high revenue is depending on costs and high turnover presumes several order batches which leads to additional costs. (Karrus 2003, 177.) High turnover means nothing unless the company can make profit from each item sale. (Inventory turnover rate 2017)

Depending on the type of business, turnover rate might vary a lot between organizations. Therefore, inventory turnover rate should be adopted according to branch of business. For example, for the primary spare part warehouse a good turnover rate might be over 20 times per year and poor turnover rate is below than 5 times per year. (Karrus 2003, 177.)

The objective of turnover rate should be determined in the way that caused costs will not exceed gained benefits. Otherwise operation would be unprofitable. Inventory turnover rate is discussed below. Inventory turnover rate can be turned into days to give more practical insight of the current situation. (Inventory turnover rate 2017)

- **Inventory turnover rate** = cost of goods sold / average inventory value
- **Days in inventory** = (average inventory value / cost of goods sold) x 365
- In formula is used carrying value of goods sold

It might be challenging to specify average inventory value in the formula. Thus, the current inventory value can be inserted instead of average value. It is difficult to provide average value because inventory value is constantly changing. (Sakki 2009, 76.)

The formula to calculate turnover rate for the specific item is the following (Karrus 2003, 176):

- **Item turnover rate** = total costs of item sold / average value of the item

4.2 Tools for analysing

4.2.1 Parreto's law

Parreto's law has been developed in the year 1908, when Italian economist Vildredo Pareto surmised the principle of factor sparsity. It states that 80% effects come from 20% of the causes. This analysis can be found as an 80/20 rule. (Emmett 2005, 30.)

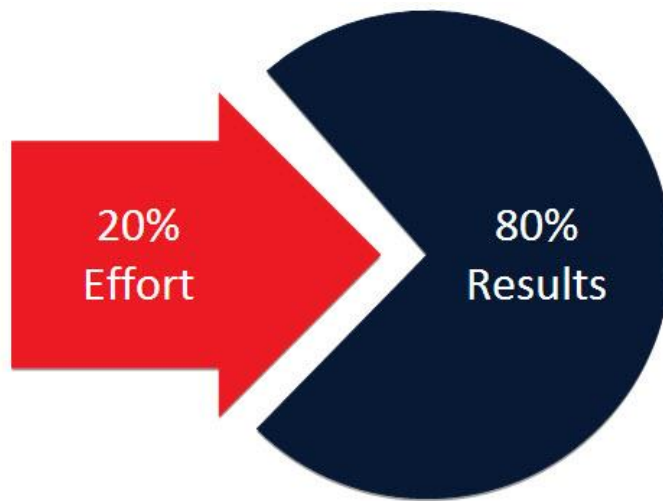


Figure 10 Parreto's law principle (Parreto's principle 2013)

Discussed analysis can be roughly associate with following situations. These percentages should not look literally but the main message is that ratio is closer to 80/20 than 50/50. (Sakki 2009, 90.):

- 80% of products bring only 20% of total revenue
- 20% of products bring even 80% of total revenue
- 80% of lines bring only 20% of total sales value
- 20% of products take 80% of storing space
- 20% of products cause 80% of delivery mistakes

4.2.2 ABC-analysis

After introducing Parreto's law, it can be assumed that each warehouse stores lot of items which have non-existent value and there are used plenty of time and resources by towards irrelevant items. Companies should allocate its limited resources effectively and try to not spend resources for worthless activities. With help of ABC-analysis, it is able to classify items importance per movement frequency or sold value. The target is that resources can be allocated according each item importance. (Sakki 2003, 91.) In the other words, the main goal is to find notable items from economic point of view. It should be allocated more resources for these item's controlling than for the other items. (Karrus 2001, 180.)

