Perttu Puonti

Setting economic order quantities and reorder levels for A-class items

Case: Metropoli Kaluste Oy & Cila Oy

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The purpose of this thesis was to improve the inventory control methods used by the logistics manager of Metropoli Kaluste and Cila. Since the current ordering process has been unsatisfactory, leading to lost sales and unwanted inventory, new approaches were needed for more accurate order quantities and better timing for an order placement.

Information needed for a proper understanding of inventory management and control was gathered. The information was arranged from top to bottom, starting from the general information, such as the financial side and the importance of inventory, finally arriving at the precise methods needed for improving the ordering process.

The economic order quantity and reorder level formula were the points of focus on this thesis, mainly because they are the most practical and usable methods for approaching the questions surrounding the ordering process. The EOQ was introduced because it is used to determine the order quantities. The reorder level defines an optimal level of stock when an order should be placed. These two formula were used to make Excel calculations with the required data.

The final result is a usable Excel sheet which can be used by Sanela to help him in deciding the right order quantities and the right times to place orders. The Excel sheet generated will give Metropoli Kaluste and Cila the first tools for improving their inventory management. Further actions should be taken such as integrating the Excel sheet into the organization’s ERP system for it to be more efficient.

Keywords	inventory control, reorder level, economic order quantity

Tekijä Otsikko Sivumäärä Aika	Perttu Puonti Taloudellisten tilauskokojen ja tilauspisteiden määrittäminen A-luokan tuotteille 31 sivua + 1 liite 21.4.2015
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Koulutusohjelma	Tuotantotalous
Suuntautumisvaihtoehto	Toimitusketjunhallinta
Ohjaajat	Yliopettaja Juha Haimala Logistiikkapäällikkö Jani Sanela

Työn tavoitteena oli parantaa varastonhallinnan työkaluja, joita logistiikkapäällikkö Jani Sanela yrityksissä Metropoli Kaluste ja Cila käyttää. Nykyinen tilausprosessi on yrityksessä huomattu toimimattomaksi, sillä kysyntään ei ole aina pystytty vastaamaan ja välillä varastoon on kertynyt liikaa tuotteita. Pyrin tällä insinöörityöllä luomaan uusia käytäntöjä, joilla saavutettaisiin tarkemmat tilausmäärät ja tilauspisteet.

Keräsin työtä varten vaadittavan teoriaosuuden varastonhallinnasta. Teoriaosuus alkaa varastonhallinnan yleistiedosta. Käsittelen myös varastonhallinnan taloudellista puolta ja varastojen tärkeyttä yrityksille. Teoriaosuuden lopussa on lueteltu eri metodeja varastonhallintaprosessin parantamiseen.

Valitsin tähän insinöörityöhön kaksi tärkeintä varastonhallinnallista metodia: taloudellisen eräkoon ja tilauspisteen. Taloudellisen eräkoon kaavan ja tilauspisteen kaavaan tutustuttaminen yrityksen varastonhallintaan on tärkeä ensimmäinen askel sen toiminnan parantamiseksi. Käyttämällä näitä kahta kaavaa hyväksi loin toimivan Excel taulukon, jonka avulla pystytään määrittämään optimaalinen tilausmäärä ja optimaalinen tilaushetki.

Työn tuloksena syntyi helposti käytettävä ja päivettävissä oleva Excel taulukko, jota yrityksen logistiikkapäällikkö voi päivittäisessä työssään käyttää. Taulukosta saatavat tulokset toimivat hyvinä ennusteina logistiikkapäällikölle kun hän tekee tilauksia. Ennusteet helpottavat oikeiden tilauspisteiden ja tilausmäärien määrittämistä yrityksen A-luokan tuotteille.

Taulukon tutustuttamisen jälkeen yrityksen tulisi päivittää sitä kuukausittain tarkempien tuloksien saavuttamiseksi. Yritys voi halutessaan laajentaa taulukkoa koskemaan muitakin kuin vain A-luokan tuotteita. Taulukosta saatavat periaatteet voidaan liittää tulevaisuudessa yrityksen ERP-järjestelmään, jotta manuaalista käsittelyä saataisiin vähennettyä.

Avainsanat	varaston hallinta, tilauspiste, taloudellinen tilauskoko

Metropolia

Contents

List of Abbreviations

D	Demand. The number of items taken from stock during a month.
EOQ	Economic order quantity. Defines the optimum quantity for a replenishment order.
ERP	Enterprise resource planning. A business management software.
HC	Holding cost. The cost for holding one item in stock for one period of time.
LT	Lead time. The time between replenishment order and when the items ordered becoming available for the organization. Lead time is usually calculated in months.
LTD	Lead time demand. The demand of an item inside the lead time of the same item.
RC	Reorder cost. The cost of placing an order for the supplier.
ROL	Reorder level. When the stock reaches the reorder level, a replenishment order will be placed.
SS	Safety stock. A number of items held in stock to reassure a selected service level.
UC	Unit cost. The price charged by suppliers for one unit of an item.
WIP	Work in progress. A semi-finished product that is stocked before it can be used again.

1 Introduction

This Bachelor's Thesis was carried out for Metropoli Kaluste Oy and its subsidiary Cila Oy. Metropoli Kaluste is a furniture retailer with its headquarters situated in Hyrylä, Tuusula. Metropoli Kaluste has four stores that are spread across the metropolitan area in Finland. Cila Oy is practically the same organization except that it operates on B2B level.

The logistics manager controls the inventory for both Metropoli Kaluste and Cila. I contacted the logistics manager and he asked me if I could make the ordering process easier for him. Recently the logistics manager had not been able to fully satisfy the customer demand, and some critical items had run out, resulting in lost sales. With some items, the stock levels had been too high, hence tying up unnecessary capital. I approached the problem by researching academic inventory management publications for finding out necessary information for placing an order.

During the making of this thesis I was in constant contact with the logistics manager. I collected information about the current ordering process by interviewing the logistics manager and assembling all of the other needed data from the organization's ERP (enterprise resource planning software). I collected a significant amount of theory from academic literature. The formulas needed for the final calculations were collected from Internet databases and inventory management related books.

The logistics manager gave me a list of the most important items (A-class items) that needed improved managing. The main goal for this thesis is to find out and develop new approaches for encountering the daily decisions that the logistics manager of Metropoli Kaluste & Cila makes relating to the chosen A-class items. The research questions therefore are, 'What are the best methods for managing A-class item?' and 'How to apply the methods in practice?'

2 Inventory management

Inventory management is a part of materials management. Materials management is composed of purchasing, warehousing and distribution of an organization's raw materials, WIP (work in progress) and finished products. The whole flow of materials from suppliers to customers is done within materials management. In the last few years one of the main trends in materials management and inventory management has been to decrease the number of stocked items. [6]

2.1 Definition of terms

Every company and an organization holds stocks. Stocks are stores of materials kept until needed. A retailer, for example, buys finished products from a wholesaler and keeps them in stock until a customer comes and buys them from the retailer. Different situations require different types of stocks. A factory keeps a stock of raw materials and all companies keep a stock of information about their customers. Materials that are not needed immediately are kept in stock. Every entry in the inventory is a distinct item and it is held in stock. A furniture store, for example, has a specific couch as a distinct item. A typical furniture store stocks around one thousand items. The most common name for distinct items in stock is a stock keeping unit (SKU). [3]

- Stock is all the goods and materials that an organization stores. It is a store of items for future needs.
- An inventory is a list of the items held in stock.
- An item is a distinct product kept in stock: it is one entry in the inventory.
- A unit is the standard quantity of an item. [3]

2.2 Stock cycle

In a retail store goods are delivered by lorry, checked, sorted and put onto shelves inside a warehouse. Then the items stay on the shelves until customers buy them. At some point stock levels get low, and the person responsible arranges another delivery as shown in Figure 1. [3]

