

Improving the procurement process for better warehouse utilization

A case study at AstraZeneca Sweden Operations in Södertälje

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

CHRISTOPHER LÖVGREN

ERIK ORRSKOG

Department of Technology Management and Economics
Division of Industrial Marketing
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2012
Report No. E2012:087

Report No. E2012:087

Improving the procurement process for better warehouse utilization

A case study at AstraZeneca Sweden Operations in Södertälje

CHRISTOPHER LÖVGREN

ERIK ORRSKOG

Examiner: Jens Laage-Hellman

Supervisor: Igor Insanic

Supervisor AstraZeneca: Noomi Olsson

Department of Technology Management and Economics

CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg, Sweden, 2012

Improving the procurement process for better warehouse utilization

A case study at AstraZeneca Sweden Operations in Södertälje

© CHRISTOPHER LÖVGREN & ERIK ORRSKOG, 2012

Report No. E2012:087
Department of Technology Management and Economics
CHALMERS UNIVERSITY OF TECHNOLOGY
SE – 412 96 Göteborg
Sweden
Telephone +46 (0)31-772 1000

Reproservice, Chalmers
Göteborg, Sweden, 2012

Abstract

The purpose of this master thesis is to investigate the current procurement process for the packing material at AstraZeneca Sweden Operations in Södertälje. Based on this investigation guidelines for a new procurement strategy has been developed and presented to AstraZeneca. Due to growing customer needs and transfer of production from other sites to Sweden Operations, production volumes have increased at AstraZeneca in Södertälje. The introduction of new markets has also resulted in that the volume of the packing material has increased. This has led to overstocking of the current warehouse facilities which has in turn hindered production operations and forced scrapping of goods in storage. A possible reason for the occurrence of overstocking has been linked to the current procurement process.

The reason for focusing on procurement of packaging material is that it is a local function and as such it should be possible for AstraZeneca to implement a new strategy for this material locally. By analyzing how the production is planned and how the production is supplied a significant difference was identified. AstraZeneca produces its medicines in batches, each batch takes between a couple of hours to a couple of days to complete. The components are however procured to cover more than a single batch at a time.

The result of this master thesis is the recommendation that the procurement of packaging material for the medicines should more closely follow the actual production, this should reduce the pressure on the warehouse by reducing average stock on hand. Further investigations are needed to determine how such a change would affect AstraZeneca both in financial terms as well as operational. Also the effect on suppliers has not been a part of the investigation and is as of yet unknown.

Keywords: ABC analysis, Manufacturing Requirements Planning (MRP), Procurement strategy.

Acknowledgement

We would like express our gratitude to everyone at AstraZeneca who has in some way helped us. The environment was always welcoming at the company either by setting aside time to be interviewed by us or by having provided us with necessary information. Without these the findings in this thesis would be greatly reduced.

We thank our supervisor at AstraZeneca Noomi Olsson for guiding us at the company, both by answering our questions and putting us in contact with relevant personnel. We also thank our supervisor at Chalmers Igor Insanic for his input on our work as it has progressed.

We hope that this thesis will help the reader to identify some of the issues that can be faced with inbound logistics and how these issues could be handled.

Christopher Lövgren and Erik Orrskog

Gothenburg, October 2012

Content

- Abstract.....i**
- Acknowledgementii**
- 1. Introduction 1**
 - 1.1 Background 1
 - 1.2 Purpose..... 2
 - 1.3 Scope and delimitations 2
 - 1.4 Outline of the thesis 3
- 2. Problem analysis5**
 - 2.1 Background to the problem..... 5
 - 2.1.1 Procurement and warehousing for packing material 5
 - 2.1.2 Supply and demand conditions at AstraZeneca 6
 - 2.2 Organization of purchasing 8
 - 2.2.1 Position of the purchasing department in a company 8
 - 2.2.2 Centralized purchasing and decentralized purchasing..... 9
 - 2.3 Material Requirement Planning (MRP) 9
 - 2.3.1 Design of a MRP schedule 10
 - 2.3.2 Bill-of-material..... 12
 - 2.3.3 Different types of stock..... 13
 - 2.4 Total logistics costs 14
 - 2.4.1 Data distribution of demand 14
 - 2.4.2 Calculations of total costs 15
 - 2.4.3 Calculating Safety Stock 18
 - 2.4.4 When to order 19
 - 2.4.5 Shortage costs and service levels 20
 - 2.5 ABC Analysis..... 20
 - 2.6 Summary of the research questions..... 22
- 3. Method.....23**
 - 3.1 Research approach 23
 - 3.2 Information collection 24
 - 3.3 Research process..... 26
 - 3.4 Quality of the research 27
- 4. Empirical Background.....29**
 - 4.1 The functional organization of purchasing and supply at AstraZeneca in Sweden..... 29
 - 4.1.1 Planning activities at AstraZeneca 30
 - 4.1.2 Material flow at AstraZeneca 30
 - 4.1.3 Warehouse operations in Gärtuna 31
 - 4.1.4 Warehouse operations for labels 33
 - 4.2 The ERP system at AstraZeneca 34
 - 4.3 ABC analysis 35
 - 4.3.1 The global ABC analysis..... 36
 - 4.3.2 Example of ABC 36
 - 4.3.3 Proposal of ABC analysis for packing material..... 37
 - 4.4 Determining safety stock and costs for material at AstraZeneca 38
 - 4.4.1 Safety stock 39

4.4.2 Cost allocated to materials.....	41
5. Analysis	45
5.1 Organization of purchasing and supply	45
5.1.1 Centralization and decentralization of purchasing.....	45
5.1.2 Planning activities at AstraZeneca	46
5.1.3 The material flow.....	47
5.1.4 Cost for materials	47
5.1.5 Safety stock	49
5.1.6 Expand the warehouse	51
5.2 The ERP system	51
5.3 ABC analysis	52
5.3.1 Procurement based on global ABC analysis	54
5.3.2 Procurement based on proposed ABC analysis.....	56
6. Discussion and conclusions.....	59
6.1 Recommendations	61
6.2 Further research.....	62
Works Cited.....	63
Appendix A.....	65
A1. Costs for warehouse.....	65

FIGURES

Figure 1 How time fences relate to each other depending on time aspect (Jonsson & Mattsson, 2009).
..... 11

Figure 2 A Bill-of-Material for a table 13

Figure 4 Illustration of normal distribution curve 15

Figure 5 Total cost as a result of ordering costs and inventory carrying costs (ibid). 16

Figure 6 inventory level over time with Wilson’s formula (ibid)..... 17

Figure 7 Systematic combining (Dubois & Gadde, 2002)..... 24

Figure 8 Research process for the master thesis..... 26

Figure 9 The organization for sourcing and supply..... 29

Figure 10 Material flow at AstraZeneca Södertälje 31

Figure 11 Total cost for the warehouse operations in percentage 42

Figure 12, Average manufacturing cost of a medicine at AstraZeneca 43

Figure 13 The issue with days cover for articles with low demand..... 50

Tables

Table 1 Some of the parameters used in a MRP and what they determine (Jonsson & Mattsson, 2009) 10

Table 2 Relation between gross and net demand. 11

Table 3 Corrected planning horizon..... 12

Table 4 Interviewed persons at AstraZeneca 25

Table 5 Parameters in the MRP 35

Table 6 The ABC classification at AstraZeneca 36

Table 7 Four different medicines with four different classifications..... 37

Table 8 A proposals for a different ABC classification of the inbound articles 37

Table 9 How the used ABC classification can effect an article 38

Table 10 Possible reduction for the new procurement strategy..... 55

Table 11 Average stock depending on number of orders per year 55

Table 12 Actual difference for three labels between two ABC analyses 57

Table 13 Procurement regularity depending on ABC classification..... 61

1. Introduction

The introductory chapter will give the reader a background to the company AstraZeneca that will serve as a basis for the whole report. The purpose of the report will also be explained and why a new procurement process needs to be developed at AstraZeneca in Södertälje. This will be combined with the scope and delimitations that will explain what is not included in the study and also the whole outline of the report.

1.1 Background

AstraZeneca is a global company that provides medicines for the healthcare industry, with focus on research, development and, marketing of medicine. In 2010 AstraZeneca employed nearly 63,000 persons worldwide with an annual turnover of 33,3 billion dollars (AstraZeneca Responsibility Report, 2011). In Sweden there are both divisions for development of medicine and production units. The part of AstraZeneca Sweden that is responsible for the manufacturing of medicine is called Sweden Operations and this is the largest manufacturing unit within AstraZeneca.

The margins in the medical business are normally very high. However as the market has entered a time where a lot of patents are coming to an end there is a need for cost reduction and better planning strategies. When the patents run out new players are allowed to enter that market and with increased competition there is a need for being competitive in all parts of the supply chain. AstraZeneca has in recent years put more effort into reducing waste in the manufacturing and distribution. The general focus in the medical business in this area is low since high margins on medicines have put focus on other parts of the company, such as R&D. One of the key elements for AstraZeneca to keep their business success is to give the customers a stable supply of quality medicines and to do this in the most cost effective way (AstraZeneca, 2011).

AstraZeneca has implemented a new Enterprise Resource Planning (ERP) system. The current procurement process used to restock the warehouse was developed some time ago and is based on Wilson's formula. The data used at AstraZeneca has not to any significant extent been updated to meet the present situation. Before the new ERP system was installed the inventory levels were manageable but there have been times where the warehouse has been overstocked and a more coherent procurement strategy is desired. During the transition period into the new system a safety stock defined in day's coverage has been added. This has led to a further need for a clear and stable procurement process.

Changes in customer demand and movement of production volumes to AstraZeneca Södertälje have increased the pressure on the warehouse operations at AstraZeneca. This is further affected by AstraZeneca entering more and smaller markets, which have market specific requirements on packaging materials. This increase of the inbound flow of materials, especially packaging materials, has at times led to overstocking in the warehouse. Therefore there is a clear need for AstraZeneca to review their procurement process/strategy of

packaging materials to ensure that the production plants have the needed materials while at the same time reduce the risk of overstocking the warehouse.

When the warehouse for the packing material is being over utilized it results in several problems that can be critical for the whole production at AstraZeneca. The current situation is that the warehouse has been over utilized during certain times, which leads to problems when new material arrives to the warehouse. Since the warehouse for the packing material is a fully automated warehouse the problem that no new material can be added also results in that it will be hard for the inventory to supply the production with the material that is needed. In the worst case this can cause disruptions to the production which can result in losses for AstraZeneca.

The packing material that is used at Astra Zeneca can differ a lot depending on what product that is manufactured. The medicines produced at AstraZeneca in Södertälje are distributed all over the world; this results in that some of the packing material is produced in very high volumes while other packing material is only produced once every year. As a consequence some of the packing material is being stored for very long periods of time before it is used. In the health care industry there are strict regulations on how the packing material is designed and what sort of information that is included in the final product. Due to new regulations and changes in the design new packing material has to replace the old packing material, which means that the old packing material in the warehouse needs to be scrapped. This is another reason why AstraZeneca would benefit from reducing safety stock since when new regulations are enforced they don't have to replace as much of the packing material.

AstraZeneca procures a number of different articles that can be grouped into separate categories, and one such group is packing material. Depending on the article that is bought it is important to have clear guidelines on when to buy and in what amount to buy. This involves several departments in the supply chain such as the warehouse, production, procurement and logistics. To be able to do this in the most effective and efficient way several performance measures from these departments need to be considered. These can be in direct conflict to each other and therefore it is important to have an overall grasp of the problem in order to create a procurement process that fits AstraZeneca's needs.

1.2 Purpose

The purpose of the master thesis is to give guidelines for a new procurement process for the packing material at AstraZeneca in Södertälje. This will be done by examination of the current procurement process and the strategies at AstraZeneca in Södertälje.

1.3 Scope and delimitations

In order to be able to present relevant results in this master thesis some delimitations need to be established. However to present a complete procurement strategy for all goods is not deemed possible within the time phase of a master thesis. This strategy is then to be used as a starting point when determining procurement for the other goods. Further it has not been possible to test and evaluate the new strategy in an actual situation. The final solution and

guidelines that will be presented in this master thesis will are not a full solution for the whole of AstraZeneca. It is rather a starting point for the complete development of a new and sounder procurement process. This will result in that there is no validation of the results. This is again connected to the timeframe of the master thesis.