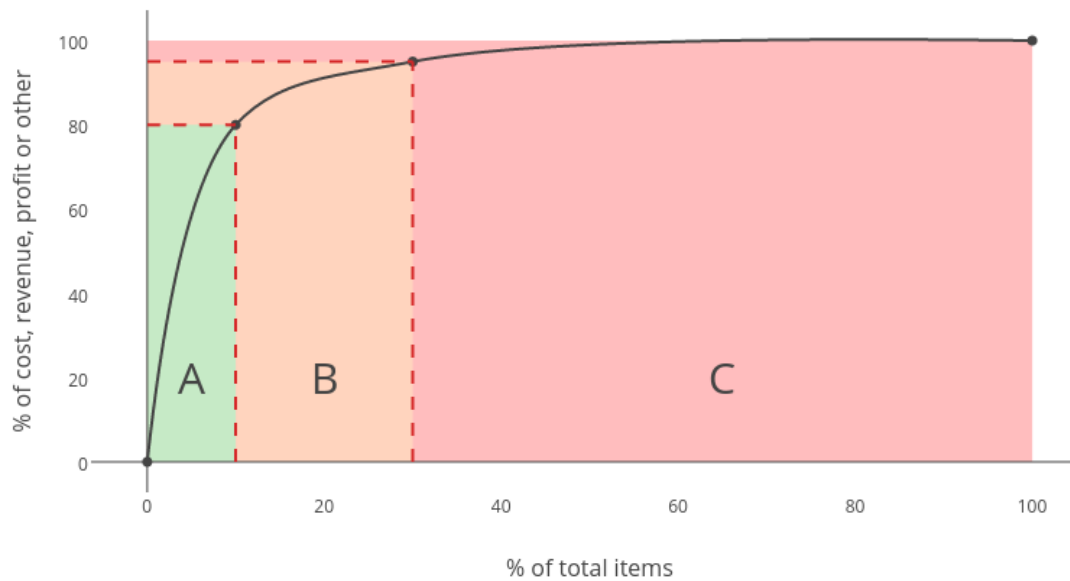
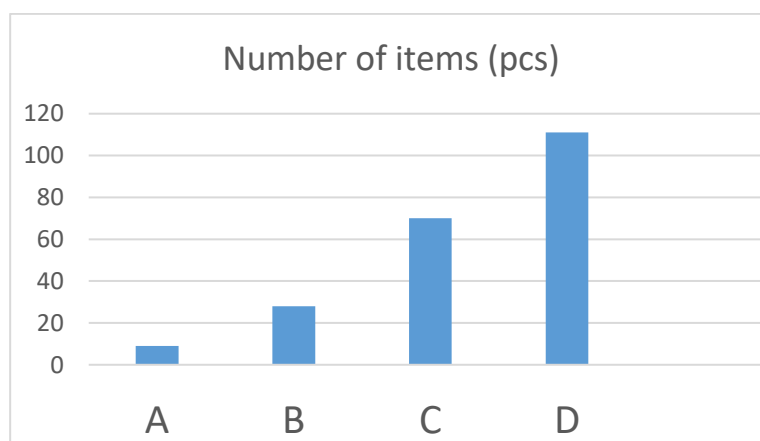


Figure 11 Graph of ABC-analysis (ABC Analysis – The Ultimate Guide to Inventory Classification 2017)

Because items have been categorized according to the sold value, it should be taken in mind that some irrelevant items could still have considerable impact to the service level. For that reason, there are always needed more encompassing research in addition of ABC-analysis before discarding items. (Sakki 1994, 60-63.)

There are various alignments of ABC-analysis but one common categorizing method is the following: (ibid. 62)

- A-items: Represents 50% of cumulative value of sold items
- B-items: further 30% of value of sold items
- C-items: further 18% of value of sold items
- D-items: the remaining 2% of sold items



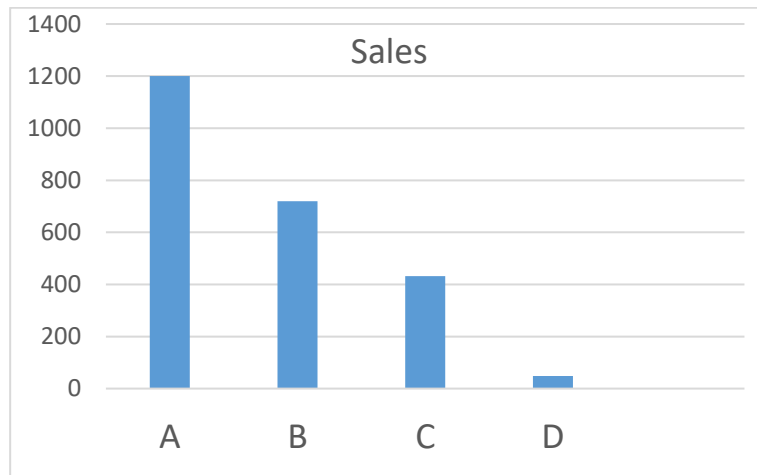


Figure 12 An example of ABC-analysis

It should be kept in mind that ABC-analysis is based on the historical data. The item's demand varies constantly and some of the items can be categorized to another class after a couple months. However, the number of A-class items stays always on the same level. The difference between classes are often caused due to changes in the product's life cycle. (Sakki 2009, 92.)