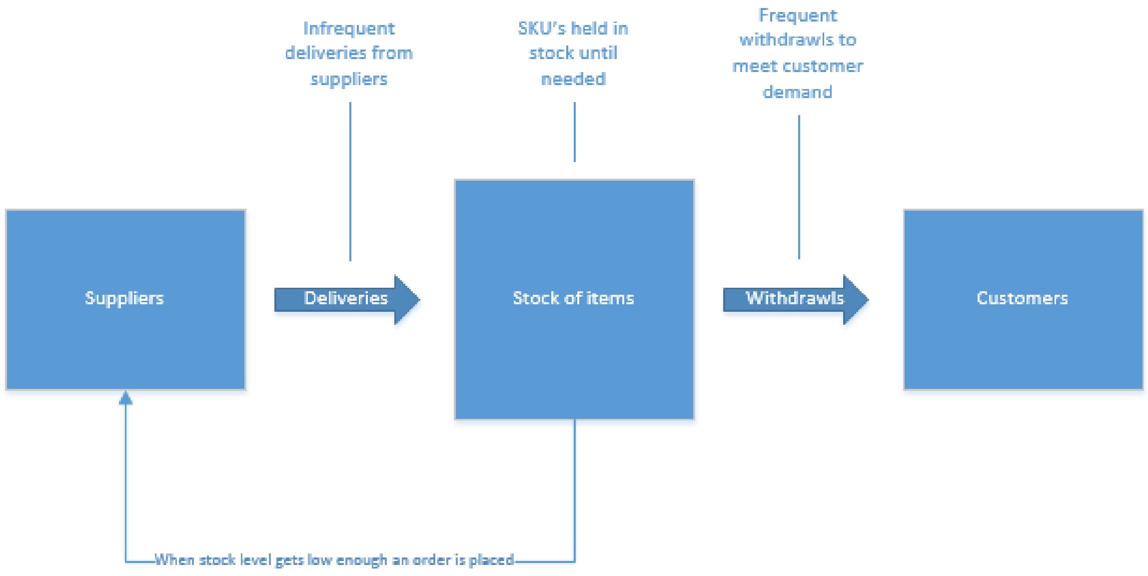

Figure 1. Representation of the participants and actions forming a stock cycle [3, p. 5].

This sequence of stock replenishment and reduction to meet the demand is done over and over again continuously in a stock cycle. Normally, each cycle has the following elements:

1. An organization buys units of an item from a supplier.

2. At an arranged time, the units are delivered to the organization.

3. If the units are not needed immediately, they will be put into storage, replenishing the stock.

4. Customers create a demand for the item.

5. Units are taken from stock to meet the demand.

6. At some point, as the stock is getting low, the organization places another order. [3]

Usually deliveries from suppliers are relatively large and inconsistent and the demands from customers are small and frequent. This gives the typical pattern shown in Figure 2. A customer is someone whose demand is met by removing units from stock. A supplier is anything that replenishes or adds to the stock. In a retail store stock cycles vary from some weeks to months [3]. A lead time is the sum of supply delay (the time it takes a supplier to deliver the goods to the organization once an order is placed) and the reordering delay (the time it takes until another order is needed). The lead time is typically calculated in moths. [8]

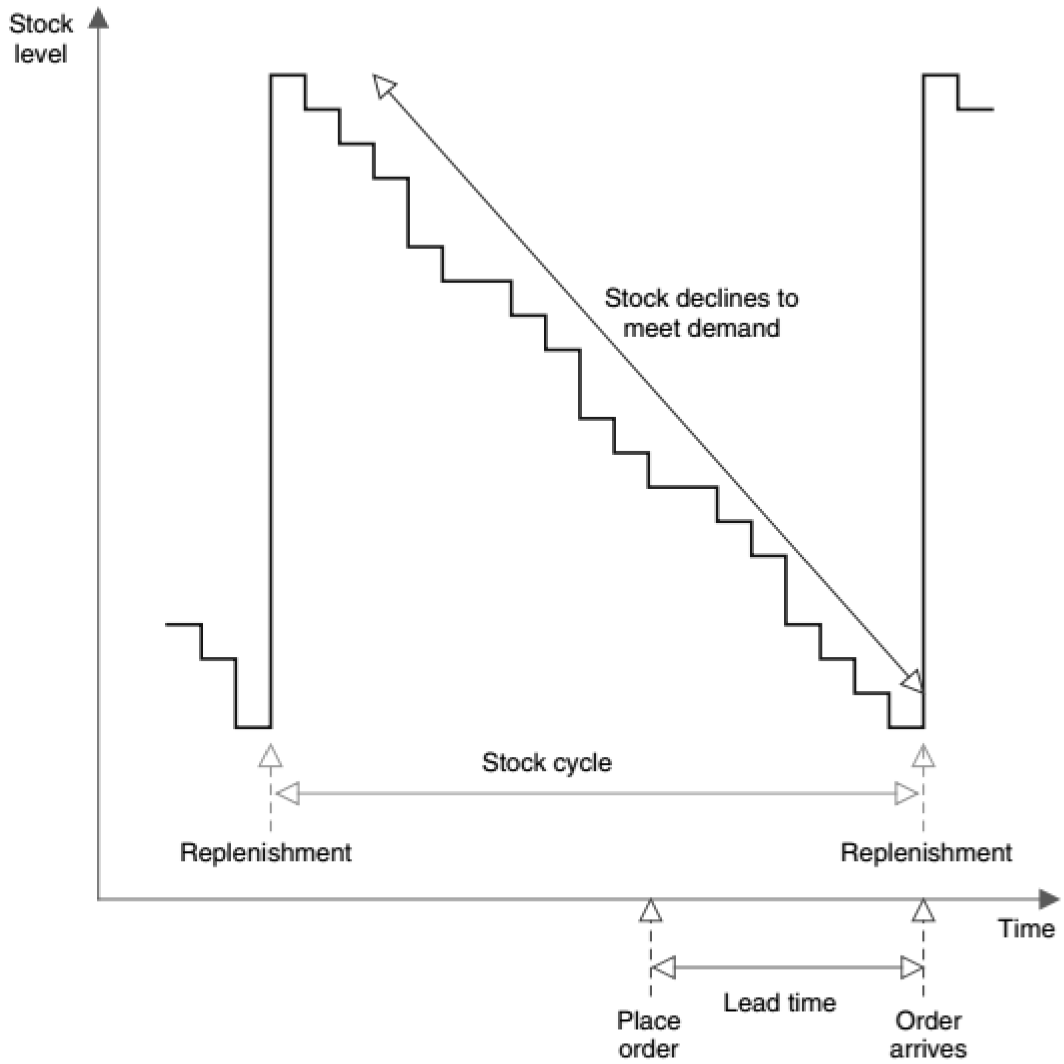

Figure 2. A typical stock level pattern in stock cycle [3, p. 6].

There are many different arrangements as materials move through the stock cycle. There are actions done in purchasing, storage and delivery. All of these arrangements have costs and organizations take a considerable amount of effort to minimize these costs. Reduction of costs is the main reason for inventory management. [3]

2.3 Reasons for holding stocks

Holding stocks is expensive, because of the tied-up capital, warehousing, protection, deterioration, loss, packaging, insurance and administration. Although having stocks might seem expensive, they have a significant role for an organization to work properly. One reason for having stocks is the need for a buffer between supply and demand (Figure 3). [3]

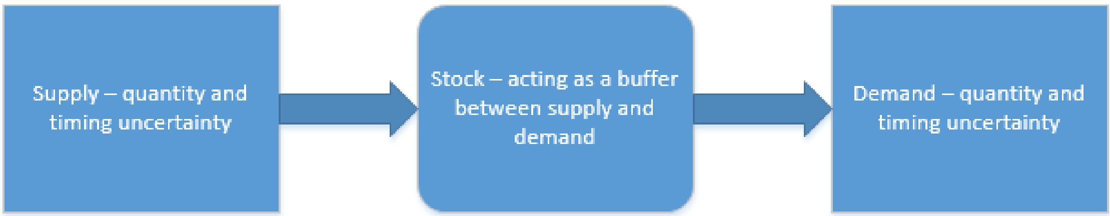

Figure 3. Stock seen as a buffer between supply and demand [3, p. 9]

It is impossible in certain industries to perfectly match the supply and demand (just-in-time deliveries), and although it might be possible, it would be too expensive. The stock allows a mismatch between the supply and demand with a fair cost. The stock also allows for variation and uncertainty in supply and demand, and lets operations to continue non-stop when there are problems. Here are some other reasons why organizations hold stocks:

- To allow demands that are larger than expected, or at unexpected times.
- To allow deliveries that are too small or delayed.
- To allow mismatches between the best rate of supply and the actual rate of demand.
- To decouple adjacent operations.