The procurement process is dependent on several actors in the supply chain. In this report the facts that are gathered are provided by data and interviews from AstraZeneca and no interaction has taken place with the customers and suppliers outside of AstraZeneca. For this master thesis report the important part is the internal factors at the company and this is where the focus will be.

1.4 Outline of the thesis

This master thesis will not only be an empirical investigation on how to manage a procurement process but also take an theoretical approach on how this can be done in the most efficient and effective way. The outline of the report will be as follows:

Chapter 1, *Introduction*, this chapter will give the reader a background to the problem, both from a theoretical point of view and also from the company point of view. The purpose of the master thesis and the outline of the report with a short summary about each chapter are described.

Chapter 2, *Problem analysis*, here the problem will be described and connected to the purpose of the report. The current situation will be defined to get an understanding about what theoretical framework that is needed. A theoretical framework for the report will also be presented; this framework will be the basic foundation for the coming chapters of the report.

Chapter 3, *Method*, in this chapter the methods for gathering information are described to the reader.

Chapter 4, *Empirical background*, this chapter will give the reader an understanding about how the current process works at AstraZeneca.

Chapter 5, *Analysis*, The current processes for material flow and procurement will be analyzed through the application of the theoretical framework on the empirical findings elucidated in chapter 4.

Chapter 6, *Discussion and Conclusions*, The results of the investigation is presented in this chapter as well as the recommendations for AstraZeneca when going forward.

2. Problem analysis

This chapter will provide the reader with an analysis of the problem that is connected to the purpose of the report. The process of how the packing material is handled at AstraZeneca in Södertälje will be described and also what departments that are involved in this process. The surrounding environment of the packing material will also be discussed to get an understanding about which factors there are that (can) affect the core process of purchasing and supply. This analysis of the problem will also be connected to the theory in a theoretical framework that will be the basis for the structure of the report.

2.1 Background to the problem

In order to get an understanding about the procurement process of the packing material it is important to get an understanding about the material flow from the start of the production to the final customer. This is also combined with the theoretical point of view when it comes to material flow and inventory control.

The focus at AstraZeneca has been in trying to keep the stock of the finished goods inventory as low as possible since this is where most of the tied-up capital is located. A finished medicine is considerably more valuable than the production material and there is also an expiration date on the medicine. This makes it important for AstraZeneca to store the medicine in the finished goods inventory as short time as possible since it is not allowed to sell medicines that are near the expiration date. The planners at the production sites are in charge of the planning of both the inbound flow of articles as well as of the finished goods inventory at their respective sites. Global planners that are located in United Kingdom help support the local planners by following up on the stock levels of finished medicines at customers/distribution to assure that they fall within agreed levels. There exists an ABC-analysis for the finished goods inventory that determines how often a medicine should be produced which helps the planning of the production. AstraZeneca receive forecasts on quantities that should be sold to different parts of the world. These forecasts are done by each Market Company that is located in each country/region and are in part what the ABC analysis has been based on.

2.1.1 Procurement and warehousing for packing material

The packing material at the warehouse in Gärtuna is procured with two different methods. The first method is Supplier-Managed Inventory (SMI), which is also known as Vendor Managed Inventory (VMI) and is a partnering initiative to improve and get quick response in the supply chain (Waller et al., 2001). In this method the supplier keeps track of the inventory and replenishes it when necessary which means that the supplier can plan their production in a more efficient way. The other method that is used is a more typical procurement process where a safety lead time is used in order to plan for fluctuations in demand. Approximately half of the articles in the inventory at AstraZeneca are procured with SMI and the other half is procured with the more typical process which takes into consideration safety lead time. One

type of article that is used in nearly all the finished products are labels of different kinds. These articles are nearly exclusively procured in the normal way with safety lead time. This is why the focus of this report will be on the procurement process for the labels. The procurement strategy for the labels can later serve as the basis for finding solutions for the rest of the articles in the inventory.

As mentioned the warehouse in Gärtuna is fully automated which means that the warehouse uses machines in the inventory that perform all the operations necessary inside the warehouse. The warehouse uses a floating placement of the pallets implying that, every time there is a new pallet that is added to the inventory it is positioned where there is space. This way of handling the inventory makes it easier to fully utilize the inventory; as this results in that the pallet capacity in the inventory does not need to be as large (Lumsden, 2007). The warehouse in Gärtuna has different number of positions for specific dimensions of the pallets and there have been some problems where some positions with certain dimensions in the inventory have been fully utilized. This result in big problems as no new material can be stored in the warehouse until there is more space. Since the finished products are a combination of several of the products in the inventory it may stop the production. There is a possibility to place the pallets with smaller dimensions where pallets of bigger dimensions should be and therefore it is normally the pallet positions with big dimensions that run out of places. Depending on the volume that is procured different number of pallet positions will be needed to store the procured products. At a certain point in time when more items are procured the volume of the bought items will need one more pallet. This may be the case in some situations where there is nearly empty pallets added to the storage. This does not result in more tied-up capital but that one more pallet position is used which results in less space of other articles and ineffective capacity utilization.

How the operations at AstraZeneca in Södertälje are executed and the inventory is structured raises the research question that will be important to investigate and analyze before the recommendations of the procurement process can be done.

Q1 – How is the current management of the finished goods inventory affecting the procurement process of the packing material?

The following section will look into some of the conditions for the industry that AstraZeneca operates in which will help in clarifying what is important to focus on.

2.1.2 Supply and demand conditions at AstraZeneca

AstraZeneca is a company that operates in the pharmaceutical industry, which in turn is a part of the healthcare industry. The focus of the pharmaceutical actors is to in one way or another provide medicines or drugs that can be used to treat and cure illnesses. The pharmaceutical industry as a whole is a large and complex entity that at the least can be said to include five distinct key players (Shah, 2004):

- The large international research and development companies both for prescription drugs and over the counter drugs, with own production facilities in multiple countries and brand presence on a global scale.

- Large international companies that produce generic medicines, where the patent has already expired.
- Small and local manufacturers that produce for the home country, both generic medicines and products under brand license or contract.
- Contract manufacturers that do not have an own medicine portfolio, instead they produce intermediate stages of the medicine, active ingredients and in some cases the end product.
- The drug discovery or biotechnical companies, typically these companies only research new medicines since they lack manufacturing capacity.

AstraZeneca is defined as large international research and development company, which is a type of company that dominates the pharmaceutical industry as whole. Historically the industry was categorized by high returns on investments and large turnovers on breakthrough medicines, which gave rise to the following practice of doing business (ibid).

- Insuring good R&D productivity, often focusing on finding cures for previously incurable disease.
- Long effective patent lives for these medicines.
- These patents were also meant to provide barriers against entry for competitors.
- Low price sensitivity

These practices led to a strategy that focused on ensuring high margins through exploitation of price inelasticity and then investing a large part of the sales profits into the R&D department to insure that new medicines were in the pipeline. However today the situation has changed and is more challenging than before (ibid). This is due to a combination of several factors. Among them are that the R&D productivity in terms of breakthrough medicines has declined and the effective patent lives have shortened. Further the effectiveness of using patents as barriers against entry has decreased and the influence from other health care players has increased both in terms of price pressure and regulations on production practices.

In summary this means that in order for a new drug to gain approval it needs to fulfil one of the following criteria:

- Provide treatment for a disease that was previously untreatable.
- Show significant improvement in treatment over existing drugs.
- Have a significant price reduction over existing drugs.

Today one of the most important factors for companies in the medicinal industry is the time to market for drugs. The largest profits on a drug almost always come early in its product life cycle. Previously this could be said to be the first five years on the market. However this has been greatly reduced today and now it is around one to two years (ibid). Due to this development companies are less willing to invest in new drugs since the potential gains are smaller. Further the industry is always under rigorous scrutiny from government regulations

due to the fact that a drug can have affects that are adverse to the health of the patient. These regulations are present from conception of the drug and all the way until it is taken of the market. It is estimated that a new drug will require investments of up to 500 million dollars and on average eight to twelve years of development before the first sale (ibid).

To summarize the environment in which AstraZeneca operates puts several criteria on the procurement process. This in combination with the transformation of the pharmaceutical industry raises several questions that are important to answer when developing the procurement process.

Q2 – What criteria are the supply and demand conditions putting on the procurement process for AstraZeneca?

Q3 – How is the current procurement process handling these criteria?

The problem will further be discussed on a more detailed level in order to get a full view of the problem and later be able to find solutions. First an explanation to the background of the problem is described and later a theoretical framework is presented followed by the questions that can be important for AstraZeneca.

2.2 Organization of purchasing

To get an understanding of how the purchasing department at a company works and how it can be working together with other departments a literature review of this is done. This will later be used in the analysis as a basis for how the recommendations to AstraZeneca should be developed regarding what role the purchasing department should have in the process of purchasing the packing material.

The primary tasks for the purchasing function in a company are much more than only executing purchasing orders. The purchasing department needs to secure supply from different vendors, reduce the total cost, and the risk exposure and contribute to the innovation of the company products (Weele, 2005).

2.2.1 Position of the purchasing department in a company

There are several different performance measurements in procurement which may be in conflict to other departments' performance measurements. Also differences can occur due to where in the company structure the purchasing department is positioned. According to (Weele, 2005) there can be four distinctive management views on purchasing in companies:

- Operational, administrative activity: this is when the management uses performance measurements such as backlog, purchasing administrative lead time, number of orders issued, number of requests for quotations issued and adherence to existing procedures.
- Commercial activity: here the management knows the potential of cost savings in purchasing and uses different targets that should be reached. This can for example be the cost reduction on the price or the total cost reduction.

- Part of integrated logistics: in this type of company the management is aware of sub optimizing as a result of putting too much pressure on the purchasing department. This can for example be when a company strives towards cost reduction and the supplier's manufacture products with lower quality to be able to meet the price requirements from the purchasing department.
- Strategic business area: here the purchasing department is a part of the core business and the part of the company that makes it competitive.

Depending on how the management in a company looks at the purchasing department it can differ a lot on what that is important. When the purchasing department is a part of a strategic business area of the company it is usually dependent on the external factors of the company (ibid).

2.2.2 Centralized purchasing and decentralized purchasing

The purchasing strategy for a company can be divided between how the company should behave towards external factors such as suppliers and the internal factors such as different departments and people. How the purchasing department should be connected to other parts of the company can differ a lot between companies. There are two main ways of organizing purchasing and these are either through a centralized purchasing department or a decentralized purchasing department. The benefits of having a centralized purchasing department is that there will be larger volumes being purchased, which results in a better negotiation situation for the company (Gadde et al., 2010). The centralized approach also results in that the person doing the procurement can be more specialized.

The decentralized approach is often done when the purchased items are seen as an integral part of the overall performance of the company (ibid). This means that every part of the company makes their own decision from where to buy and in what amounts. This alternative doesn't get the benefits of economies of scale as the centralized alternative but the people that use the bought material have better control over the material. In big companies a mix between these two alternatives can be used to get benefits from both (ibid).

2.3 Material Requirement Planning (MRP)

Materials requirement planning (MRP) enables a company to produce and procure the material in an organized and structured manner. This chapter strives to better understand how this process works and to create a better understanding about how it can be used to create a better procurement process.

MRP is a widely used planning method in manufacturing companies today, and it is used to determine when the inventory level becomes negative and hence when planned deliveries are needed. The MRP method has been proven to be especially effective when dealing with dependent demand in contrast to finished products, which may have an independent demand that dictates the demand of all the other sub components (Jonsson & Mattsson, 2009). This dependence has to be taken into account when planning the production schedule and the inventory control. This requires more integration of production and sales then compared to

more traditional reorder point systems. The degree of integration can vary from case to case but it is necessary that there exist calculations for the required demand based on the bill of materials (Axsäter, 1979). With the development of contemporary MRP systems this integration is more or less complete, a new sales order is directly registered in the production schedule. In order for MRP to be possible the following criteria needs to be fulfilled (ibid)

- The production schedule for the finished products, which can be based on traditional forecast methods, needs to be updated continuously
- Access to the bill of materials.
- The inventory for all articles must be available.
- The lead time for all articles has to be given.

Since the demand for components is dependent on the demand of the finished product there exists a need to know when and how many finished products are needed. This is in order to allow for effective planning of the production. This is usually what is known as the planning horizon and it is dependent on the present lead times (Jonsson & Mattsson, 2009). The planning horizon is typically always in motion, when one workday has passed the planning horizon moves one day forward. As such there is always an overview of what is going to be produced for the same amount of days.