As a summary, recommendation for item policy is described in the below: (Ritvanen, V. and Koivisto, E. 2006, 39; Karrus 2001, 182; Sakki 2009, 95)

A- and B-class products:

- The goal is to purchase these items according to EOQ (see Chapter 3.5.2.)
- Reserve stock should be held small and it should be monitored regularly
- Purchaser must procure these items inexpensively and aim to maintain reasonable turnover rate
- Items must be monitored closely and purchase batches should be potentially reduced
- The frequency of monitoring should be between daily or weekly basis
- Service level must be on the high level, about 90-98%

C- and D-class products:

- Several months demand can be ordered in one batch
- Pursuing to minimise additional costs
- Replenishment orders are scheduled and order point calculations are used (see Chapter 3.5.1)
- The frequency of monitoring can be lowered
- Service level can be dropped to 80-85%
- It should be considered discounts, returns or scrapping for D-class products

4.2.3 XYZ-analysis

XYZ-analysis are usually done alongside of ABC-analysis. XYZ-analysis classifies items according to variability of demand. Like in ABC-analysis, items are categorized to three classes: (XYZ inventory management 2017)

X-items:

X-items have characteristically constant usage over the time and the variation is minimal. Upcoming demand can be forecasted precisely so management of these items can be automatized.

Y-items:

Y-items usage is neither constant or occasional. As an example, item might have a seasonal fluctuation whereupon usage is momentarily increased or decreased. Hence, its more complicated to provide accurate demand forecast.

Z-items:

Z-items have the most volatility since these are not used regularly. The fluctuation is high because item might be ordered only couple times in a year which is illustrated below in Figure 13. There are no any trend or factors which would allow to make reliable demand forecasts. Therefore, item policy should be considered as replenish to order. (ABC/XYZ Inventory Control 2014)

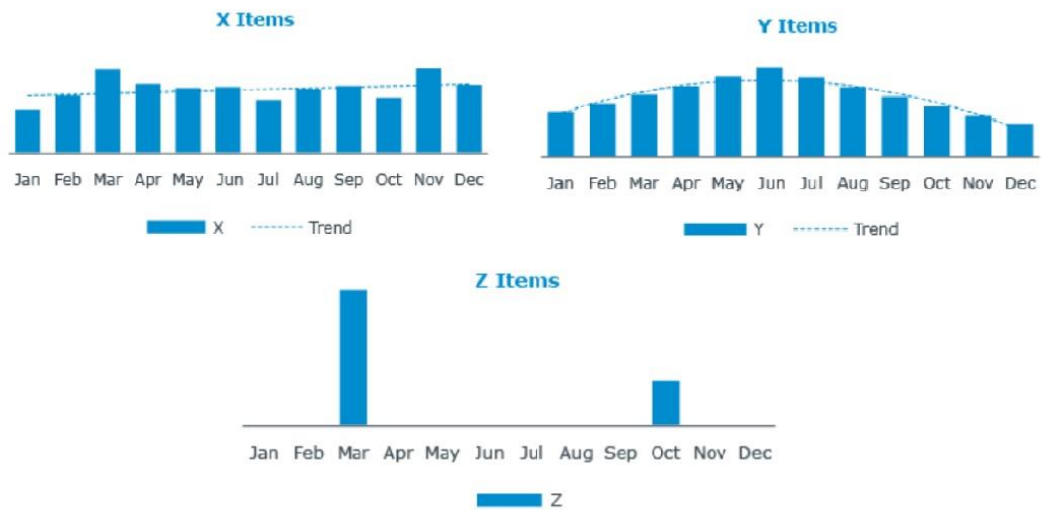


Figure 13 An example of XYZ-items variation (XYZ inventory management 2017)

4.2.4 Kraljic matrix

XYZ- and ABC-analysis can be combined to the matrix where items are categorized according to both classifications. This method can be applied to aid sales or purchase planning. Matrix is illustrated below in Figure 14.

IMPORTANCE, ABC-CLASSIFICATION	high	AZ		AX Ensure availability
	average		Balance risks and importance	
	small	Minimize costs CZ		Bottleneck items CX
		small	average	high
VARIATION AND RISKS, XYZ-ANALYSIS				

Figure 14 An example of Kraljic matrix

Vertical axis describes item importance for the company. The higher importance, the more resources and time should be used towards supplier relationship to ensure item availability. Horizontal axis describes characteristics of supplying an item. Risks are high if demand variation cannot be forecasted precisely or item supply is unreliable. (Hankintastredegiaat ja ostoportfolio 2017)

5 The current state and development ideas for Valtra spare parts

In this chapter, the research objectives, the current state and, finally, the gained results are introduced. The results include cost calculations for a valid evaluation of this study.

5.1 Illuminating research objectives and method

1. Providing a list of items that should be discarded

The first part of the analyses consists of providing a list of recommendations for discarding. The item selection is based on items whose service life has already ended or on the fact that the item's age exceeds 15 years since its release.