- To avoid delays in passing products to customers.
- To take advantage of price discounts (large orders).
- To allow the purchase of items when the price is low and expected to rise.
- To use the full capacity of a delivery and reduce transport costs.
- To cover for emergencies. [3]

2.4 Types of stocks

Organizations hold different kinds of stocks. Stocks are always connected to operations as shown in Figure 4. There are three main types:

1. Raw materials: these are from suppliers and are kept until needed for operations.
2. Work in progress (WIP): these are units currently being worked on.
3. Finished goods: these are waiting to be sold to customers. [2]

Two additional stock types are:

1. Spare parts: these are for machinery.
2. Consumables, such as cleaners, oil and paper. [3]

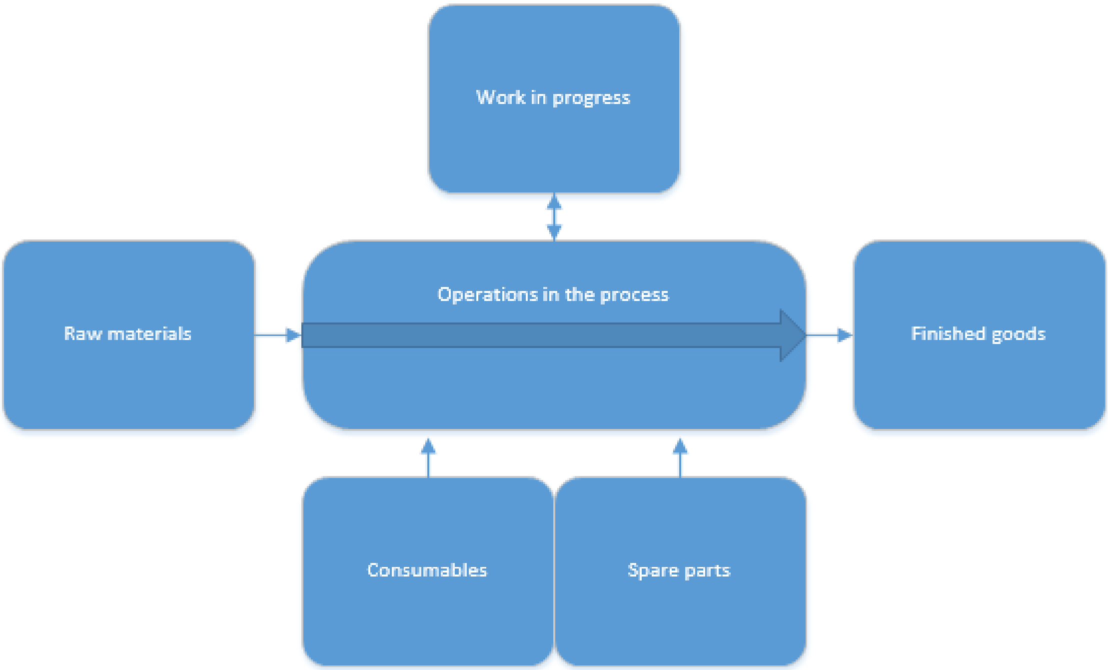

Figure 4. Different types of stocks [3, p. 10]

There are some other descriptions for stocks which are cycle stock (normal stock used during operations), safety stock (a reserve of materials for emergencies), seasonal stock (used to maintain operations during seasonal variations) and pipeline stock (currently being moved from A to B). [3]

2.5 Financial performance and stocks

Stocks affect production lead times and availability of materials, thereby affecting customer satisfaction and customer service level. A financial view of an organization is connected to stocks because they affect operating cost and therefore profit, return on assets/investments and many other measures of financial performance [2]. Figure 5 demonstrates how stocks affect return on assets (ROA, profit divided by assets). ROA gives a measure of how well the available resources are used in the organization. A high value of ROA means better performance. [3]

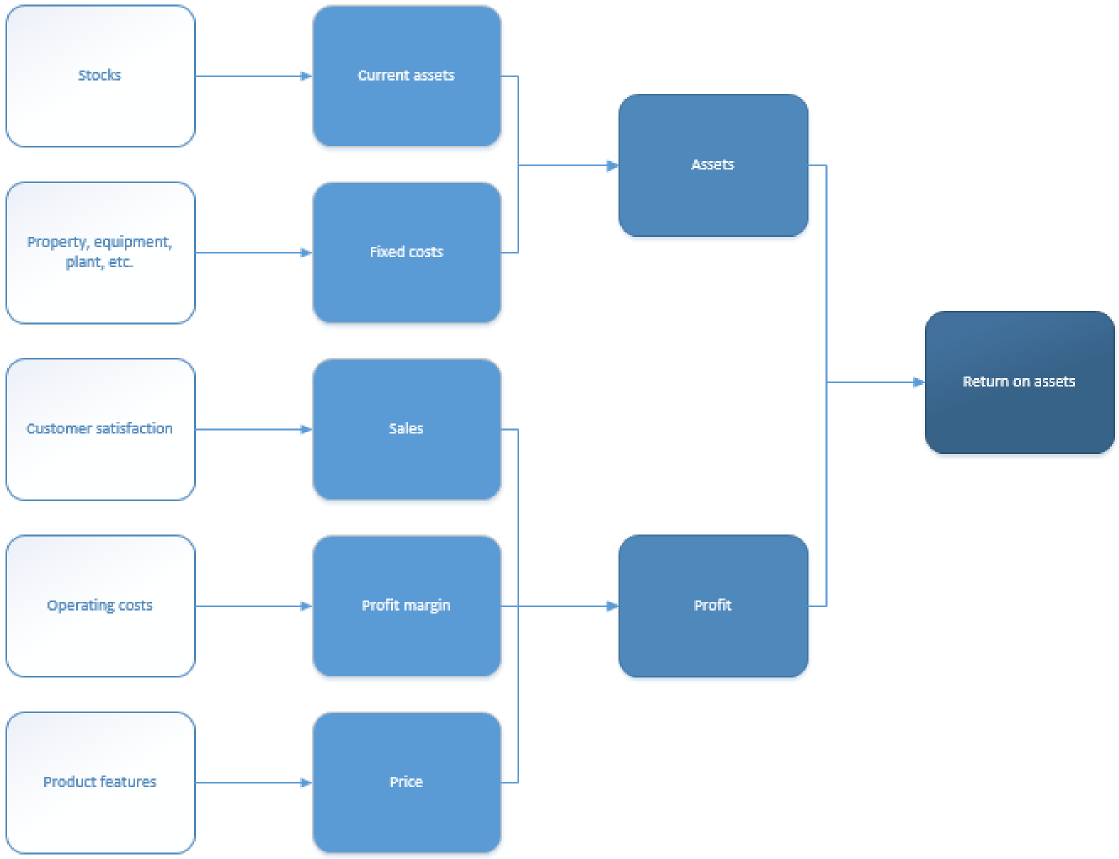

Figure 5. Linking between return on assets and stocks [3, s. 46]

In Figure 5 we see that the first two points reduce the value of assets and the last three increase profits. The combination can have a great impact on ROA. Here are the points explained:

1. Current assets

    a. Stocks are seen as current assets.

    b. Good inventory management can reduce stock levels and hence the current assets.

    c. Lower stock levels free up cash for more productive purposes.

2. Fixed assets

    a. Warehouses holding stocks are property.

   b. Information systems that manage stocks form a part of fixed assets.

   c. Material handling equipment is also a part of fixed assets.

   d. Good inventory management can reduce all of these parts.

3. Sales

   a. Increased availability of products allows proper delivery frequency and faster deliveries.

   b. Availability adds value to products and gives higher customer satisfaction.

   c. Higher customer satisfaction gives more orders, greater customer loyalty, new customers and higher sales.