2.3.1 Design of a MRP schedule

When designing the MRP a number of parameters need to be selected and determined in order to have a successful implementation. In Table 1 some of the more widely used parameters are presented.

Parameter	Determines
Planning frequency	How often the MRP schedule is updated
Planning time fences	Length and function, there exists multiple time fences in a MRP schedule
Planning horizon	How far into the future does the MRP stretch
Rescheduling	How and when rescheduling is allowed in the MRP schedule

Table 1 Some of the parameters used in a MRP and what they determine (Jonsson & Mattsson, 2009)

The planning frequency refers to how often the MRP schedule is updated with information (Jonsson & Mattsson, 2009). This can be on a day by day basis. However in a production where batches have a long production time, like in the steel industry, a weekly update might be more appropriate. The MRP schedule incorporates a number of different time fences in order to allow for effective and successful scheduling. The most widely used time fences are: *release*, *demand*, *forecast*, and, *planning* time fence (ibid). Figure 1 illustrates how the different time fences relate to each other.

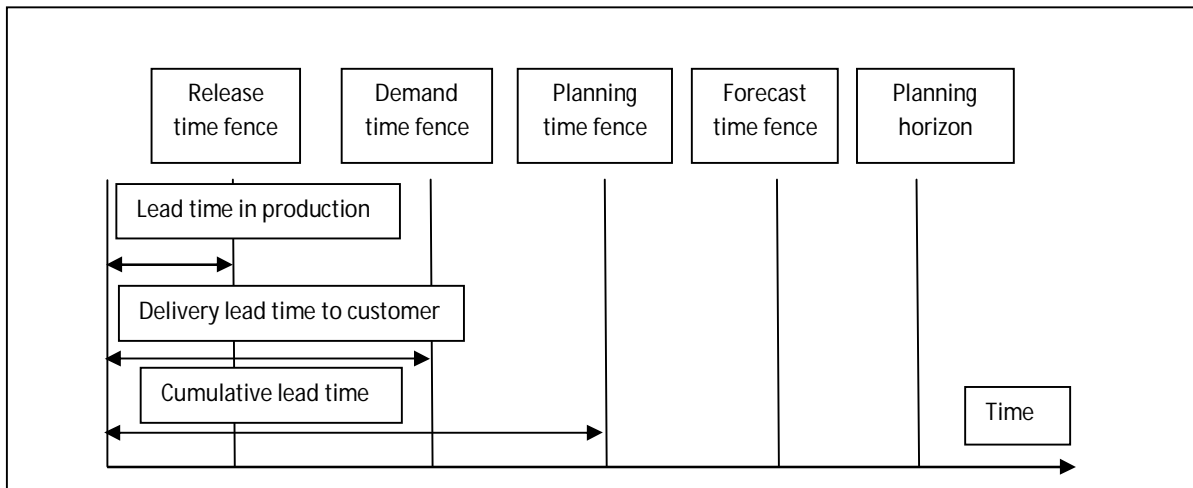


Figure 1 How time fences relate to each other depending on time aspect (Jonsson & Mattsson, 2009).

Within the demand time fence new customer orders are not allowed. In other words the production schedule is frozen. The forecast time fence is set so far that the order backlog is as small as to be insignificant when compared to the forecast. The orders that lie between planning and forecast time fence are more or less unfrozen, meaning that orders can switch place, change in batch quantity or even be cancelled. The release time fence is set for how far ahead of production start that the order is released. Once released materials/articles that are needed for production are allocated to the order, implying that they are no longer available to be used for other orders. The planning time fence inside this the orders are all planned and more or less firm. The gap between the demand time fence and planning time fence allows for orders to change sequence. Finally the planning horizon is present in the schedule mainly in order to detect possible trends in the future. If for example the number of orders is showing a significant increase or reduction there can be reasons to make changes in the production capacity.

The planning horizon in a MRP has to at least cover the longest accumulated lead time for production and procurement of all the included components (ibid). If it is shorter then production will not be planned in sufficient time and production will run behind schedule. In most cases the planning horizon is significantly longer then the accumulated lead time. Table 2 illustrates a simple case of how a MRP planning horizon can look.

Period	0	1	2	3	4	5	6	7	Total
Gross need		10		15			15	10	45
Planned deliveries							40		40
Storage	20	10		-5	-5	-5	20	10	10
Net need				5					5

Table 2 Relation between gross and net demand.

As can be seen in the Table 2 gross and net demand is not in balance and therefore a new planned delivery in period 3 is needed. When it should be released is dependent on the lead time, if it is one week it should be released in period 2 and the MRP would then be as seen in Table 3.

Period	0	1	2	3	4	5	6	7	Total
Gross need		10		15			15	10	45
Planned deliveries				5			40		45
Storage	20	10	10	0	0	0	20	10	10
Net need									0

Table 3 Corrected planning horizon

Since this is a simplified example the planned delivery of five items might be larger depending on different factors, which could be batch size if, it is produced in-house or it could be the economic order quantity if it is a sourced component. In addition this is for a single product and for a company like AstraZeneca there would exist one such schedule for each medicine produced. Also since each medicine is composed of multiple sub components there would be corresponding schedules for these articles, which are based on the final product demand. It is also of course possible that the sub components themselves consist of components which in their turn would also need schedules.

2.3.2 Bill-of-material

The finished product that a company sells is often a combination of several products that are procured externally or produced internally. The relationship between these parts of the product is called Bill-of-Material (Jonsson & Mattsson, 2009). The Bill-of-Material tells what a specific product consist of. This is a very important part when planning the whole supply chain of a company since the only part that needs to be forecasted is the main product. From the forecast of the main product the company should be able to tell exactly how much material they need of a specific product from the Bill-of-Material.

An example of how a bill of material works can be portrayed by a wooden table. To be able to produce this table the company needs one tabletop, four legs, eight screws and 1 dl glue. The Bill-of-Material will consist of the parts in Figure 2.

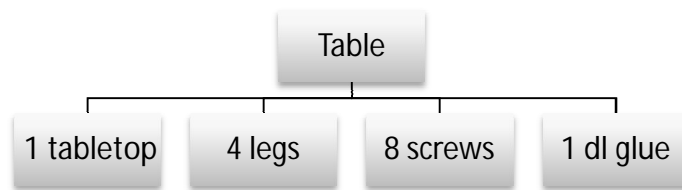


Figure 2 A Bill-of-Material for a table

The company then only has to make a forecast of how many tables they should sell and not a forecast on all the parts that the table consists of. In the Bill-of-Material the lead time of all the parts should be stated so that the company is able to plan the procurement of parts in time to the production.

Originally MRP would determine the production either by registering a new customer order on the schedule or producing to a forecasted demand. The only real constraint was that a new order is not planned within the frozen time fence (ibid). This lack of constraints can sometimes cause issues since there are limits to the production capacity in a facility. If this constraint is not taken into consideration the producing company may be promising more than it can deliver, an issue that AstraZeneca has to be aware of in order to effectively plan its production. And in the case where a company produces multiple products there is also the possibility that different products require the same production resources which further increases the constraints on the production capacity.

Q4 – Does the MRP at AstraZeneca take capacity constraints into consideration?

Production of any product requires the manufacturing company to keep stocks of articles in its inventory. The following section will look into stock classification.

2.3.3 Different types of stock

A company will typically categorize the stock it holds into a couple of different types. The categorization depends on the intended use of the stock. Two commonly used stock types are cycle stock and safety stock (Jonsson & Mattsson, 2009). Cycle stock, also called working stock, is the stock that is used in the everyday operations at a company. The size of the stock is dependent on the period of one cycle, the time between two replenishment points, and the demand for the same period (ibid). This means that longer cycles give higher stocks since a larger demand has to be covered. Usually components that have a high demand will have short cycles since they otherwise occupy too much of the storage facility, though this is not always the case. If for example space is no real issue or the number of different components is few longer periods can be used since this will reduce the ordering cost.

Safety stocks are used to guard against goods that are delivered late, order lines that are missing items, goods that have quality issues and more. There is a clear need for calculating the required safety stock since just adding an arbitrary level of safety stock is more likely to hide issues rather than preventing them. First of all a safety stock is a cost, in some cases as

high as 40 % of the annual stock holding value (Zizka, 2005), which companies should try to minimize. Second, it may also take up precious space in the storage facility. Instances where 50% of the inventory is safety stock are not uncommon (ibid), which can lead to difficulties in managing it properly. Third, there is also the possibility that safety stocks hides supplier issues such as late deliveries and, finally it can also provide false safety, since goods can expire or they can have quality issues that are not found before they are used.

2.4 Total logistics costs

The ERP system and many other functions in a company need to calculate costs and other measurements to be able to control the company in the right way. To get an understanding of how this is done, several theories of how safety stock and total logistic costs are calculated, are described in this chapter and this will later be used to give recommendations for AstraZeneca that both will be realistic and also fit to the ERP system that is used in the company.

2.4.1 Data distribution of demand

In order to estimate costs accurately a company needs to understand the demand for its products. Since it is the demand that determines how much it should produce and consequently how much it needs to procure in form of goods. It is nearly impossible to have a perfect synchronization of supply and demand, i.e. to have exactly what is needed when it is needed at any given point in time (Jonsson & Mattsson, 2009). This is offset by storing goods in inventory before they are actually needed (Axsäter, 1979). When an order is needed and how much is to be placed in an order can be generated by the MRP as is described in section 2.3.1. The MRP for these operations are based on order-point systems that will be described in this chapter. Further distribution of actual demand has to be taken into consideration, 100 percent of the demand is not connected to one single point in time but rather distributed over time.

Safety stocks are used to hedge against the risk of stock outs between two reorder points. Normally the reorder quantity is equal to the demand between these points. The demand is typically set as an average of the demand for the given time period, meaning that it can in actuality be more or less than the average (Jonsson & Mattsson, 2009). The safety stock is then present to cover the instances when the actual demand is larger than the average. The average demand is usually derived from historical data. By investigating the data distributions the actual demand can be found. These distributions can have different characteristics. Figure 3 illustrates a normal distribution curve.

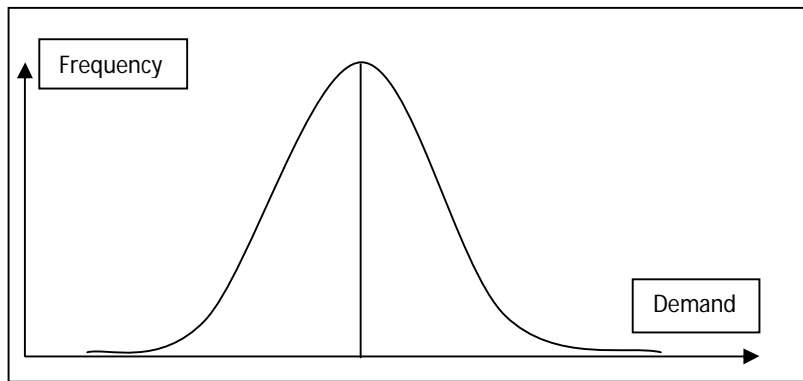


Figure 3 Illustration of normal distribution curve

In a normal distribution the data is evenly distributed around the center, the area under the curve is the same on either side of the center line. The demand can be said to be normally distributed if during the lead time the average demand is larger than two standard deviations (Jonsson & Mattsson, 2009). The advantage of relying on normal distribution is that it is only dependent on two parameters and it is therefore easy to adjust these two parameters depending on the situation (Axsäter, 1991). Further it is also fairly easy to utilize it for calculations of safety stock. There are situations where it is not advantageous to utilize normal distribution, e.g. when the demand for a product is low. The reason for this is that it is an approximate method and for such cases the impact of the approximation can be too large (ibid). Another situation where it is inappropriate is when the data is skewed to either side of the centre line. This means that it is more likely that the actual demand is focused to one side of the centre line, implying that it is most likely higher or lower than the average demand (Jonsson & Mattsson, 2009). When estimating total costs for production accurate demand data is required in order to get an accurate estimation, the next section describes how demand is used to calculate costs.

2.4.2 Calculations of total costs

There are several costs that arise for production companies. Two very important costs when looking at the procurement process are the procurement cost and the cost of keeping the material in stock. The basic issue of material planning is in what quantity the goods should be produced or procured. There is also a time dimension and in the perfect environment the order quantity is equal to the demand at that time. In this environment the tied-up capital is as low as possible but due to the lead time in the supply chain this is not realistic.