According to bookkeeping, each item has a market value, and the item's value is reduced when it is approaching the end of its service life. When the item reaches the end of service life, its write-down rate is defined as 100% from the bookkeeping point of view. The write-down rate is calculated monthly for each item according to AGCO's obsolescence policy. The main problem is that write-downs and write-offs occur constantly, but actions for disposing obsolete items are executed rarely. Therefore, the first part of the study concentrates on items whose write-down rate is already 100%. It allows finding the obsolete items in the data.

AGCO's obsolescence policy

In order to determine an item's current value in bookkeeping, AGCO Parts has designated its own obsolescence policy for its products. Obsolescence is calculated monthly at the part number level, and it comprises the depreciated inventory value of a part. New parts are obsolescence free in the first three years of their storing in order to allow establishing a demand profile. The demand profile can be constructed according to weighted average of the last 36 months' demand. Obsolescence policy can then be calculated as the current inventory is divided by the demand profile. The policy is applied across AGCO's warehouse network by considering the network as one warehouse. Inventory levels are summed across the network before applying the obsolescence calculation. (Obsolescence policy 2017)

2. Providing a list of items that should be transferred from Suolahti to Säynätsalo

The Suolahti warehouse operates as the primary warehouse that handles the most important functions of all the warehousing operations. These analyses are executed to investigate if there are slow-moving items in Suolahti. The slow-moving items occupy limited storing space in Suolahti so that these items should be transferred to Säynätsalo under the 3PL-operator's control. Item justification was made according to the ABC-analysis, and the current trend was examined in case of abrupt increases or decreases in recent demand.

3. Calculating needed storing area in the 3PL-operator's warehouse

Finally, the study includes a section for calculating the required storing area in Säynätsalo. Currently, items are stored in multiple locations inside the premises, and Logistikas is handling several customers' products in the same storing area.

However, the upcoming Valtra's warehouse management system (WMS) transformation requires that all items should be stored in the same area in order to construct the warehouse layout and logical picking sequence for the new WMS. Introducing a fixed storing area would significantly ease the WMS transformation project, and Valtra would be paying only for the area that it needs to run its operations.

The data of the currently stored pallets allowed to calculate an estimation of the required pallet storage area. The new warehouse layout would be based on narrow-aisle racking instead of the existing wide-aisle racking. It allows a better aisle-to-storage ratio, which means higher concentration in the storing area. Accordingly, only an estimation of the required storing space has been included in this study. Therefore, the layout planning, the cost calculations of the reform and for the execution of the tasks were excluded from the content.

5.2 Present state

Suolahti storage has been divided under two sections, pallet item storage and small-item storage. Since the pallet storage area is limited, the analysis should be allocated towards pallet item storage. It is challenging to find available storing location for pallets due to high degree of fullness in the Suolahti warehouse. However, the degree of fullness is distinctly lower in the small item storage. Therefore, the resources have been allocated towards pallet items.

Table 2 Present state in both warehouses

Present state (10/2017)			
Items stocked		44 049	items
Suolahti		31 119	items
Säynätsalo		12 930	items
Pallets stored			
Suolahti		~ 8 500	pallets
Säynätsalo		~ 6 400	pallets
Storage area in Säynätsalo		2 735	m2
Unheated covered racked storage		500	m2
Heated covered racked space		2 235	m2

3PL-operator's storage consists of large, slow-moving items which have been stored already for many years. Thus, the major part of the scrapping recommendations is

presumably concentrating to Säynätsalo warehouse. The volumetric efficiency is significantly lower due to the fact of wide-aisle racking storing solution.

Composing an ABC-analysis

ABC-analysis was constructed to perceive the variance of items. Analysis was made according to sales over the last five years (10/2012 – 10/2017). The risk of seasonal variance is minimized by using a five-year consumption. However, it should be considered that five years is a long period of time and item's demand might change dramatically in a few years. Thus, the recent consumption must be critically analysed to see the latest trend in demand.

According to the theory of ABC-analysis (see Chapter 4.2.2), items were classified in the following order:

- A-class: Represents 50% of cumulative sales value
- B-class: The following 30% of sales (50% - 80% of all items)
- C-class: The following 18% of sales (80% - 98% of all items)
- D-class: The remaining 2% of sales (98% - 100% of all items)

Analyse covered items both in Suolahti and Säynätsalo inventories in order to have relevant data for comparison.