4. Profit margin

   a. Efficient inventory management gives lower inventory costs.

   b. Lower inventory costs result in higher profit margins, or lower product prices for higher sales. [3]

2.6 Inventory performance

All stocks have costs. These costs vary largely, but a rule of thumb is that they are about 25 per cent of the value held a year as shown in Table 1. [6]

Table 1. Total cost for having stocks compared to the stock value [6, p. 444]

1	Interest costs	10 - 20%
2	Rental costs	1 - 5%
3	Labor costs	1 - 5%
4	Wastage costs	2 - 5%
5	Insurance costs	0,5 - 1%
	Total	19,5 - 36%

It is quite difficult to monitor inventory performance over time by using costs. A better way is to use more direct measures. Inventory turnover is the most common measure for deducing inventory performance.

$$Inventory\ turnover = \frac{number\ of\ units\ sold}{average\ inventory} \quad (1)$$

$$Average\ inventory = \frac{beg.\ inventory + end.\ inventory}{2} \quad (2)$$

Inventory turnover is a measure of the number of times the inventory is sold a year. [1]

3 Inventory control

Inventory control consists of inventory decisions that are immediate and affect the proper functioning of the stock cycle. There are three main questions surrounding inventory control: 'What items should we keep in stock?', 'When should we place an order?' and 'How much should we order?' In this section we will explore the tools for these important questions. [3]

Inventory control has two types of methods for answering the previous questions as shown in Figure 6. [3]

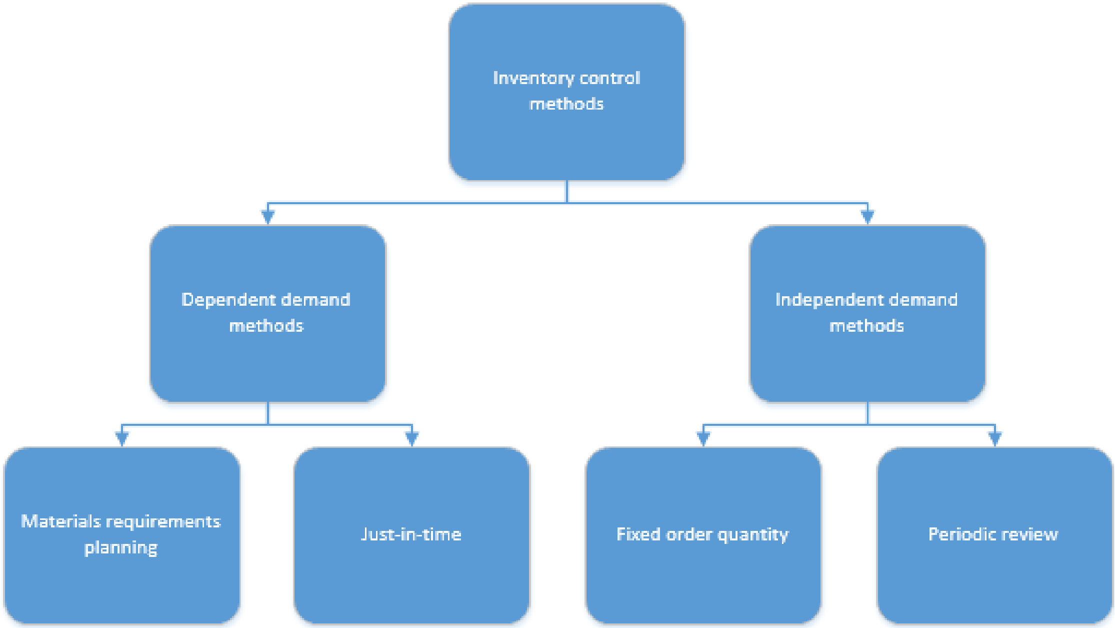

Figure 6. Different types of inventory control methods [3, p. 58]

Independent demand methods use forecasts of demand to define the optimal order times and quantities. Dependent demand methods use other kinds of methods of coordinating the supply and demand. Independent demand methods presume that every item has a demand that is prescribed from many independent demands from separate customers. In this way the only practical way to make forecasts is to look at the sales history. [6]

If we use the ABC analysis (Section 3.1) and the given lead times, we can make conclusions about which inventory control method to use as shown in Table 2.

Table 2. Choosing the right inventory control method [6, s. 458]

Lead time			
More than one month	*Fixed order quantity*	*Periodic review*	*Periodic review*
Between one month and one week	*Fixed order quantity*	*Periodic review*	*Periodic review*
Less than one week	*Periodic review*	*Visual control*	*Visual control*
	A	**B**	**C**

The classification technique shown in Table 2 tells that items in classes B and C, with a lead time less than one week, should be controlled with a visual control method. The visual control method is described as having a two-bin system. Items are stocked in two bins and as the first bin runs out it will be seen visually and an order can be placed. The order should arrive before the other bin runs out. [6]

3.1 ABC analysis

The ABC analysis is an inventory categorization method. Categorization is very important because it keeps the costs of inventory management reasonable by focusing the resources on where they are needed. The main idea is to divide items that are held in stock into three categories, A, B and C. The ABC analysis uses Pareto's principle as a base method. Pareto's principle states that 80% of the overall consumption value is based only on 20% of the total items, so there are top items that bring in most of the money from sales. An organization should focus resources on category A-items and category C items should get the least amount of attention. The visual illustration can be seen in Figure 7.

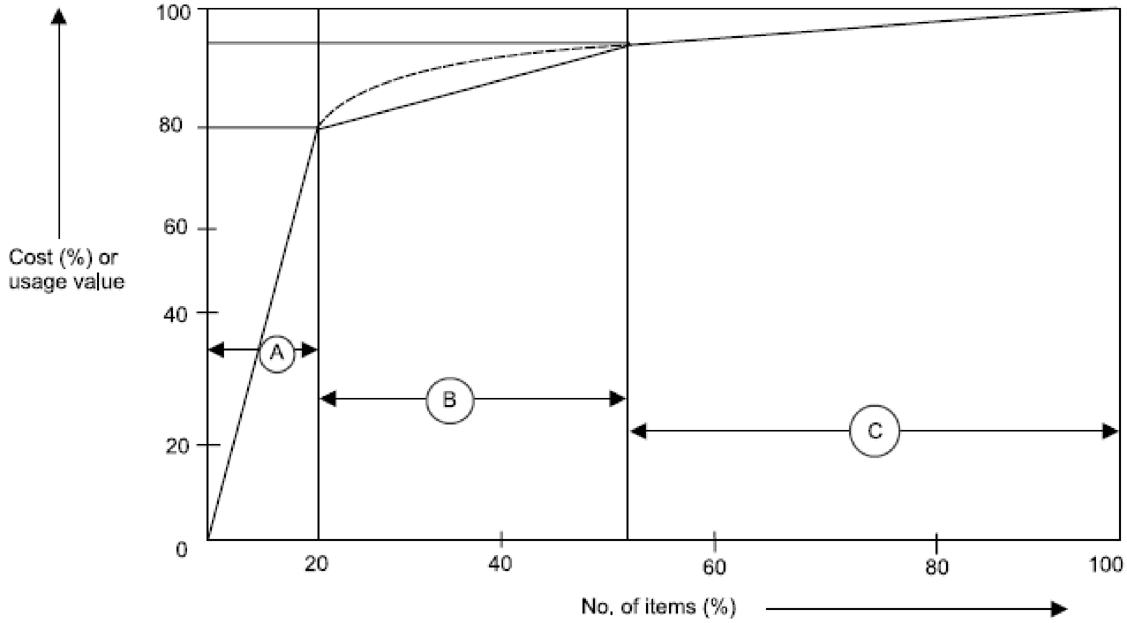

Figure 7. Graphical representation of ABC analysis (9)

The rules for the categorization are as stated in the following

- A-items have the highest annual consumption value (approximately 80% of the annual consumption value of the company accounts for only 20% of the total inventory items).

- B-items are between classes A and C, with a medium consumption value (approximately 15% of the annual consumption value accounts for 30% of the total inventory items).