To solve this problem companies need to consolidate the demand from several occasions in to one quantity that can be produced and procured at a certain point in time. This is what is called lot sizing and will result in a stock that is called turnover stock. Most lot sizing methods are developed with regard to tied-up capital, customer service and internal utilization of resources (Jonsson & Mattsson, 2009). This can be described by a graph that shows how the ordering and inventory carrying costs results in a total cost that should be minimized, see Figure 4.

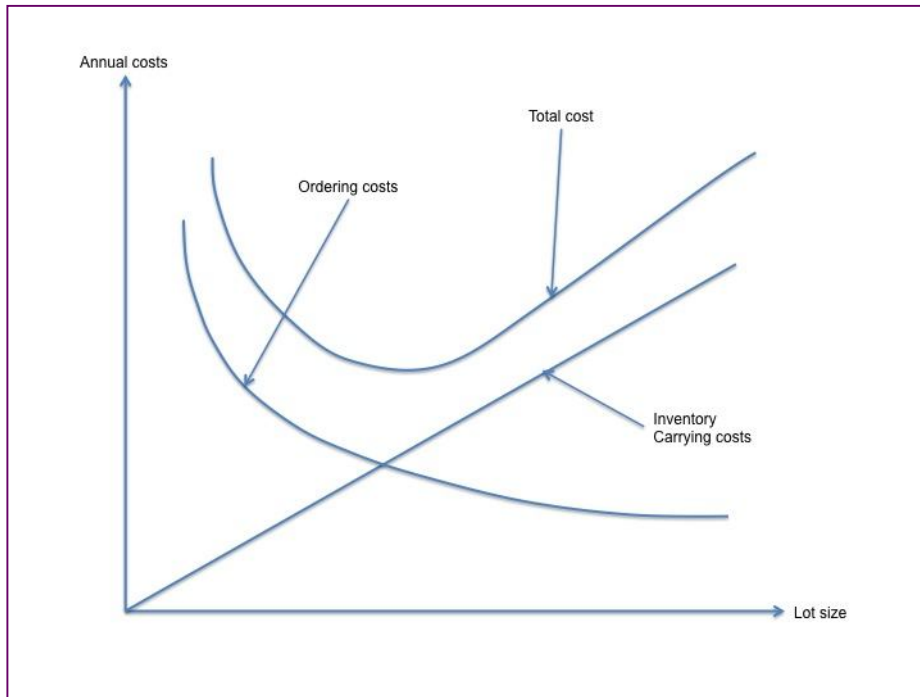


Figure 4 Total cost as a result of ordering costs and inventory carrying costs (ibid).

The ordering cost is the sum of all costs that are connected with the execution of the procurement; the inventory carrying cost is the sum of costs for the storage of the product. There are several different methods for deciding the lot size. These methods can be differentiated by if they have a fixed or variable quantity and if the time period of which it should last is fixed or variable (ibid).

The method that is used in many cases is named Wilson's formula and is a method that uses a fixed lot size (ibid). If there is a change in demand or other circumstances are changed the order quantity also needs to be changed to be able to keep a good level of customer service and keep the total cost as low as possible. When using Wilson's formula, there are several conditions that need to be accounted for (Axsäter, 1991). These conditions are:

- The demand is constant and sustained.
- The ordering cost and warehousing cost is constant.
- The order quantity does not need to be an integer.
- The whole amount of an order is delivered at the same time.
- The formula does not consider failure costs.

To get a better understanding of how Wilson's formula works and how it is created some definitions of variables needs to be done, which are as following:

h = warehousing cost per unit and time unit.

A = the ordering cost.

d = the demand per time unit

Q = ordering quantity

C = total cost

From the conditions above and by using the variables that are defined there is a possibility to show how the inventory of material will vary over time, see Figure 5. Here the inventory first is full at time zero and over time when orders are produced the inventory level gets lower. A new order needs to be placed so that the inventory is replenished and when this new material arrives at the inventory the inventory gets full immediately. The conditions stated earlier in this chapter are important to understand. When using this formula in a company there can be several drawbacks if the real situation does not match the conditions of the formula.

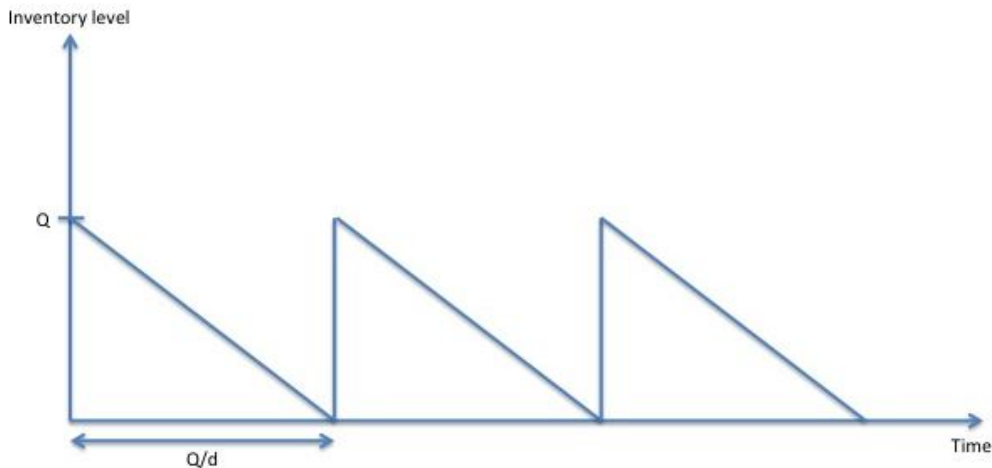


Figure 5 inventory level over time with Wilson's formula (ibid).

To create and define Wilson's formula an equation for the total cost first needs to be defined, which comes from adding both the equations for the ordering cost and inventory carrying cost shown in Figure 4. The total cost for having the inventory then becomes:

$$C = \frac{Q}{2}h + \frac{d}{Q}A \quad (2.7.1)$$

The first part of the equation is the inventory carrying cost; this cost is calculated as the average inventory multiplied by the warehousing cost. The second part of the equation is the ordering cost, which is calculated by multiplying the ordering cost with the number of orders per time unit (ibid). To get the total cost with regard to the order quantity as low as possible the derivative of the total cost should equal zero. This equation looks as follows:

$$\frac{dC}{dQ} = \frac{h}{2} - \frac{d}{Q^2}A = 0 \quad (2.7.2)$$

From the equation (2.7.1) Wilson's formula is calculated by finding a solution to what Q equals, see equation (2.7.3).

$$Q = \sqrt{\frac{2Ad}{h}} = \text{Wilson's formula} \quad (2.7.3)$$

It is important to have a good understanding of what conditions that need to be present when a specific formula is used for calculating the optimal cost for a company. In AstraZeneca's case the conditions very much looks like the above stated conditions for Wilson's formula.

2.4.3 Calculating Safety Stock

There are many different methods for calculating safety stock, from easy methods such as using manual estimations to methods that try to balance out the cost of different service levels and the shortage costs. An easy method for calculating the safety stock is presented below (Jonsson & Mattsson, 2009):

$$SS = k * \sigma_{DDL T} \quad (2.6.1)$$

Here SS is the safety stock, k is a chosen safety factor and $\sigma_{DDL T}$ is the standard deviation of demand during the lead time. $\sigma_{DDL T}$ is dependent on the demand distribution. For a normal distribution the equation is as follows (ibid):

$$\sigma_{DDL T} = \sqrt{LT * \sigma_D^2 + \sigma_{LT}^2 * D^2} \quad (2.6.2)$$

Where LT is the average lead time between two reorder points, D is the average demand per period, σ_D is the standard deviation of demand for one period, and σ_{LT} is the standard deviation of lead time. As stated in 2.6.1 when demand is low normal distribution is not valid and hence the equation is not valid. Instead another method for modeling the distribution is used in order to account for the demand variation. This can be anything from simple approximation methods to more complex methods. One of these methods is Poisson distribution (ibid) In a Poisson distribution the values are skewed towards higher values which means that, there are more data points that are larger than the mean value. The equation for $\sigma_{DDL T}$ would then be as follows:

$$\sigma_{DDL T} = \sqrt{D} \quad (2.6.3)$$

When determining safety stock it can be advantageous to approach it from a coverage point of view. The reason for a safety stock is to provide coverage in case of unforeseen events. Coverage in this case can be defined as the number of days/weeks/months that safety stock level is sufficient given a certain average demand (Gadde et al., 2010). So as an example a safety stock of 20 units will provide coverage for one week if the average demand is 20 units per week. Depending on the circumstances a company's safety stock can have a vast coverage in terms of days/weeks/months while the actual amount in terms of units is small (due to low average demand). Conversely the safety stocks can be large in units while the coverage is low.

AstraZeneca safety stock is used in a combination with safety time, which means that AstraZeneca wants the delivery from supplier the given number of days, the safety time, before scheduled production start. The actual level of safety stock is calculated for days covered, which means that the amount of safety stock is given as a number of how many days it is supposed to cover. So five days coverage means that the safety stock can cover five days of production. Further the exact figure for what a day covers is depends on the product demand. A product with high demand will have a higher amount than the one with a lower demand though they can have the same number of days covered. As with the regular ordering of goods at AstraZeneca the safety stock levels are based on a combination of figures that were calculated several years ago and experience of how it is "supposed to be". With the new system for generating orders that is being implemented at AstraZeneca the need to investigate this issue has increased. In addition labels and packaging materials have different designs for

the same medicine depending on which country it is to be sold in. This further increases the variation of goods at AstraZeneca which in turn gives rise to more safety stocks. This adds extra costs and takes up storage place as well since there is a risk for overstocking in the warehouse.

Q5 – Should the safety levels be dependent on the ABC-analysis?

Q6 – How should safety levels be determined when faced with overstocking?

The safety stocks are used to hedge against risk of for example late orders. The next section will describe when and how a company should place orders.

2.4.4 When to order

Two of the most commonly used methods when designing reorder-point systems are *continuous review* and *periodic review* (Axsäter, 1991). In continuous review when goods are allocated to an order the stock on hand is updated and checked against the reorder-point . (ibid) If it goes below the set point a purchase requisition is generated. In periodic review the stock on hand is checked against the reorder-point at predetermined time intervals (ibid), which could be once per week. If it is below the reorder-point then a purchase requisition is generated.

There are of course advantages and disadvantages with both methods. The continuous review reduces the required safety stock level since orders are generated the moment stock on hand goes below the set level. The periodic review on the other hand needs higher safety stock level since the stock on hand can be just over the reorder-point when checked (ibid). Basically the continuous review only needs a safety stock that covers the demand during delivery lead time while the periodic review requires coverage for demand during lead time plus the demand between two review points . (ibid) The advantage of the periodic review is that it is easier to coordinate purchasing of different goods. If the stock on hand for all goods is reviewed once a week then all purchase requisitions can be performed at once, which will help to lower the cost for inventory control. The disadvantage of the continuous review is that it typically is a more expensive method than periodic review for inventory control, though modern computer systems have reduced the difference between the two methods (ibid).

These two methods require two different approaches when designing the reorder-point system. For continuous review the method used is called a (R, Q)-system (ibid). As described when the stock on hand goes below the set level, the value R, a purchase requisition of a set order quantity is generated, the value Q (ibid). The value R is set as the safety stock level and is calculated to cover the demand during delivery lead time. Q is a fixed figure and can be determined through a number of different calculations for order quantity, e.g. Wilson's formula. The method for periodic review is called (s, S)-system (ibid). When the stock on hand is less than the safety stock, the value s, a purchase order is generated. However in this case the order quantity is not a fixed figure. Rather the order is set so that the stock on hand will reach maximum inventory level (ibid), symbolized by the value S.