As a result, the classification was the following:

- **A-class:** 422 items, **1%** of all items were representing 50% of cumulative sales
- **B-class:** 1 756 items, **4%** of all items were representing the following 30% of sales
- **C-class:** 9 295 items, **21%** of all items were representing the following 18% of sales
- **D-class:** 32 365 items, **74%** of all items were representing the remaining 2% of cumulative sales

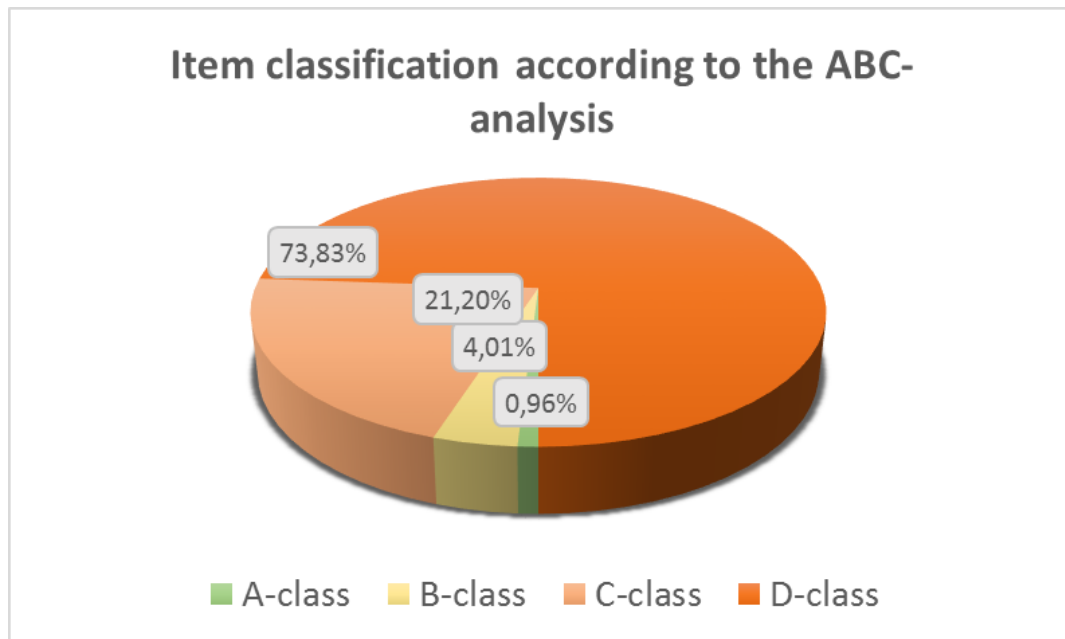


Figure 15 Item classification according to ABC-analysis

As it has been illustrated in Figure 15, only 422 items were classified under A-class. Items for B-class were only 1 756 pcs. Therefore, less than 2 200 items are providing even 80% of the all sales.

On the other hand, 6 193 items (14% of all items) were not sold at all during the research period. Moreover, over 32 000 items are providing only a fraction (2%) of the sales. Thus, it is crucial to examine these items in order to figure out reason for storing. Otherwise these should be preferably scrapped or at least transferred under 3PL-operator's control in Säynätsalo.

5.3 Recommendations for discarding

Scrapping process requires comprehensive analysis to uncover irrelevant items from the inventory. The research found out numerous items with 100% write-off rate. As it has been mentioned in chapter 3.6.1, item's value would be entirely lost when it has 100% write-off rate. The expected profit from these items is minimal so it is recommendable to dispose these kinds of items in a theory. However, practically justification requires more aspects to pay regard for scrapping process.

For instance, Valtra has promised that it provides spare parts for 15 years since tractor model manufacturing has been ended. Naturally some slow-moving items might lose its value entirely but promise obliges that all items must be stored until end of service life. Hence, analyse excludes those items from scrapping recommendations.

In addition, it must be considered that some items have been ordered according to the all-time requirement (ATR) because suppliers do not provide any service for some items anymore. Naturally, that type of items might have been ordered slightly more than there are needed to avoid risk for out-stock in the near future. Once again, item's stage in the service life is a decisive factor in justification process.

The scrapping analysis has been made according to following variables:

- Item's consumption over last 5 years, 2 years and its recent trend
- ABC-analysis classification
- Item's bookkeeping write-off rate
- Item's stage on its service life

Overall, scrapping recommendations include 1 461 items which should be disposed. It means that approximately 660 pallets can be reduced from the storage. It should be also noted that over 1 300 items of recommendations were not consumed at all over last 5-year period.

Table 3 Overview of scrapping recommendations

Scrapping recommendations		
Total number of items		<u>1 461 items</u>
	In Suolahti	36 items
	In Säynätsalo	1 425 items
Saved pallet space		<u>~660 pallets</u>
Items with no consumption over 5 years		1 341 items

The distribution of scrapping recommendations is majorly targeted to Säynätsalo warehouse which is illustrated below in Figure 16. It confirms that recommendations

are focused at the correct location. Naturally slow-moving item storage has significantly more obsolete items than primary warehouse.