- C-items have the lowest consumption value (approximately 5% of the annual consumption value accounts for 50% of the total inventory items). [7]

$$Annual\ consumption\ value = (annual\ demand)\ x\ (item\ cost\ per\ unit) \qquad (3)$$

3.2 Economic order quantity

Economic order quantity is one of the simplest ways of answering the inventory management question of how much to order. The approach is to construct a model of an ideal inventory system and calculate the fixed order quantity that minimizes the total cost for an order. The result is an optimal order size called the economic order quantity (EOQ). The EOQ comes from operations management and it is the most important analysis of inventory control. [3]

The stock levels of items change over time, with the following pattern shown in Figure 8. At one point delivery arrives from a supplier and the stock level rises. After this there are several points where the stock level declines (a customer buys the item and it is removed from the inventory). As the stock level decreases, there will come a point where an order is placed to replenish the stock level. This pattern repeats itself over time with some variations. Sometimes an unexpected demand occurs and the stock level goes below zero level to negative stock levels, which means that the demand was not satisfied. [3]

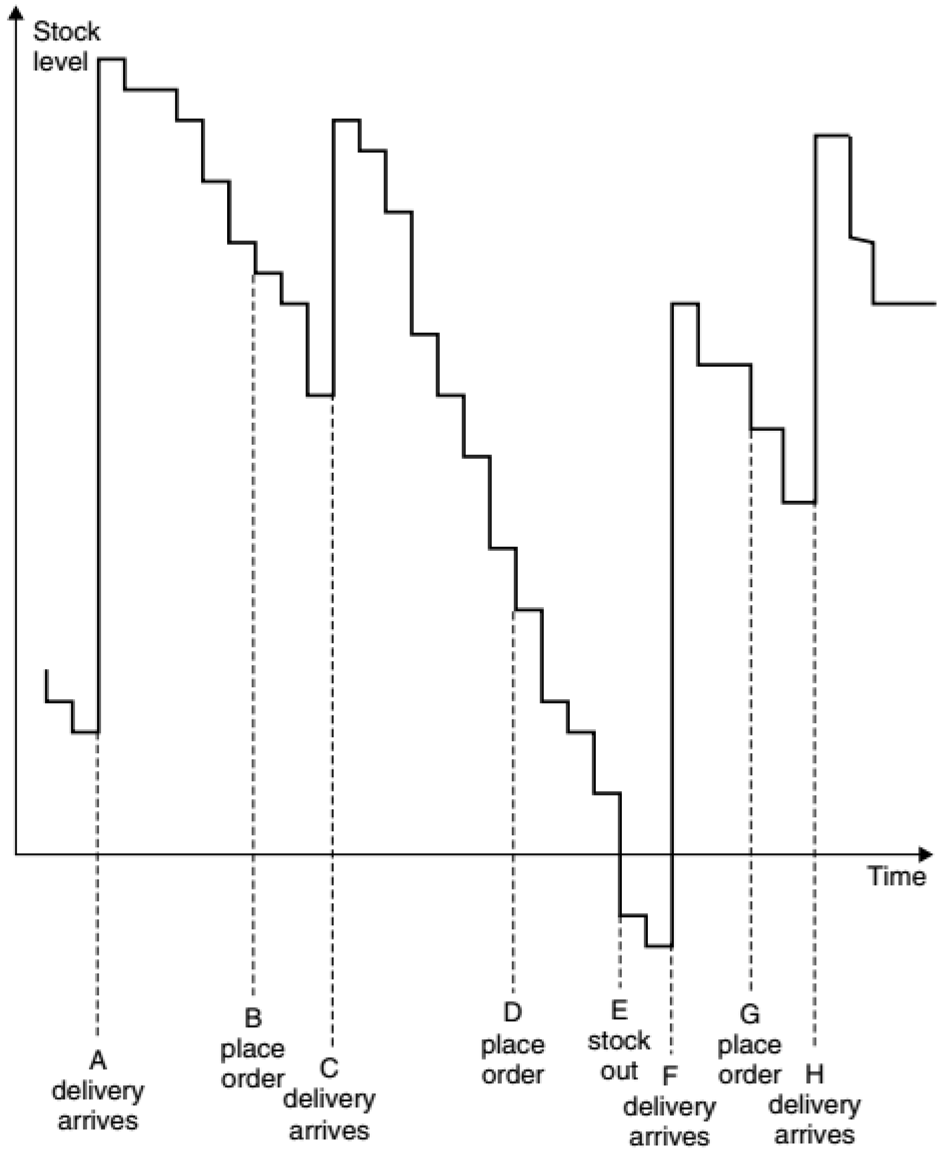

Figure 8. Pattern for an uneconomical order size (3, s. 66)

Figure 9 demonstrates one stock cycle with an optimal order size. The demand and cycle time must be equal because the stock level at the beginning and the end of the stock cycle is zero. [5]

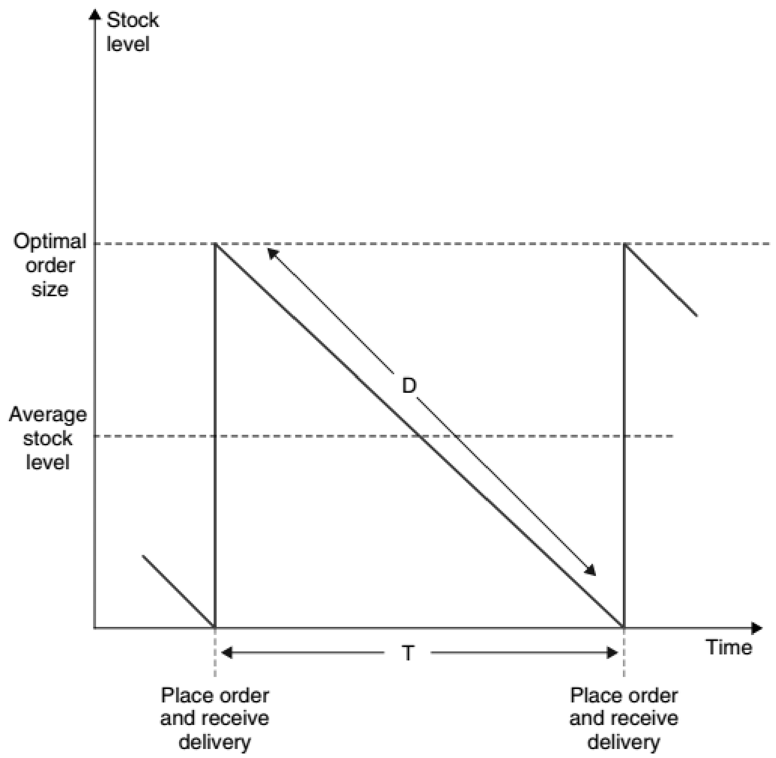

Figure 9. Demonstration of one stock cycle with an optimal order size (3, s.70)

The letters in Figure 9 are explained as follows:

- Order quantity (Q) is the fixed order size, here seen as 'optimal order size'.
- Cycle time (T) is the time between to orders.
- Demand (D) is the number of items taken from stock in a given time period. [3]

The optimal order quantity is always:

$$Q = D\ x\ T \quad (4)$$

Before the introduction of the EOQ formula we need to know the basic information about how the ordering quantity affects the total cost of the order (Figure 10).

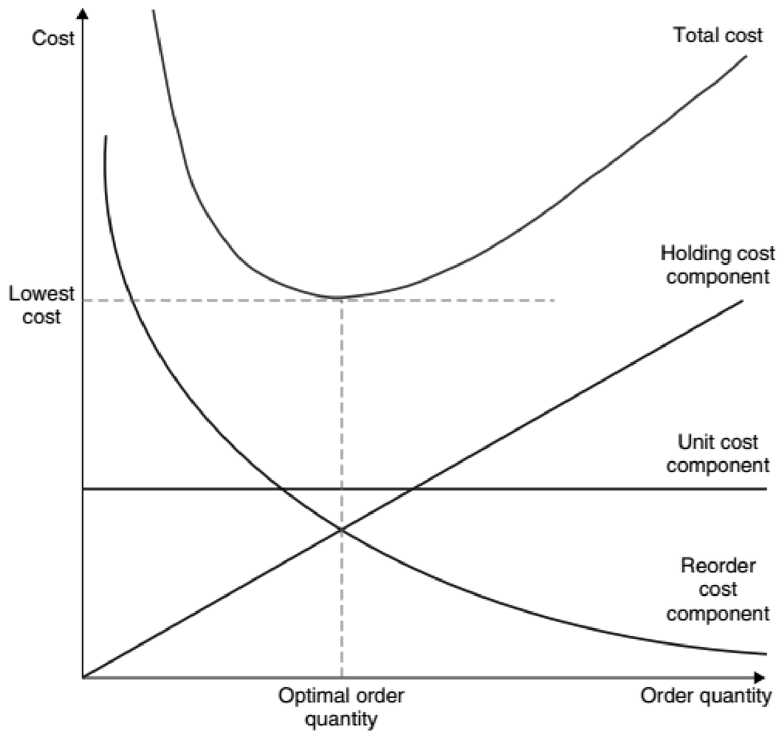

Figure 10. Effect of order quantity on the total cost (3, s. 72)

We can demonstrate the total cost curve and find the lowest total cost by calculating them with different order quantities. In Table 3 there are eight different order quantities and from those quantities we can calculate the HCC (holding cost component) and RCC (reorder cost component). The RCC sum HCC gives us a total cost with the chosen order quantity. The UCC (unit cost component) is not noted because it does not affect the results. We can find the optimum order quantity by looking at the results [3].