2.4.5 Shortage costs and service levels

One of the more difficult areas to estimate and plan against when calculating the total cost is shortage costs. A shortage cost is when for one reason or another a company is unable to produce the products that the customer needs (Axsäter, 1991). This can be due to that the goods needed are not available for production, the production might be stopped due to emergency repairs or there could be personnel shortages (ibid). The reason for why estimating how much a shortage may cost is difficult and lies in how the customer reacts. If a product is highly important for the customer, be it for the own production or use, it is likely that the customer will look at other providers of this product in order to cover the shortage. This is where difficulties arise in the estimation, as there will of course be shortage costs due to missed sales for the specific order. Further the customer may find that the competitor that it used to satisfy its own needs provides better service or better price and might use it as the main supplier. Now the company has lost future sales due to shortages for the current order (ibid). This cost is obviously significantly higher than the shortage for a single order. So the difficulty with shortage costs lies in appraising how they may affect the future, and hence how much resources should be allocated, in form of extra production capacity or higher safety stocks, to hedge against the shortage costs . (ibid)

A different approach to this issue is focusing on the used service level. It is typically easier to estimate the cost for a given service level since it is an internal function (Axsäter, 1991). When discussing service levels in an inventory there are two common definitions (Jonsson & Mattsson, 2009):

- $Serv_1$ = The probability for shortages during an order cycle
- $Serv_2$ = The amount of goods, in percent, that can be supplied directly from inventory

Of these two the most useful definition is $serv_2$, the reason for this is that $serv_1$ is often too much of a simplification of reality. $Serv_2$ is somewhat more difficult to calculate, but it often mirrors the reality quite accurately (Axsäter, 1991) which is the reason why it is applied in this study. Having the same service level for all products or components in a company is likely to cause issues. This can be high stock levels of less important goods which unnecessarily ties up capital while more important goods might get too low stock levels which leads to missed sales opportunities (ibid). At the same time deciding a service level for each component is probably a very time and resource consuming operation. A typical solution is to set service levels after the ABC analysis, which is described in the following section.

2.5 ABC Analysis

ABC analysis is a method of classifying articles/products according to certain properties. Based on this classification management can then determine the appropriate amount of resources to allocate to each article/product. The normal way of dividing the inventory is in classes called A, B, C etc. hence the name ABC analysis (Jonsson & Mattsson, 2009). This means that the class A is very important, B moderately important and C not that important.

This makes the work for the managers easier since they only have to focus on the A classification when making improvements. This is a well know inventory control system and the most common way of dividing the classes is in annual dollar usage. The thought behind this way of dividing the inventory builds on the Pareto principle and is also called the eighty/twenty rule (ibid). This means that normally 20 percent of the articles in the inventory account for 80 percent of the annual dollar usage and these are the articles the managers should focus on when they want to get the biggest payoff when doing the improvements.

There have been several papers that argue that only using the annual dollar usage is too much of a simplification and that there should be multiple criteria when deciding in what group the articles should be placed. According to Flores et al (1992) the use of annual dollar usage can under-emphasize low annual cost items that are important. The problems that can occur when only using the annual dollar usage for the ABC analysis can be that articles with low price and high consumption ends up together with articles that have high value and low consumption. This method does not consider the profitability of the articles either which means that an article that has very high profitability for the company may end up in the classification which says that the management should not consider the article important (Lumsden, 2007). There can also be problems when the finished product is a combination of several articles that is divided into classes, which may result in that a finished product has articles in the inventory that belong to all the three classes (ibid).

Depending on what industry the company operates in different criteria are important for controlling the inventory. This can for example be a company that operates in an industry with high margins where the cost of shortage is very high; here they might have to use different criteria when they place the products in different classifications. (Flores & Whybark, 1993) discuss different criteria that can be relevant for companies apart from the annual dollar usage; they also conclude that within one firm there can be different criteria that are important to different departments. The criteria that are discussed are obsolescence, lead times, substitutability, reparability, criticality and commonality, which also can be used when dividing the inventory. They use a joint criteria matrix to decide in what categories each article should belong to. This is an improvement from only using annual dollar usage, but there are some limitations with this way of dividing the inventory, as it will be hard to combine more than two criteria. According to Flores & Whybark (1993) most companies only use the annual dollar usage when doing the classifications but they seem to use other criteria in a more arbitrary way.

A way of using Analytic Hierarchy Process (AHP) when dealing with the complex task to use several criteria in the ABC classification is described by Partovi & Burton. In this method each criteria gets a weight that depends on how important it is for the inventory control. In a real life example that was done and the ordering cost became marginally higher with the AHP but other cost such as downtime and average inventory investment, were reduced (Partovi & Burton, 1993). The problem with a method like this is that it is very subjective and the result can differ a lot depending on the person doing the weights. In recent years there have been people trying to come up with a simpler model that can be used to combine different criteria. (Ng, 2007) proposes a method where a weighted linear model is formulated. This model still has the same problem as the one developed by (Partovi & Burton, 1993) since there can be a

problem when decision makers need to put weights on the different criteria, especially when there is a lot of criteria.

All these methods have different solutions how to use multiple criteria when doing the ABC classification. But they all conclude that using multi criteria solutions can create a better solution to the problem than by only using the annual dollar usage. As the annual dollar usage seems to be a highly important criteria, it can be combined with other criteria to get a better result, which has already been done in many companies but then in a more arbitrary way.

At AstraZeneca there are several different inventories and the whole supply chain will be affected when different rules for the inventories are changed. Also there are different parameters that are important in the different inventories. For AstraZeneca there is already a global ABC analysis done for the products in the finished goods inventory and an analysis has also been done for the articles in the inventory for the packing material. With a good procurement process it is important for the management to be able to focus on the article in the inventory that is important for the company. This raises some interesting research questions for the procurement process at AstraZeneca.

Q7 – How is the ABC classification in the finished goods inventory affecting the classification in the warehouse where the packing material is located?

Q8 – Should other criteria than the annual dollar usage be considered when doing the classification and how could this be done in the most effective way?

2.6 Summary of the research questions

The research questions that have been raised throughout chapter two will here be stated once more to get a better overview of the questions. These questions will later be answered to support the findings and give recommendations to AstraZeneca.

Q1 – How is the finished goods inventory affecting the procurement process of the packing material?

Q2 – What criteria are the supply and demand conditions putting on the procurement process for AstraZeneca?

Q3 – How is the current procurement process handling these criteria?

Q4 – Does the MRP at AstraZeneca take capacity constraints into consideration?

Q5 – Should the safety levels be dependent on the ABC-analysis?

Q6 – How should safety levels be determined when faced with overstocking?

Q7 – How is the ABC classification in the finished goods inventory affecting the classification in the warehouse where the packing material is located?

Q8 – Should other criteria than the annual dollar usage be considered when doing the classification and how could this be done in the most effective way?

3. Method

In this chapter the method used for this master thesis is presented. This master thesis has been a case study that combines several kinds of sources of information. The chapter starts with explaining the research approach followed by how the literature and data for the master thesis were collected. The chapter will also explain how the research was done and how the validity of the report can be assured.

3.1 Research approach

The research approach chosen in this master thesis is a case study approach where both quantitative and qualitative data are used. A case study approach makes it possible to use several types of data and combine them. According to Eisenhardt (1989) the case study approach often combines several types of data such as archives, interviews, questionnaires and observations. Recent studies have shown a positive outcome of using case study approach, as this method is an effective means of learning from specific situations from specific situations. According to Yin (2009) case studies are used in several research areas such as psychology, sociology, political science, anthropology, history, economics, urban planning, public administration, public policy, management, social work, and education. Many articles describe how a case study should be carried out as a linear process where a certain step is performed before another step is started. This is described by Eisenhardt (1989) where the process is as follows:

- Getting started, here the research questions are selected which will focus the efforts of the report and provide a foundation for measures.
- Selecting cases, this is where the case/cases are chosen to make it possible to choose theoretically useful cases.
- Crafting instruments and protocols, this is where the methods for collecting data are constructed; this can be both quantitative and qualitative data.
- Entering the field, in this step the data is collected with different flexible methods.
- Analyzing data, this is where the case is analyzed and if there are several cases these can be compared.
- Shaping hypotheses, here hypotheses are constructed which confirms or shapes new theory.
- Enfolded literature, here the literature is compared to find similar literature and literature that is in conflict with the hypothesis.
- Reaching closure, here the process ends when new contributions provide little or no improvement.

This way of conducting case studies is very systematic and there are clear steps that have to be carried through before the next step is started. Yin (2009) also describes the case study approach as a linear process but also mentions that it should be an iterative process.

Instead of using a strict and stiff linear process when doing the case study this report will be more flexible. This will increase the understanding of both the literature and also the empirical findings. This is described by Dubois & Gadde (2002) as systematic combining which is when the researcher is going back and forth between the different steps in the case study research. This can also be seen as a way of doing the process more iterative as Yin (2009) explains it.

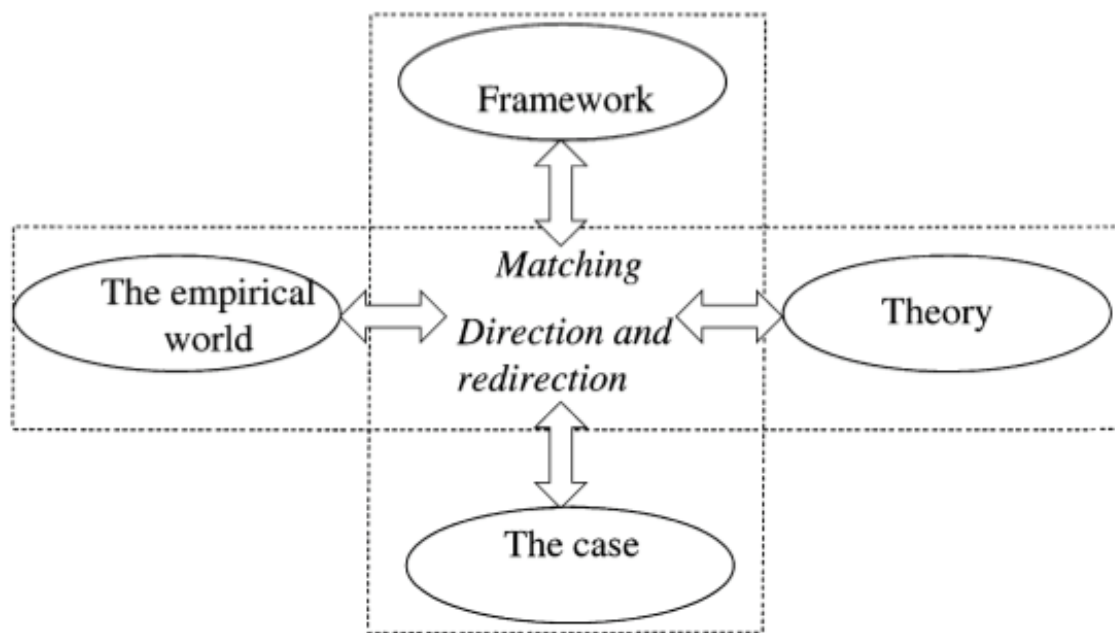


Figure 6 Systematic combining (Dubois & Gadde, 2002)

All the steps described above will be used in the report but instead of doing the case study as a linear process, systematic combining will be used. This can be seen in Figure 6 and is a way of jumping back and forth between the different research steps (Eisenhardt, 1989).

3.2 Information collection

The information needed for this thesis has in one part been data that AstraZeneca could provide, both in the form of figures and interviews with persons with insight into relevant processes. The other part is background information that has been gathered outside of AstraZeneca. This has been done interchangeably, an interview has led to the gathering of information outside of AstraZeneca which in turn led to the need for further interviews or gathering of facts/figures from people at AstraZeneca.

The literature can be divided into two parts where the first part is the more academic literature and the second part is the more general literature in the form of empirical data and material printed by AstraZeneca. The literature review is a secondary data gathering method (Björklund & Paulsson, 2003). Secondary data is information gathered by other researchers.

Although the researchers have not gathered the data specifically for this thesis, the data can help in creating a deeper understanding for the subject (Bryman & Bell, 2011). The academic literature was the literature that gave the structure of the report and served as a basis for finding the empirical material at AstraZeneca. This process has also been an iterative process where the interviews and data in the empirical findings have resulted in that more and deeper knowledge in the theoretical findings was needed.

AstraZeneca provided the more general literature and this resulted in more knowledge about the case and also how the company is working. This information was gathered through interviews and secondary data provided by AstraZeneca. Some information was also gathered from internal documentation and yearly reports from AstraZeneca.

The interviews done for this master thesis was one of the most important sources of information together with the secondary data. Interviews are a primary data gathering method (Björklund & Paulsson, 2003). Interviews are a flexible method for gathering information and are therefore considered an attractive method (Bryman & Bell, 2011). The interviews were done with key personnel within each department that was interesting for the master thesis. Some interviews also resulted in raw data, in form of charts and excel sheets, provided by the interviewed person. The number of persons interviewed was carefully chosen to be able to stay within the time frame of the master thesis.