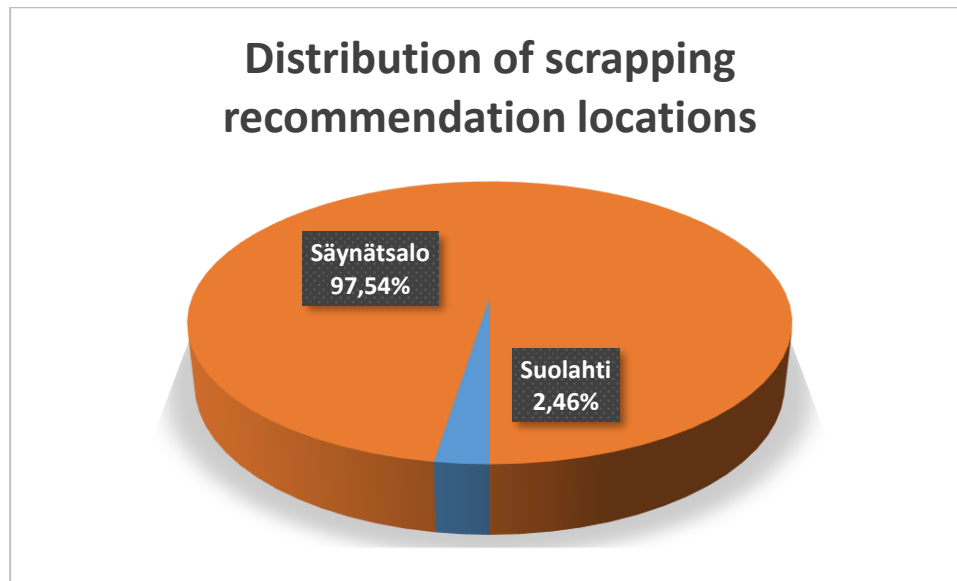


Figure 16 Scrapping recommendation distribution between Suolahti and Säynätsalo

5.4 Recommendations for warehouse transfers

From Suolahti to Säynätsalo

Due to limited pallet storage in Suolahti, it is relevant to manage inventories to avoid storing irrelevant or slow-moving items in the primary warehouse. Therefore, this part of analysis was focused entirely on pallet items in Suolahti.

In a theory, the data from XYZ-analysis would be beneficial to provide recommendations for warehouse transfers. XYZ-analysis reveals the variance of demand, as it has been mentioned in Chapter 4.2.3. Constantly moving items should be stored in Suolahti and vice versa in Säynätsalo. However, the gained data of picking frequency was inadequate to compose complete XYZ-analysis for all the items. Kraljic matrix method was based on both ABC- and XYZ-analysis so it should be disregarded too.

Thus, the item justification has been made according to the ABC-analysis because it reveals item's importance. However, by examining solely to the ABC-analysis would visualize incorrectly some item's current trend. The current stage of the item's service life must be considered because item might have been released recently so it

has still a low-consumption rate. For that reason, there were excluded items which have been released on 2016 or 2017.

On the other hand, item might have been released already some time ago but it will be consumed in the later stage of the tractor service life. Therefore, item has a little consumption in the beginning of its service life but likely it would have a demand peak after year or two of its release. For example, some service kits are required to change when the tractor has reached to the certain amount of working hours. Again, those items must be individually examined and potentially excluded from the transfer recommendations.

Additionally, transfer list included couple items which have been classified to rather important, as a B-class. However, these items consumption has recently abruptly degreased so these trend is presumably weakling.

The transfer recommendations were selected according to the following variables:

- ABC-analysis classification
- Item's consumption during the recent 2 and 5 years and its recent trend
- Picking frequency over the last 21 months (1.1.2016 – 30.9.2017) (For items when the data was available)
- Item's stage on its service life
- Size and weight
- Current inventory amount

Altogether, transfer recommendations included 712 items which were advisable to transfer to the Säynätsalo warehouse. Analysis found 88 items which did not have any consumption at all over the last 5 years. According to the estimation, about 460 - 480 pallets can be saved by executing these recommendations.