- UCC (Cost of the ordered units) = UC x Q

- RCC (Reorder cost of one order) = RC

- HCC (Annual holding cost for average stock level) = (HC x Q x T) / 2 [3]

In Table 3 we can see that the optimum order quantity is 200 because both HCC and RCC are as low as possible. [10]

Table 3. Excel calculations for finding the minimum total cost (10)

	A	B	C	D	E
1	Demand (units per year)	1000		Q (Order quantity)	
2	RC	20		HCC (Q / 2 x HC)	
3	HC	1		OCC ((D / Q) x RC)	
4					
5	Q	HCC	RCC	Total cost	
6	50	25	400	425	
7	100	50	200	250	
8	150	75	133	208	
9	200	100	100	**200**	*
10	250	125	80	205	
11	300	150	67	217	
12	350	175	57	232	
13	400	200	50	250	
14					
15	* Minimum total cost				

Although we can find the optimum point with the previous method, it is more practical to use the EOQ formula which finds the optimal order quantity by searching the point where the total cost is lowest.

EOQ formula [5]:

$$EOQ = \sqrt{\frac{2\ x\ RC\ x\ D}{HC}} \tag{5}$$

EOQ has the following variables:

1. Unit cost (UC) is the price charged by suppliers for one unit of an item.

2. Reorder cost (RC) is the cost of placing an order for the supplier. This cost includes everything from drawing-up an order, correspondence and telephone costs, receiving operations cost, supervision, use of equipment and follow-up.

3. Holding cost (HC) is the cost for holding one unit of an item in stock for one period of time. This cost includes administration, rental cost and handling cost. [3]

The EOQ assumes that the demand is known exactly, is continuous and is constant over time, all costs are known, no shortages are allowed and the lead time is zero. The results of the EOQ might not be optimal but they are good assumptions for inventory control purposes. EOQ tells the inventory manager the size of an order with the least costs for the organization. [4]

3.3 Reorder level

The economic order quantity assumes that there is no delay between when an order is placed to a supplier and when it arrives at the organization and can be used. This delay is called the lead time. There are many factors that generate the lead time. The time needed for order preparation, the time it takes to get the order to a supplier, the time the order spends at the supplier, the time it takes to deliver the items and the time it takes to process the delivery when it arrives at the organization. All of these factors together make up the lead time. A retailer for example might have lead times between one and four weeks. For the stock cycle to be working correctly and for there to be no stock-outs, the lead time will have to be noticed. A stock-out occurs when units in the inventory run out. [3]

When we know the lead time and the demand of an item, we can calculate the exact time an order needs to be placed so that would arrive at the same time the stock runs out. This way there will not be any excess stock or unsatisfied demand. This is called defining the reorder point (ROP). It is not practical for an inventory manager to calculate the reorder point repeatedly as the stock cycle repeats itself. Therefore it is more logical to calculate the reorder level (ROL), which is the optimal stock level for a replenishment order to be placed so that the stock level will not run out. Figure 11 explains how the reorder level works. [3]

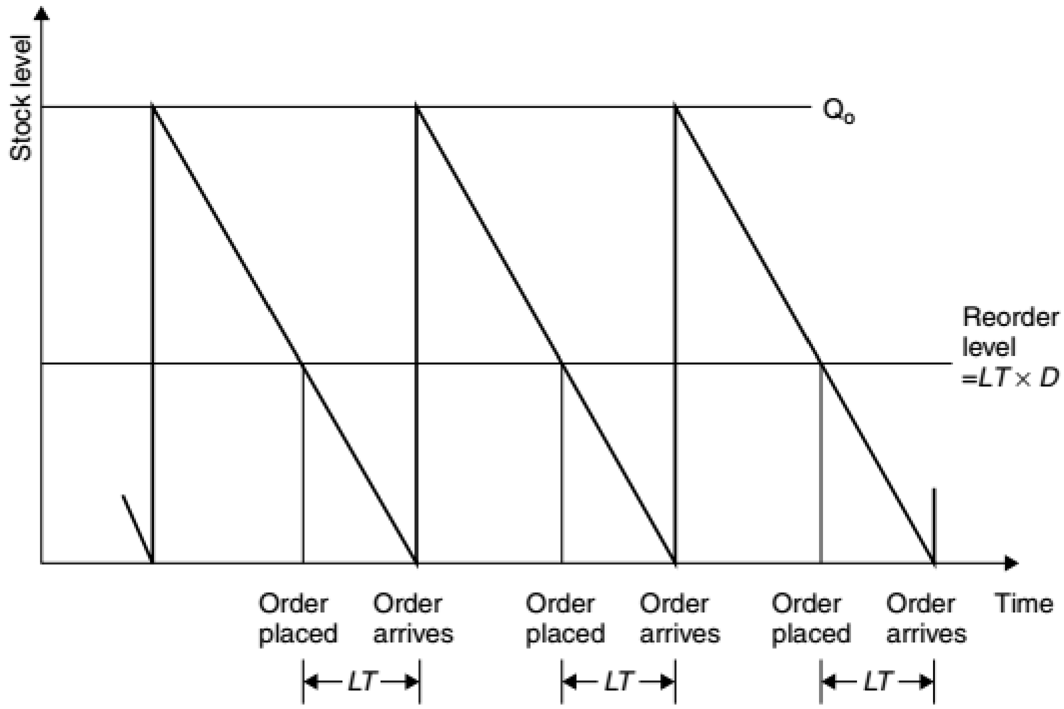

Figure 11. Stock cycles with a reorder level (3, s. 91)

Reorder level formula without safety stock is as follows:

$$Reorder\ level = lead\ time\ demand = lead\ time\ x\ demand\ per\ unit\ time \tag{6}$$

$$ROL = LT\ x\ D \tag{7}$$

This method takes lead time demand into account, but it leaves out the fact that lead time and demand both vary [3]. For example if we have calculated the lead time and the demand per unit time, we might still be wrong. A safety stock is added to make sure that the stock will not run out with some percentage. Safety stock is calculated here [11]:

$$Safety\ stock = Z\ x\ \sqrt{LT\ x\ STDEV(D^2) +\ D^2\ x\ STDEV(LT^2)} \tag{8}$$

$$Z = NORMSINV(Service\ level) \tag{9}$$

The service level can be taken from the ABC analysis. A-items were the top 20% products and they have a high service level of 98%. B items' service level is 93% and C items have a service level of 85% [7].

The final reorder level formula therefore is:

$$ROL = LTD + SS \tag{10}$$

SS is the safety level and LTD is the lead time demand. There are multiple Excel sheets that can be used for calculating the reorder level. Table 4 shows a simple sheet that uses the collected data to create the reorder level. [10]

Table 4. Excel sheet showing calculations for the reorder level (10)

	A	B	C	D	E	F	G	H	I	J
1										
2	Assumptions	Past Sales						Forecasted Sales		
3		heinä.07	elo.07	syys.07	loka.07	marras.07	joulu.07	tammi.08	tammi.08	tammi.08
4		5,91	5,01	5,03	5,29	5,97	5,89	5,5	5,5	5,5
5										
6		Lead time (months):		3						
7		Service level:		0,98						
8	Calculations				Formulas		Comments			
9		Lead time demand:		16,5	SUM(H4:J4)		Summing the forecasts			
10		Standard Deviation:		0,457063	STDEV(B4:G4)		Deviation in the past sales			
11		Service factor:		2,053749	NORMSINV(D7)		Inverse of the normal distribution			
12		Lead time factor:		1,732051	SQRT(D6)		Square root of lead-time to forecast ratio			
13		Safety stock:		1,625864	D10*D11*D12		Combining factors			
14		**Reorder level:**		18,12586	D9+D13		Lead time demand + safety stock			

In Table 4 past sales are entered up monthly because lead time is also entered as months. [10]

The numbers used in Table 4 are fictitious and they are only showing how the formula works inside Excel. In Section 4.2 I will discuss the methods chosen to be applied in the development proposal in more detail.

4 Case Metropoli Kaluste Oy & Cila Oy

4.1 Current state analysis

The current state analysis was done by interviewing the logistics manager both face-to-face and via email. In this analysis I will open up the ordering process and have a closer look at those parts of the process that needed improvement.