The questions in the interviews were formed so that a conversation took place during the interview. This was done by having questions prepared for the interview and when the answers were given by the interviewed person attendant questions were asked (Hair et al., 2011). This gave the flexibility to ask questions during the interview that seemed important for the task and also let the interviewed person contribute with the information that they thought was important to know for the task.

The interviews were carried out face to face. Some interviews were followed up with new questions at another occasion to get a full understanding of the process. The following persons were interviewed at AstraZeneca.

Name	Position
Noomi Olsson	Asset planner BFS
Stefano Correnti	Line manager Warehouse and Dispensing
Roland Gustafsson	Line manager Warehouse and Dispensing
Johan Forsgård	Logistics Development Manager
Mats Östin	Senior Supply Planner BFS
Jakub Maczel	APO Consultant

Table 4 Interviewed persons at AstraZeneca

The data that was analyzed in the report was provided by AstraZeneca and was an important part in the result of the report. The interviews gave insights about what needed to be changed in the company. The data made it possible to show how these changes would affect the company. Some of the data gathered and given by AstraZeneca involved economical data and the biggest part of the data involve the demand of medicine during a certain time. The economical data gave good insight in how the changes would shape the economical aspect of the company and the demand data showed how the changes would affect the space of the inventory for the packing material at AstraZeneca

3.3 Research process

The research process was a combination of both interviews and data collection and contains several steps where some steps gave new information which resulted in that a previous step was repeated. First the theoretical background to the problem was investigated together with discussing the problem given at AstraZeneca. The empirical findings were then analyzed with the theoretical framework as a basis, which resulted in new findings for AstraZeneca.

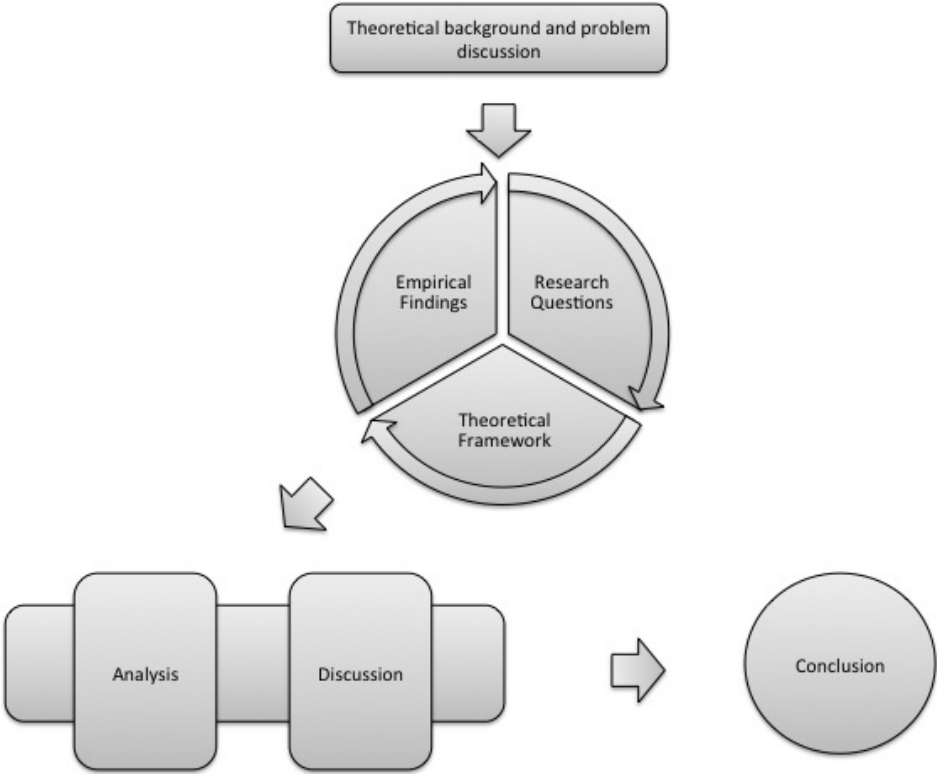


Figure 7 Research process for the master thesis

The research process can be seen in Figure 7 and is a case study approach using systematic combining. This process was chosen to be able to make the learning iterative and

gain deeper knowledge within the three fields of empirical findings, research questions and theoretical framework.

3.4 Quality of the research

To be able to judge the quality of the research it is important that there is both validity and reliability for the report according to (Bryman & Bell, 2011). The research design should represent a logical set of statements. This master thesis uses systematic combining to be able to show these measurements of credibility so that the report follows a logical set of statements. Following will the two criteria of validity and reliability be explained more thoroughgoing.

Validity refers to whether a measure of a concept accurately measure that concept (Bryman & Bell, 2011) explains it by asking if the measure of IQ really measures how smart a person is and if that measure is valid. The validity of this report can be assured by using several types of data that leads to the same recommendation. Also the qualitative findings were applied on the quantitative data showing that the result would go in the direction that the qualitative findings were pointing at.

Reliability concerns the consistency of measures and can be divided into three different meanings according to (ibid). If a study is repeatable the reliability of the study can be seen as higher. If this is the case the study should also consist of fewer errors (Yin, 2009). This report follows a structured way of working and every step of the process is described which should make it possible to use the analytical framework to similar situations or settings. This is how the reliability of this report can be assured.

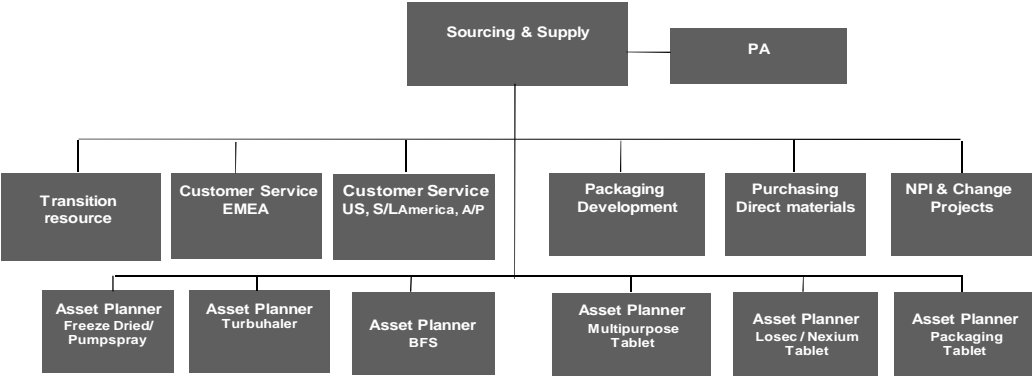
There may be some issues with the solutions presented in this report since other actors in the supply chain have not been a part of this investigation. This may result in that some solutions that are presented may be hard to execute exactly as they are presented. This is due to the fact that there can be restrictions from other actors in the supply chain that need to be considered. An example of this can be that the suppliers have a minimum or maximum restriction on how much that can be bought at a certain time and this may result in that a bigger order needs to be placed than was planned.

4. Empirical Background

This chapter will provide the data and information that will be used to create an understanding of the current procurement process at AstraZeneca. The chapter starts with a view of the planning process and then goes on to describe the warehouse operations, how inventory is categorized and finally an insight into the costs for procuring and storing articles is described.

4.1 The functional organization of purchasing and supply at AstraZeneca in Sweden

AstraZeneca is a global company with operations all over the world. The headquarters are located in United Kingdom and AstraZeneca have both its own production of medicine and also their own research of new medicines. The part of AstraZeneca Sweden that is focused on in this report is AstraZeneca Sweden Operations Sourcing and supply. This department is tasked with supplying the production plants with materials and to ensuring that the customers receive the medicines they want. See Figure 8 for a chart of the organization. The plants produce everything from the active substances to customer packaging. The production is divided into seven Production Execution Teams (PET); each PET has separate management teams and functions.



Updated 2012-01-30



Figure 8 The organization for sourcing and supply

The operations in Södertälje are located at two different sites, though from a fiscal point it is counted as one site, one is located in the center of Södertälje and is called AstraZeneca

Snäckviken and the other site is located outside Södertälje and is called AstraZeneca Gärtuna. These two locations use the same warehouse for the packing material, which is located in Gärtuna. To transport the material between the two locations there are trucks departing at established times during the day.

The different PETs are relatively independent, which means that they have separate management teams and each PET is also responsible for making their own plan of the production. The planning team that is responsible for that the right amount of material is procured in the right time is a part of the sourcing and supply department. There is one team for every PET.

4.1.1 Planning activities at AstraZeneca

Each PET has its own planning team who are tasked with releasing orders to the buyers who in turn place orders at the suppliers. The planners decide when orders should be released, how much should be purchased and, what articles should be purchased. The buyers will then place these orders at the suppliers; the purchasing department will rarely change anything in the order though it does happen if the supplier has a minimum production quantity that exceeds the placed order from the planners. The PET planners use the information that has been put into the MRP to plan both the procurement and production sequence. The procurement process is only performed for the articles that are procured in the traditional manner. There are also articles that have SMI agreements and these articles are not handled directly by the PET planners. However the planners are responsible to assure that required articles are in stock, and if this is not the case to notify the suppliers about it. For the SMI articles AstraZeneca and the suppliers have made an agreement that it is the supplier's duty to assure that AstraZeneca has the articles in storage within a predetermined range.

Finally at AstraZeneca there are some medicines in the portfolio where the demand is higher than AstraZeneca's production capacity. So for these medicines most distribution centers will not be able to get the quantity they actually need. It is therefore important to plan the production of these medicines thoroughly, in this case AstraZeneca will allocate the quantities to each customer. An easy fix might seem to be to just increase production volumes but the production lines for these are already running at more or less full capacity, and a new production line takes at least two years to reach full capacity.

4.1.2 Material flow at AstraZeneca

As previously described there are mainly two types of inventories at AstraZeneca Södertälje, the finished goods inventory and the production materials inventory. The finished goods inventory is smaller than the production materials inventory and this can be contributed to the fact that AstraZeneca has no interest in having high levels of finished goods. This is in part due to the fact that finished goods have a much higher monetary value than the individual components, and are more expensive to keep in stock. The other part is that once a medicine has been produced it will be given an expiration date. AstraZeneca has to ship this medicine to the distribution centers as soon as possible. A standard rule is that around 75% per cent of the expiration time for the medicine has to remain when it is shipped from the production,

though there exists stricter and laxer rules. If the expiration date is too close in time the medicine has to be scrapped according to regulations.

The inventory for the production material is a fully automated inventory, which means that the inventory is operated by a computer system that decides where to position the goods. This inventory supplies most of the production material for the different PET units at AstraZeneca in Södertälje. Separately from this fully automated inventory is the inventory for the labels due to the special regulations for how the labels can be stored. For the labels there are two inventories, one at Snäckviken and one at Gärtuna. These labels are later combined with the other materials in the production at the different PETs. See Figure 9 for the full material flow from the supplier to the distribution centers.

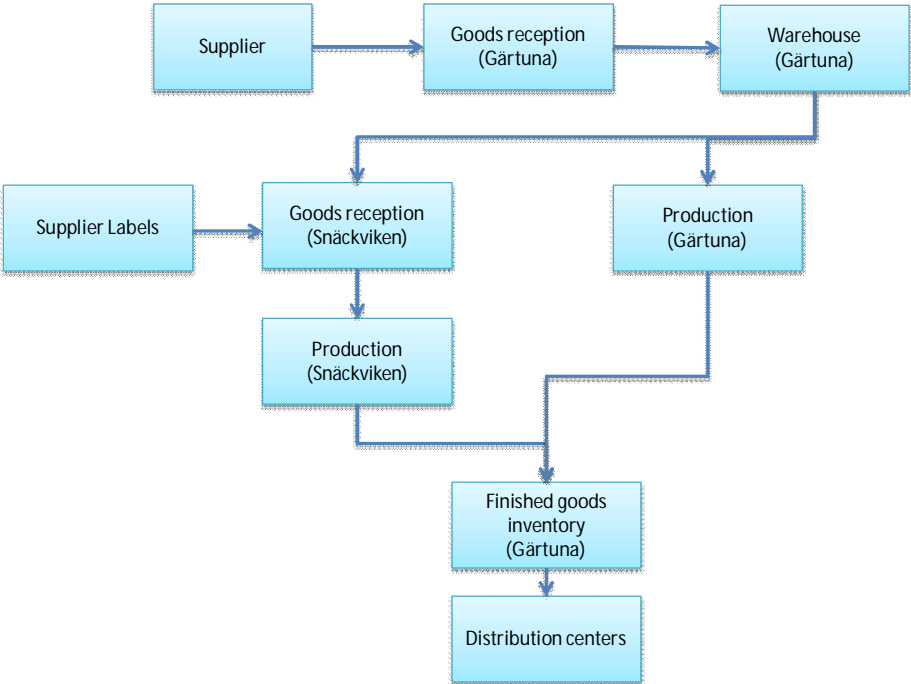


Figure 9 Material flow at AstraZeneca Södertälje

The warehouse for the packing material is located at Gärtuna. From this warehouse the production material is sent to both of the facilities in Gärtuna and Snäckviken.