Table 4 Overview of Suolahti - Säynätsalo transfer recommendations

Recommendations from Suolahti to Säynätsalo			
Number of items:		712 pcs	
	B-class items:	6 pcs	
	C-class items	149 pcs	
	D-class items	557 pcs	
Estimated saved pallet storage in Suolahti:		~460 - 480	pallets

5.5 Storing area calculations

Storing area calculations are constructed in the following order:

1. Calculate the number of stored pallets
2. Calculate the length of shelf in one layer to store all the items
3. Calculate on the average pallet's height and how many layers can be fitted to the storage
4. Calculate the length of shelf in the multiple layers to store all the items
5. Calculate the total area of storage

According to Warehouse Supervisor's estimation, there are stored 6400 pallets. The height of the warehouse is 5 meters. The major part of pallets have 2 or 3 pallet collars (see Figure 17.). Thus, the storing area calculations are based on the following estimation:

- 40% of stored pallets have 2 pallet collars => 2560 pallets
- 40% of stored pallets have 3 pallet collars => 2560 pallets
- 20% of stored pallets have 4 pallet collars => 1280 pallets



Figure 17 Pallet collars (Lavakaulus 800x1200)

The average weight of stored pallet is considerably low so 4 pallets can be placed into one 3,6 meters width beam. The length of needed shelf length can be then calculated. As the result of calculation, there are needed 5,76 kilometres of shelves to store all the items.

Table 5 Shelf length calculation

PALLET TYPE	NUMBER OF PALLETS	NUMBER OF PALLETS FOR 3,6m	SHELF LENGTH (m)
Pallets with 2 collars	2 560	4	2 304
Pallets with 3 collars	2 560	4	2 304
Pallets with 4 collars	1 280	4	1 152
TOTAL	6 400		5 760

Used dimensions in the following calculations:

- EUR-pallet height: 0,15 meters
- Pallet collar height: 0,2 meters
- Beam thickness: 0,08 meters
- Pallet handling height: 0,15 meters
- Storage height: 5 meters

When the needed shelf length for one layer is known, it allows to calculate needed shelf length for multiple layers. Process starts by calculating one layer height and

then estimating that how many layers can be fitted to the storage height. Then, the length of shelf with the all layers can be figured out. As a result, about 1,13 kilometres of shelves are needed.

Table 6 Pallet height and shelf length calculation

PALLETS	RATIO	NUMBER OF PALLETS	HEIGHT (m)	HEIGHT with handling space (m)	SHELF LENGTH (m)	NUMBER OF LAYERS	THE LENGTH OF SHELF WITH LAYERS (m)
Pallets with 2 collars	40 %	2 560	0,55	0,78	2 304	6	384,0
Pallets with 3 collars	40 %	2 560	0,75	0,98	2 304	5	460,8
Pallets with 4 collars	20 %	1 280	0,95	1,18	1 152	4	288,0
TOTAL		6 400			5 760		<u>1 132,8</u>

The new storing solution would be narrow aisle racking. Thus, the aisle width can be narrowed even to 1,75 meters. One aisle width with shelves would be then:

$$1,75m + 1,1m + 1,1m \Rightarrow 3,95m$$

Finally, total needed storing area can be calculated by multiplying shelves length by the width of the area. It does not matter if the storing area has only one aisle or ten aisles, the needed total storing area is always the same.

Total area storing area would be then approximately 2240 m². According to calculations, narrow aisle racking allows to decrease 500 m² of the storing area which means over 18% reduction compared to the current storing solution. In addition, all the items would be stored in the one area so picking process would be more efficient due to the shorter distances.



Figure 18 Storing area comparison

New storing area = 2 237 m²
Saved storing space = 498m², 18,2 %,

5.6 Cost calculations of recommended actions

In this chapter is estimated the costs which are caused due to the scrapping and transfer recommendations. Cost calculations have been estimated to aid item justification process. To make valid evaluations of recommended actions, it is needed to consider also disadvantages which are caused due to actions. It should be noted that there are not used exact values in cost calculations. The results are based on estimation so these are steering towards to the correct solution and the recommended actions can be put into perspective.

The costs of discarding

Before estimating scrapping costs, it is needed to understand the steps of scrapping process. Firstly, it should be considered the needed time to move items from the shelves to the skip. According to the estimation, it takes 10 minutes to scrap one item. 10 minutes per item is a reasonable time period because in addition of items physical movements, it should be considered some organizing actions, such as setting

up pallets to the correct location and deleting item's location from the WMS. Only labour costs have been considered so transportation costs have been excluded from this study.

Overall, scrapping recommendations included 1461 items. Estimation of labour costs are 25€/h. Scrapping costs can be then calculated:

$1461 \text{ items} * 10 \text{ minutes/item} * 25\text{€/hour}$

=> 6 087,5€

The costs of warehouse transfer

To calculate items transferring costs, it is needed to consider labour costs and transportation costs. According to the estimation, it takes 5 minutes to move one item from shelves to the truck and again 5 minutes to do vice versa in the destination location. Items will be transported by the full trailer combination. The estimated cost of one full trailer combination would be 230€ between Suolahti and Säynätsalo. Labour costs are still 25€/h.