The logistics manager goes through all of the items in stock included in an order. He then calculates, by experience, the estimated demand until the point the order arrives. The ordered number of items is an assumption which is based on background information that some of the ordered items are already booked for customers and the items left from the order will fill up the stock as much as possible considering the limitations of the stocking space. Most of the items ordered have an established slot in the warehouse. The logistics manager only orders enough to fill up the stock levels to their maximum levels. The lead times for different items from different suppliers are more or less accurate. It takes The logistics manager about 20 minutes to place one replenishment order. The need for placing an order comes from the daily feedback received visually from stock and verbally from auditing the sales representatives.

There are no real calculations done in the process and therefore everything is based on assumptions. The typical stock cycle for the organization is illustrated in Figure 12.

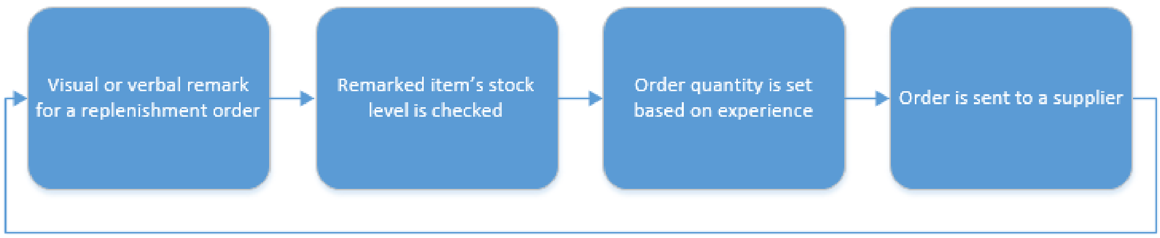

Figure 12. Actions done in the stock cycle of Metropoli Kaluste & Cila

The ordering process described here is very inaccurate, and because of this, the replenishment order is often sent too late and the ordered quantities do not match with the demand within the lead time.

4.2 Methods for development proposal

As I mentioned, in Section 4.1 the problem with the current ordering process is that there are no real calculations done. Nothing is based on sales history data or the real lead times, and the logistics manager has not made any calculations for a safety stock.

From a wide variety of different approaches for developing the ordering process, I chose, with the logistics manager, two main areas of improvement:

- Better timing for placement of orders.
- More accurate quantities for those orders.

Metropoli Kaluste is a retailer and therefore the demand for items comes from individual customers. This means that the methods should be found under the independent methods described in the Chapter 3. As I will explain in Section 4.3, the chosen items under examination are A-class items, and they are under regular monitoring, so I should use methods found under the area of the fixed order quantity method.

For finding out which fixed order quantity methods I should use, I searched the company's ERP system for sales history data. I found that all of the data was available and therefore I could use the methods described in Chapter 3. Table 5 describes the parts of the ordering process that needed improvement and the methods I used to improve them.

Table 5. Solution proposals

Problem	Solution proposal
Inaccurate quantities	EOQ (economic order quantity)
Inaccurate reorder point	ROL (reorder level)

Because there was a great amount of data needed for the calculations, the solution proposals was made as Excel calculations.

4.3 Items

The logistics manager gave me a list of the critical items that I should examine in this thesis. These items had a leverage effect on the organization's profitability. Table 6 shows the related A-class items.

Table 6. List of the A-items considered

Supplier	**LT** (months)	**Items**
Unituli	0,4	Runotar jenkki (bed), Runotar runkopatjapaketti (mattress)
Furnico	0,7	Aalto plus jenkki (bed), Aamu jenkki (bed), Uni runkopatja 120 (mattress), Uni runkopatja 80 (mattress), Uni petauspatja (pad)

Mobil House	1,5	Lombarda vitriini (showcase), Lombarda senkki (side-board), Lombarda tv-taso (tv stand)
Brandas	1,5	Metro jenkki 160 (bed), Metro jenkki 120 (bed), Petra vs. (armchair), Angelo vs-divaani (couch)
Neiser	1,5	Magna (couch), Nemo (couch)
Fleming	1,5	Manhattan (couch)
Scapa	1,5	Friday (armchair), Zero 2HA (couch)

LT in table 6 is the lead time for each supplier. Every product under its supplier has the same lead time.

The EOQ and reorder level calculations rely on sales history. I collected the sales history from a period of six months. The sales history was from the months between September 2014 and February 2015. Unit costs were also needed for the calculations. All of the collected data is illustrated in Table 7.

Table 7. Sales history for the requested A-class items

	2014				2015			
Item	**September**	**October**	**November**	**December**	**January**	**February**	**Item num.**	**Unit cost**
Runotar jenkki	11	4	2	4	3	2	P316086	434
Runotar rp-setti	7	3	8	5	8	10	P316094	352
Aamu jenkki	4	4	1	10	11	5	154020	202
Aalto jenkki	5	7	2	3	6	6	P320848-perus	328
Uni runkopatja 120	**0**	17	17	22	12	6	212012	119
Uni runkopatja 80	**0**	6	9	4	7	3	212011	82
Uni petauspatja	**0**	5	3	6	5	1	212013	28
Lombarda vitriini	0	0	0	1	1	1	11552N	360
Lombarda senkki	0	1	0	1	0	0	11581N	365
Lombarda tv-taso	0	0	2	1	1	1	11663N	306
Metro jenkki 160	3	5	1	7	3	4	102311	403
Metro jenkki 120	3	6	8	6	1	11	102310	316
Petra vs.	0	0	0	0	2	1	179040	258
Angelo vs-divaani	0	0	0	0	1	5	17900103	279
Magna	9	8	1	7	4	4	112009	618
Nemo	2	0	0	1	2	0	112664-erä	865
Manhattan	7	0	6	5	0	4	126112	409
Friday	0	0	0	0	1	0	140206	490
Zero 2HA	3	2	0	0	0	1	1286746339	403
All sales (thousand)	554	564	546	402	773	464		
All sales (items)	2916	2517	1915	1939	2189	2030		

Some items in Table 7 have sales only in one or two months. This makes it impossible to make trustworthy calculations based on their sales history. For the final calculations I chose´the items Runotar jenkki, Runotar rp-setti, Aamu jenkki, Aalto jenkki, Uni runkopatja 120, Uni runkopatja 80, Uni petauspatja, Metro jenkki 120, Magna and Manhattan. The selected items had enough sales history for reliable results.

4.4 Development proposal

I made the calculations for the EOQs and Reorder levels based on the collected theories and formula. I used two different methods for creating the reorder levels. One has the safety stock and the other does not. In Table 8 there are five items (the rest of the items can be found in Appendix 1). First I enumerated six months of sales history, then three months of forecasts and then the lead times and demands. The annual demand is based on the collected six months' sales history. Other figures were based on calculations (formula behind the calculations can be found in Appendix 1).

Table 8. Excel calculations for EOQs and ROLs

	Runotar jenkki	Runotar rp-setti	Aamu jenkki	Aalto jenkki	Uni runkopatja 120
September 2014	11	7	4	5	0
October	4	3	4	7	17
November	2	8	1	2	17
December	4	5	10	3	22
January 2015	3	8	11	6	12
February	2	10	5	6	6
March (forecast)	4,3	6,8	5,8	4,8	12,3
April (forecast)	4,3	6,8	5,8	4,8	12,3
May (forecast)	4,3	6,8	5,8	4,8	12,3
Lead time (moths)	0,4	0,4	0,7	0,7	0,7
Service level	0,98	0,98	0,98	0,98	0,98
Lead time demand	1,7	2,7	4,1	3,4	8,6
Standard deviation	3,4	2,5	3,9	1,9	8,1
Service factor	2,1	2,1	2,1	2,1	2,1
Lead time factor	0,6	0,6	0,8	0,8	0,8
Safety stock	4,4	3,2	6,6	3,3	13,9
Reorder level with safety stock	**6**	**6**	**11**	**7**	**23**
Annual Demand	52,0	82,0	70,0	58,0	148,0
Ordering cost	10,0	10,0	10,0	10,0	10,0
Annual Holding cost (%)	0,2	0,2	0,2	0,2	0,2
Unit cost	434,0	352,0	202,0	328,0	119,0
Moths per year	12,0	12,0	12,0	12,0	12,0
Lead time (months)	0,4	0,4	0,7	0,7	0,7
Annual holding cost/unit	86,8	70,4	40,4	65,6	23,8
EOQ (units)	**3**	**5**	**6**	**4**	**11**
Number of orders per year	15,0	17,0	11,9	13,8	13,3
Annual ordering costs	150,2	169,9	118,9	137,9	132,7
Annual Holding Costs	150,2	169,9	118,9	137,9	132,7
Total Costs	300,5	339,8	237,8	275,9	265,4
Total Purchase Price	22568,0	28864,0	14140,0	19024,0	17612,0
Purchase + Inventory Costs	22868,5	29203,8	14377,8	19299,9	17877,4
Reorder level without safety stock	**2**	**3**	**4**	**3**	**9**

As we can see in Table 8, there are two different reorder levels, one includes calculations for a safety stock and the other one does not.