4.1.3 Warehouse operations in Gärtuna

The warehouse operation in Gärtuna is as already mentioned fully automated. There have been times when the inventory has been over utilized. The overstocking of the inventory has created issues for the supply chain, both upstream and downstream. If there is no room for new material to be stored in the inventory shortages for some of the materials/articles can

occur. In turn if there is a shortage of materials/articles production could stop which is costly. Also if there is no room to receive goods this causes issues for the suppliers.

The order for materials/articles is placed at the supplier by the procurement department and is sent by truck to the inventory in Gärtuna. At the gate the truck driver announces the arrival and the inventory personal receives a request to accept the truck. Before this can be done the inventory personal needs to check if there are any slots that are free in the goods reception area. At the goods reception area there are five slots for unloading the trucks. If there is a slot free the truck is accepted and it in turn drives to the goods reception. If there are multiple trucks waiting to discharge goods they have to wait in queue for a free slot at the goods reception. There are times when the truck drivers are in a hurry and they are only able to wait in queue for a couple of hours. This can create problems since if the truck driver can't wait for a free slot they drive back with the goods to the supplier and AstraZeneca has to pay an extra cost for this. This can happen when the inventory is over stocked since no new material can be added to the inventory. The truck drivers then have to wait for material to be sent out from the inventory before new material can be added to the inventory. If this continues for a longer time the problem of shortages for some materials/articles will arise. As the finished product is a combination of material and components it is important that there is enough of each article otherwise the entire production is halted. There have been discussions about implementing a new system for the arriving trucks where the goods can be scanned immediately so the unloading of goods would go faster. This is not in place yet but could be a solution for reducing the waiting time for the truck drivers. Nevertheless if the inventory gets over stocked this solution would not make any difference.

When the truck arrives at the discharge in Gärtuna the inventory personnel starts unloading the truck. The person unloading the truck is at the same time controlling the goods for damages and other possible issues. The problems that can occur with the goods are that it has been damaged, wrongly packed and, that the goods need to be repacked on new pallets. The goods need to be controlled consistently for damages since if there is a scratch on a box the goods have to be investigated. This is due to the regulations when producing medicine to ensure the quality of the products. The box that is damaged is positioned at a special place in the inventory for further investigation. It is important that the material/articles have not been in contact with something outside of the supplier's production since it is crucial to keep the medicines in a clean environment. Incorrectly packed goods are normally due to the fact that either goods are stacked too high on a pallet or that material is outside of the pallets. This makes it problematic when the fully automated inventory places the goods in the inventory if the dimension is wrong and it also results in more damaged goods. Then goods need to be reloaded on the pallets, which is time consuming for the inventory personnel and may result in that other trucks need to wait before they can unload their goods.

The offloaded material is positioned in the goods reception area and another person controls it once more for damages and other mistake. This is done twice so that nothing is missed before it is positioned in the inventory. The damaged goods are positioned at a special place in the inventory where it is investigated. This investigation consists of taking photos of the goods and a report is written about the damage. The report is later sent to the procurement department that needs to contact the supplier. The goods are then positioned in the inventory

until the investigation is done and it can be scraped or used depending on the status of the goods.

The production is in a clean environment and the material that is going in to the production from the inventory needs to be positioned on special pallets. This is something that the personnel in the inventory need to check and is also a reason to repack materials/articles. When the material/article is offloaded from the truck and if there are damaged goods the truck driver and the staff in the inventory need to sign that damages occurred during transport. This is an important process in order to know who is responsible for the cost of damaged goods.

If the material is going to the production in Gärtuna the material is going directly from the inventory on conveyor belts to the production in Gärtuna. This is not the case for the material that is needed in the production in Snäckviken. Here the material is sent out to the goods reception in the inventory again and put on a truck that takes it to Snäckviken.

The management at the inventory in Gärtuna follows up on how each truck is unloaded and also how many trucks that are planned to get unloaded during the day. A lean way of working is used where different colors on a board describe how far in the process each truck have come. This makes it very visual how far each load has come in the process and if something is wrong. A proposal has been put forward where this visual system is put in a computer system so that this information is spread to all the planners at AstraZeneca. The idea behind this is to make it easier to follow the flow of material since the planners do not sit where the material is. With the current situation there is a lot of people calling the management in the inventory to get an understanding where their specific goods are located and the thought behind this proposal is to increase the transparency in the supply chain. This would also help to process damaged goods since then it would be clear that there are damaged goods waiting for the investigation.

4.1.4 Warehouse operations for labels

The warehouse operations for the labels are divided into two separate inventories, one for Gärtuna and one for Snäckviken. It is important that the correct label is positioned at the right place in the inventory. There are two categories of labels, the ones that AstraZeneca prints themselves and the ones that are printed and produced at the suppliers. The majority of labels are from the latter category; here the planners decide the amounts that should be bought. This order is then sent to the procurement department, which places an order at the suppliers. This order is later sent to either the warehouse in Gärtuna or the warehouse in Snäckviken. The other category of labels, which AstraZeneca prints themselves is produced in the amount that the production schedule suggests.

In the inventory each type of label has a specific position so they do not get mixed up. These two inventories differ a lot from the warehouse for the packing material since every part of the process is done manually. The labels arrive and are directly put into the system and positioned at the correct place in the inventory until it is time to use them.

There have been some problems with the material handling process of the labels with the new MRP system that has been introduced at AstraZeneca. Some of these problems are

connected so that the production does not run as normal. Other problems that have been present are when a new order of labels is delivered as this order has to be positioned at a new space in the inventory and cannot be merged with the labels of the same type. This creates a need for extra space that is not really necessary.

4.2 The ERP system at AstraZeneca

The planners receive suggestions for orders from the ERP system, both in terms of quantity and when the materials/articles are needed. It is the planner's duty to make sure that the ERP suggested quantities are correct. As stated above the implementation of the new ERP system has had some issues and one of them is that the suggested quantities differ greatly from the amount that is to be produced (Östin, Mats 2012). Staff believes that this is most likely caused by an error in the ERP system where it suggests orders that will cover the demand for planned future orders. Typically each placed purchase requisition covers one production order, for the sake of the reduction of the risk for overstocking or expiration of materials/articles. Further each order of a material/article is linked to the production of one medicine so the planner needs to go through the entire bill of materials for a medicine.

When the planner views a suggested planned order there are a couple of parameters that can be changed. The ERP system gives suggestions for start and finished dates of the orders to the planners. It is then the planner's job to determine if these dates are correct and either confirm them or change them to suit the actual production schedule. These dates are set as scheduled dates and are combined with a release date that is set by the planner. Depending on the type of material/article in question different standard release dates are set. This is finally followed by a confirmation date. This date is a safety measure in that no order is released before a planner has approved the order. The difference in the standard release date times between articles/materials is due to that they enter production at different times. Moreover production of each medicine is divided into stages. Each stage requires multiple components and each stage has its own scheduled start. Also the weekday, that the order is scheduled to, effects the release date time.

It is the MRP schedule that generates orders for the planners to either approve or adjust as needed. The quantities and release times that are proposed are based on data that is input into the MRP system. Some of the parameters that the system uses as input are presented in Table 5.

Parameter	Purpose
Lead time	The lead time between different steps in the supply chain
Maximum stock level	The maximum quantity that should be on hand
Minimum stock level	The minimum quantity that should be on hand
Fixes order quantity	The amount of goods ordered

Table 5 Parameters in the MRP

The lead time between two steps in the supply chain can be in minutes, hours, days, weeks or months, depending on where in the process the current step is. The lead time is simply set to correspond the reality, if the transport time from production to customer is ten days than the lead time is set to ten days. The maximum stock level is the quantity that is set as the target level that should be reached when a need arises to reorder a component. This means that when the planners order a new article they order the amount needed to reach the maximum stock level. The minimum stock level is the point where new material is ordered; which implies that when the stock level would drop below this point the ERP system triggers the reorder request. The system will then propose an order with delivery so that the actual stock on hand does not drop below the minimum level. The difference between maximum and minimum stock levels gives the reorder quantity for finished goods. The difference between maximum point and minimum point depends partially on how often the component is procured; more regular procurement means that difference is smaller and vice versa. The other part is dependent on constraints from the supplier; the supplier can have a minimum batch size for its own production, which then AstraZeneca has to buy. The order quantity is used to set the amount of goods procured on a component level and is based on theoretical models. The order quantity is connected to Wilson's formula and the safety stock levels are based on calculations presented in section 4.5. However it seems that these equations are not continuously updated to more accurately model the reality. Therefore the data that is inserted into the system is also based on the planners' experience of appropriate quantities.

4.3 ABC analysis

As already mentioned there are two types of inventories at AstraZeneca, the finished goods inventory and the inventory for the production material. For the finished goods inventory there is an ABC analysis that is done globally and for the production material there has been an ABC analysis has been proposed. The proposed ABC analysis was done as a recommendation but has not been overviewed and implemented. These two analyses are currently not dependent on each other and may have different goals when it comes to what is decisive for how to procure the products. The global ABC analysis focuses on the capital use

for the inventory with finished products while the purposed ABC analysis focuses on the volumes for the packing material.

4.3.1 The global ABC analysis

The ABC analysis for the finished goods inventory is based on tied-up capital. This means that they try to minimize the amount of tied-up capital in the inventory without jeopardizing the service level to the customers. AstraZeneca does not use the global ABC analysis to determine which medicines are the most important for the balancing of the supply and demand, since the availability for all medicines is equally important. The ABC is used to determine the production regularity by classification of how often they should be produced. In addition it is crucial to keep the amount of medicine low since there is an expiration date for the medicine. This results in that AstraZeneca does not have the finished medicine in the inventory for a long time. This has resulted in an ABC analysis where the A classified articles are produced often while the B, C and D classes are produced less frequently. See Table 6 for how the finished goods inventory is divided into four different classes.

Classification	Production regularity
A	Produced once per week
B	Produced once per month
C	Produced three to five times per year
D	Produced two times per year

Table 6 The ABC classification at AstraZeneca

The classification above is not followed strictly for every medicine, as it is rather developed as a guideline for each PET. The ABC analysis in the finished goods inventory is done globally and is something that each production unit has no control over. As a consequence the production units need to follow the global ABC analysis when making the schedule for how and when to produce each medicine. Depending on the forecast different production units need to manufacture the medicine according to the ABC analysis.

4.3.2 Example of ABC

The following is an example of an ABC analysis that has been done at AstraZeneca for the medicine Naropin, and its corresponding labels, which is produced in Södertälje. Depending on country and dosage Naropin has different ABC classification, which can be seen in Table 7. Naropin is a local anesthetic drug for adults and children over the age of twelve. The ABC data will be used in section 5 in order to analyze the potential for a couple of possible solutions to AstraZeneca’s procurement process

Classification	Medicine	Corresponding label	Annual Volume
A	Naropin liquid 10 mg for China	ETIK NAROPIN 10MG/ML PPAF 10ML CN	2 293 000
B	Naropin liquid 2 mg for Germany	ETIK NAROPIN 2MG/ML PPAF 10ML DE	505 000
C	Naropin liquid 5 mg for Canada	ETIK NAROPIN 5MG/ML PPAF 20ML CA	60 000
D	Naropin liquid 2 mg for Hungary	ETIK NAROPIN 2MG/ML PPAF 20ML HU	7 000

Table 7 Four different medicines with four different classifications

4.3.3 Proposal of ABC analysis for packing material

For the production material there has been a proposal of how to divide the material into classes and this is dependent on if the material is bought via SMI or ordinary procurement. Articles that are bought with SMI typically have higher volumes than the articles procured in the normal way since they have different price agreements. Another problem that has been occurring is that each production unit has different practices when procuring the material, which has resulted in a lot of variation when looking in the history how articles with the similar volumes are bought to different production units.