Overall, recommendations included 712 items which should be transported to the Säynätsalo warehouse. All the items can be fitted into 4 full trailer combinations. Transferring costs are then the following:

$(\text{Labour costs at Suolahti}) + (\text{Labour costs at Säynätsalo}) + (\text{Transportation costs})$

$(25\text{€/h} * 712 \text{ items} * 5 \text{ min/item}) + (25\text{€/h} * 712 \text{ items} * 5 \text{ min/item}) + (230\text{€} * 4)$

=> 3 886,7€

5.7 State after recommendations

Finally, in this chapter is mentioned the gained results if all the recommendations would be executed. Table 7 illustrates gained storage reductions and caused costs to execute recommendations and then Table 8 shows the difference to the original values.

Table 7 Overview of recommendations

Overview of recommendations					
			Gained reductions		Cost to execute project
SCRAPPING					
Number of items			1461	items	~ 6 100€
Saved pallet storage			~660	pallets	
TRANSFERRING FROM SUOLAHTI TO SÄYNAÄTSALO					
Number of items			712	items	~ 3 900€
Saved pallet storage			~460	pallets	
TOTAL					~ 10 000€

Table 8 State after all recommended actions

State after all recommendations						
		Original value		New value		Change to original
Total items stocked		44 049	items	42 640	items	-3%, -1469 pcs
Suolahti		31 119	items	30 423	items	-2%, -748 pcs
Säynätsalo		12 930	items	12 217	items	-6%, -713pcs
Pallets stored						
Suolahti		~ 8 500	pallets	~ 8 040	pallets	-5%, -460 pallets
Säynätsalo		~ 6 400	pallets	~ 6 220	pallets	-3%, -180 pallets
Storage area in Säynätsalo		2 735	m2	2 237	m2	-18%, ~500m2

It would be a cost-effective solution to enhance inventory by executing mentioned scrapping and transferring recommendations. It allows to save from the storage approximately 460 pallets in Suolahti and 180 pallets in Säynätsalo by investing approximately 10 000€ towards to this project. On the other hand, if the recommendations will be dismissed, warehouse performance would be likely dropped and caused costs would be significantly higher.

Valtra has been considered to invest for the new storage due to high degree of fullness in the existing ones. Investment to the brand-new warehouse would cost about 850€ - 900€ per square meter. The pressure for the new storage investment can be

reduced by executing recommended enhancement project and saving hundreds of pallets from existing storages. In addition, disposing obsolete items would lead to significant storing costs reductions.

6 Discussion

The objective of this research was to find out the actions to enhance inventory management by scrapping obsolete items and transferring them to the most suitable location. The current state in Suolahti is alarming due to a high degree of fullness which causes challenges to find available storing location.

As a result of the research, various recommendations were introduced to achieve more effective inventory management. The research authenticity was evaluated constantly by presenting research material to supervisors to prevent practical conflicts related to the research topic. The results were only recommendations, hence, professionals must determine the lucrativeness of the mentioned actions. Thus, the analyses were returned for more comprehensive investigation. In addition to the recommendations, the cost calculations were introduced to provide encompassing solution for the research. Therefore, main research objectives were fulfilled.

The study was of great current interest for the company because proper analyses of inventory management were missing from recent years. If the work routines do not change, there is likely a desperate need to enhance inventory management in the near future. Thus, it is highly recommendable to research the strategical mistakes in the management which are causing disorder and growth of obsolete items. The most common reasons are associated with the poor service level agreements, incomplete inventory planning strategy and inadequate write-off process. The key is to construct systematic write-off process which analyses items periodically and actions are executed when obsolete items has been occurred. The frequency of executing the analysis should be considered according to available resources but preferably in quarterly intervals. Therefore, the items have been checked regularly and the project will not engage excessive amount of resources at a time.

This research's main principles can be used as a guideline in the next inventory enhancing project. Upcoming project length can be reduced by using this research model since the main consideration and reasoning has already been made. In case of unexpected changes, it is easier to modify the constructed model than remake the whole project again.

Primarily, this research was concentrated to pallet items. In addition, Suolahti warehouse is storing thousands of low consumption items in the small item storage. The risk for obsolete items is high since encompassing analyses are missing from recent years. For example, the analyses found over 1 500 items which have not been consumed at all during the last five years. Naturally, the lucrativeness of this task should be considered carefully. Small items usually have a lower value and scrapping would not lead to massive storing space savings. Nevertheless, these actions should be executed regularly since the expected profit of these items is minimal.

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