Table 8 is the development proposal for the ordering process. With this Excel sheet the logistics manager can improve the order quantities and order times for his A-class items.

4.5 Results

The first item (Runotar Jenkki) has a steady sales history of about 4 items per month. Therefore the three following months have forecasted values of 4.3 items per month. The lead time for the item is 0.4 months. The service level is 0.98 deduced from the ABC analysis. The calculated demand for the lead time of 0.4 months is 1.7 items. The standard deviation calculated is based on the sales history and it softens up the calculations. The service factor is 2.1 and it is the Z number deduced from the service level. The lead time factor of 0.6 is based on the same principle. The safety stock is the two factors and the standard deviation multiplied. The safe stock calculations come from the idea of how much stock we need so that the stock will not run out with the probability of 0.98. The reorder level with the value of 6 is the safety stock added to the lead time demand.

EOQ is calculated with the reordering cost (10€), annual holding cost (86.8€) and annual demand (52 items). The EOQ, economic order quantity, is 3 units with the first item on the list.

The last calculations of the reorder level without the safety stock match with the lead time demand inside the first calculations of the reorder level with the safety stock as the lead time demand is 1,7 and the reorder level without the safety stock is 2. For example, the logistics manager should order the item Runotar jenkki when its stock level falls to 6 items and he should order a number of 3 items.

The logistics manager can use the final Excel calculations with his ordering process. If some of the changeable values in the excel sheet change, the logistics manager can overwrite them in their proper places within the excel sheet, and make the calculations more accurate. The six months of sales history should also be updated every month, so that the results were more precise.

The logistics manager might get respectable benefits by introducing the ROL and EOQ formulas into his ordering process. By examining the theory behind the overall results, we know that ROL and EOQ are well recognized in the field of logistics and inventory management. The benefits might be better customer satisfaction, increased sales, better usage of storage space, decreased inventory management costs and a leaner, more cost-efficient ordering process. Although we do not yet know how the introduction of these formulas will affect the functionality of the ordering process, we can deduce that their effects will most probably be positive.

For more accurate results, lead times and the desired service levels should be surveyed. Also exact unit, holding and ordering costs should be discovered. In my calculations I used pure assumptions based on the discussions between me and the logistics manager because their effect on the results was marginal.

5 Conclusion

Inventory management is an area of study concerned in the functionality of managing an inventory. The importance of inventory management and control is remarkable for an organization. Although the trend is towards reducing the amount of inventory to a near zero, small organizations cannot afford investing in projects that could lead to a zero inventory. In many organizations the purpose of inventory management is not all about reducing inventory but to control the inventory more efficiently.

There is a wide range of different inventory control methods. The methods concerning this thesis were fixed order quantity methods. Fixed order quantity methods are used when the stock is reduced by individual customers who together create an independent demand for an item. This independent demand can be forecasted with data from the related item’s sales history.

This bachelor of engineering thesis was done for Metropoli Kaluste Oy and Cila Oy. During this thesis I worked closely with the logistics manager of these two organizations. The whole process from contacting the logistics manager to the final results was exciting because at some moments, while working on this thesis, I discovered the real usability of my work.

I calculated the economic order quantities and reorder levels for the chosen A-class items. The development proposal is the Excel sheets I created in this thesis and they can be used by the logistics manager to create a better ordering process.

If the logistics manager introduces the development proposal and it ends up giving valuable results, the development should be continued. The Excel sheets can be used further for other products, although only for products that have at least 6 months of sales history.

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Excel calculations for EOQ and ROL

		Runotar jenkki	Runotar rp-setti	Aamu jenkki	Aalto jenkki	Uni runkopatja 120	Uni runkopatja 80	Uni petauspatja	Metro jenkki 160	Metro jenkki 120	Magna	Manhattan	
15													
16	**September 2014**	11	7	4	5	0	0	0	3	3	9	7	
17	**October**	4	3	4	7	17	6	5	5	6	8	0	
18	**November**	2	8	1	2	17	9	3	1	8	1	6	
19	**December**	4	5	10	3	22	4	6	7	6	7	5	
20	**January 2015**	3	8	11	6	12	7	5	3	1	4	0	
21	**February**	2	10	5	6	6	3	1	4	11	4	4	
22	**March (forecast)**	4,3	6,8	5,8	4,8	12,3	4,8	3,3	3,8	5,8	5,5	3,7	=SUM(B16:B21)/6
23	**April (forecast)**	4,3	6,8	5,8	4,8	12,3	4,8	3,3	3,8	5,8	5,5	3,7	
24	**May (forecast)**	4,3	6,8	5,8	4,8	12,3	4,8	3,3	3,8	5,8	5,5	3,7	
25													
26	Lead time (moths)	0,4	0,4	0,7	0,7	0,7	0,7	0,7	1,5	1,5	1,5	1,5	
27	Service level	0,98	0,98	0,98	0,98	0,98	0,98	0,98	0,98	0,98	0,98	0,98	
28													
29	Lead time demand	1,7	2,7	4,1	3,4	8,6	3,4	2,3	5,8	8,8	8,3	5,5	=(SUM(B22:B24)/3)*B26
30	Standard deviation	3,4	2,5	3,9	1,9	8,1	3,2	2,4	2,0	3,5	3,0	3,0	=STDEV(B16:B21)
31	Service factor	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,1	=NORMSINV(B27)
32	Lead time factor	0,6	0,6	0,8	0,8	0,8	0,8	0,8	1,2	1,2	1,2	1,2	=SQRT(B26)
33	Safety stock	4,4	3,2	6,6	3,3	13,9	5,5	4,2	5,1	8,9	7,6	7,6	=B30*B31*B32
34	**Reorder level with safety stock**	**6**	**6**	**11**	**7**	**23**	**9**	**6**	**11**	**18**	**16**	**13**	=B29+B33

37	Annual Demand	52,0	82,0	70,0	58,0	148,0	58,0	40,0	46,0	70,0	66,0	44,0	=B24*12
38	Ordering cost	10,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0	
39	Annual Holding cost (%)	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	
40	Unit cost	434,0	352,0	202,0	328,0	119,0	82,0	28,0	403,0	316,0	279,0	409,0	
41	Moths per year	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	
42	Lead time (months)	0,4	0,4	0,7	0,7	0,7	0,7	0,7	1,5	1,5	1,5	1,5	
43													
44	Annual holding cost/unit	86,8	70,4	40,4	65,6	23,8	16,4	5,6	80,6	63,2	55,8	81,8	=B39*B40
45	**EOQ (units)**	**3**	**5**	**6**	**4**	**11**	**8**	**12**	**3**	**5**	**5**	**3**	=SQRT(2*B37*B38/B44)
46	Number of orders per year	15,0	17,0	11,9	13,8	13,3	6,9	3,3	13,6	14,9	13,6	13,4	=B37/B45
47	Annual ordering costs	150,2	169,9	118,9	137,9	132,7	69,0	33,5	136,2	148,7	135,7	134,1	=B46*B38
48	Annual Holding Costs	150,2	169,9	118,9	137,9	132,7	69,0	33,5	136,2	148,7	135,7	134,1	=B45/2*B44
49	Total Costs	300,5	339,8	237,8	275,9	265,4	137,9	66,9	272,3	297,5	271,4	268,3	=SUM(B47:B48)
50	Total Purchase Price	22568,0	28864,0	14140,0	19024,0	17612,0	4756,0	1120,0	18538,0	22120,0	18414,0	17996,0	=B37*B40
51	Purchase + Inventory Costs	22868,5	29203,8	14377,8	19299,9	17877,4	4893,9	1186,9	18810,3	22417,5	18685,4	18264,3	=SUM(B49:B50)
52	**Reorder level without safety stock**	**2**	**3**	**4**	**3**	**9**	**3**	**2**	**6**	**9**	**8**	**6**	=B37/B41*B42
53													
54	**The calculations and the results are on the same rows, and they are marked with boxes!**												