The proposal that has been made is that the ABC analysis should depend on what volume that is produced. This means that the articles that have a high volume should be positioned in the A classification while the articles that are produced in smaller volumes should be classified as B and C. The different criteria and how an article should be classified can be seen in Table 8 according to the proposed classification.

Classification	Quantity
A	Article that is produced more than 900 000 per year
B	Article that is produced between 90 000 and 900 000 per year
C	Article that is produced up to 90 000 per year

Table 8 A proposals for a different ABC classification of the inbound articles

This proposal was done for articles that belong to labels and packing material and has to some extent been applied to the new MRP system for articles procured via SMI. The amount of safety lead time was then decided for each class. This resulted in a formula that is as following:

$$A = OLT + ADM + 14 \text{ days safety}$$

$$B = OLT + ADM + 21 \text{ days safety}$$

$$C = OLT + ADM + 21 \text{ days safety}$$

This way of calculating the safety lead time considers both the lead time for the order (OLT) and the lead time for the administration (ADM). Added to both of these lead times is also a safety lead time that depends on what classification the article belongs to. This new ABC classification would reclassify some of the labels and it is therefore interesting to study these. Three labels and their new classification are presented in Table 9.

Label	Global ABC	Quantity	Proposed ABC
ETIK NAROPIN 2MG/ML PPAF AU	A	21 000	C
ETIK NAROPIN 7.5MG/ML PPAF 20ML NRC	B	69 000	C
ETIK NAROPIN 7.5MG/ML PPAF 5X20ML AU	C	386 000	B

Table 9 How the used ABC classification can effect an article

The case for most of the existing labels, and hence the other components for a given medicine, is that the classifications will be the same for both methods. This would mean that there will not be a great difference between the global ABC and the proposed ABC. But for the instances where there is a difference a comparison and analysis is needed so that the benefits and drawbacks of both methods can be discussed.

4.4 Determining safety stock and costs for material at

AstraZeneca

The calculations that are done at AstraZeneca and that will be in focus in this report will be the calculations of safety stock and total cost. The safety stock calculations will give an understanding of how the safety stock levels are set for AstraZeneca’s inventory and the total cost calculations will try to show where AstraZeneca can make savings.

4.4.1 Safety stock

At AstraZeneca the finished goods stock is divided into four different categories. Each category fills a specific function. The four categories are working stock, safety stock supply, safety stock demand and, policy stock.

The calculation for each article usually requires 20 separate data points in order to support a statistical approach, but there are instances at AstraZeneca where such data does not exist. This is typical for articles that are bought very infrequently or for articles that are new and hence without demand data. If there exist fewer than seven data points statistical approach is considered inappropriate and instead reviews of historical stock data of similar articles is to be used. If there exist between eight and fourteen points the statistical approach can be used but extra safety stocks should be considered to cover uncertainties in the analysis.

When total stock size is to be calculated AstraZeneca considers variability to be one of the most important factors to take account for, both in terms of supply and demand. There are different types of variation in supply and demand that can be divided into normal and non-normal distribution. It is of importance to separate these distributions since they require different approaches when used in calculations. At AstraZeneca for the normal distributed variation a technique of statistical process control is used which performs calculations based on moving ranges and it is independent of the underlying distribution data set. But for the non-normal variation, where patterns in the data can be identified, there is a possibility of calculating the variation statistically. In such situations the outliers of the data set are eliminated from the studied data set by considering the largest variation from the mean by three standard deviations.

Working stock is the inventory that is required to cover the average demand between two replenishment points. The average demand is in this case a function of the average daily demand between two replenishment points and the replenishment lead time. Safety stock supply is the inventory that is needed to cover the variation in supply lead times and quantities. This stock is determined by the average daily demand over lead time variations and differences between actual and planned quantities. Safety stock demand is an inventory that is required to cover variations in the normal demand and is determined by average daily demand availability and customer service levels. Finally policy stocks are inventories that AstraZeneca has agreed to hold in order to cover supply chain risk for its suppliers or customers.

In order to calculate the working stock, which is the largest of the four stock types, the replenishment lead time is required (RLT). RLT at AstraZeneca is defined by the time elapsed in calendar days from a customer demand trigger and availability of released stock at customer, either for sale or further processing.

At AstraZeneca safety stock supply is used to hedge against variability in time and quantity. Time is in this instance the variability in lead times for the RLT. By assessing this variability across the entire RLT issues such as shipping delays can be taken into account when deciding stock levels. Quantity variability is the variability in required quantity and

actual quantity being available for use. Further quality issues and its potential impact are to be considered in the time variability calculations.

The safety stock demand is required to hedge against normal variation in demand in relation to determined customer service levels. Access to an article's different historical data is required to perform the necessary calculations with which to determine the stock levels. A minimum of twelve months of consecutive data points are set as required, though 24 months of data points is deemed as optimal. In cases with articles where the variability is high weekly data points are used instead.

Calculations for safety stock at AstraZeneca

For supply variability the following calculations are used to decide appropriate safety stock for a given article, first is the quantity variability which is affected by the RLT.

$$SS_{RLT} = z * \sigma_{RLT} \quad (4.5.1)$$

σ_{RLT} is the replenishment lead time variation in days and z is a factor that corresponds to the chosen service level. Next is the calculation of the safety stock due to the quantity variability:

$$SS_{Qty} = z * \sigma_{Qty} / \sqrt{ADD} \quad (4.5.2)$$

σ_{Qty} is the quantity variation in number of units for the chosen article and ADD is the average daily demand for the same article.

These two equations will then be used to determine the total safety stock for supply variation. However they are used in two different ways depending on if the demand distribution is considered dependent or nondependent. If considered nondependent the following equation is used:

$$SS_s = z * \sqrt{\sigma_{RLT}^2 + \sigma_{Qty}^2 / ADD^2} \quad (4.5.3)$$

On the other hand if the distribution is considered dependent then the equation is simply as follows:

$$SS_s = \sigma_{RLT} + \sigma_{Qty} \quad (4.5.4)$$

For safety stock demand variability is calculated using this formula:

$$SS_D = z * \frac{\sigma_D}{ADD} * \sqrt{ADD} \quad (4.5.5)$$

σ_D is the demand variation in units for the chosen article. Finally the calculated SS_D and SS_s are used to determine the total safety stock. Again this calculation is dependent on if the distribution is dependent or non-dependent. For dependent distribution total safety stock is simply as follows:

$$SS = SS_D + SS_s \quad (4.5.6)$$

For the nondependent distribution the equation is:

$$SS = z * \sqrt{SS_D^2 + SS_S^2} \quad (4.5.7)$$

This is how AstraZeneca determines the necessary safety stocks for medicines and a safety stock has been determined for all medicines.

4.4.2 Cost allocated to materials

The cost for the materials handling of medicines at AstraZeneca in Södertälje can roughly be divided into three segments. The first is the procurement costs for the goods, the second is the warehouse operations for both inbound and outbound goods and, the third is the production costs. The total cost for the materials handling of the medicine is then the combination of these three parts. There are of course more functions at AstraZeneca that have some bearing on the cost of the materials handling for medicine but these three are the largest and most important to take into consideration. The budget for the production of medicines is in part based on these figures. The budget at AstraZeneca Södertälje does not include the sales price for medicine, which means that the production units at AstraZeneca does not have the responsibility of selling the medicine but only to assure availability.

The procurement costs, apart from the costs for the goods, include the transportation costs from supplier to AstraZeneca and the personnel costs for the procurement department. The warehousing costs are the personnel costs required to manage the warehouse, the utility costs for heating and electricity etc, the stock keeping costs for having goods in inventory. The production costs are mainly due to personnel and machine costs as well as some utility costs. The bulk of the warehouse costs are located at the facility in Gärtuna as this is where goods are received from customers, put into storage, and later distributed out into the production.

The cost for the storage of labels, which has a separate warehouse facility in Gärtuna, is allocated to the costs for the main warehouse. There is also a separate cost for the storage of labels in Snäckviken, which has its own cost center. For exact numbers over the costs at the different parts of the inventory see appendix A1. The total costs for the main warehouse and the two label storages can be seen in Figure 10 where only the main costs are shown and the other costs are summarized under the post others. The total cost for all the inventory activities during one year can be written in millions. However in comparison to the turnover of the whole company this can be seen as a small cost.

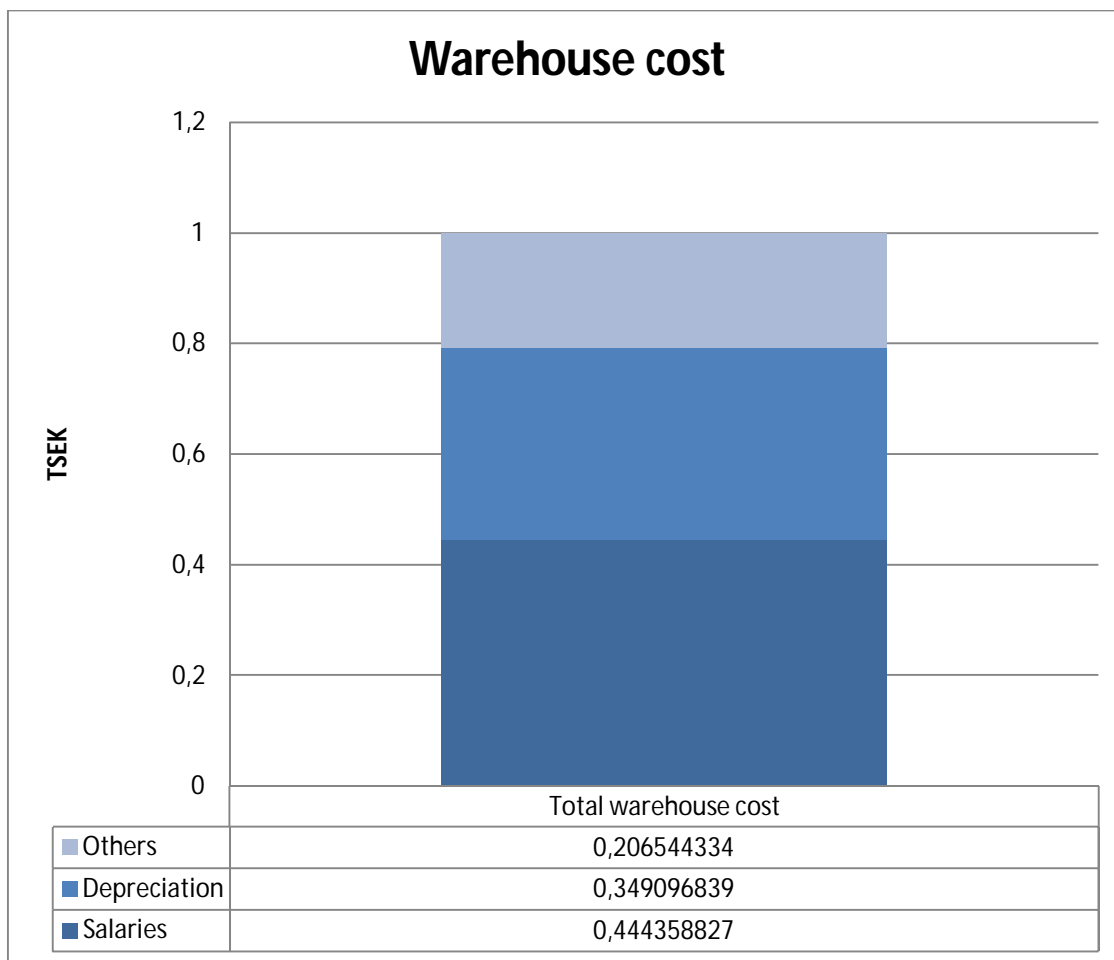


Figure 10 Total cost for the warehouse operations in percentage

As can be seen in figure Figure 10 the cost of the inventory mainly comes from depreciation and salaries. Since AstraZeneca have a fully automated inventory it is understandable that the main cost derives from these two sources.

When manufacturing a medicine there are several costs that have to be accounted for. The average manufacturing cost of a medicine can roughly be divided into Overhead, Raw materials ICM, Raw materials External, Packing materials Quality control and Manufacturing costs. See Figure 11 for a description of the average manufacturing costs. The inventory cost described above is a part of the Overhead cost but here there are also other costs such as all the salaries for development and supporting functions.

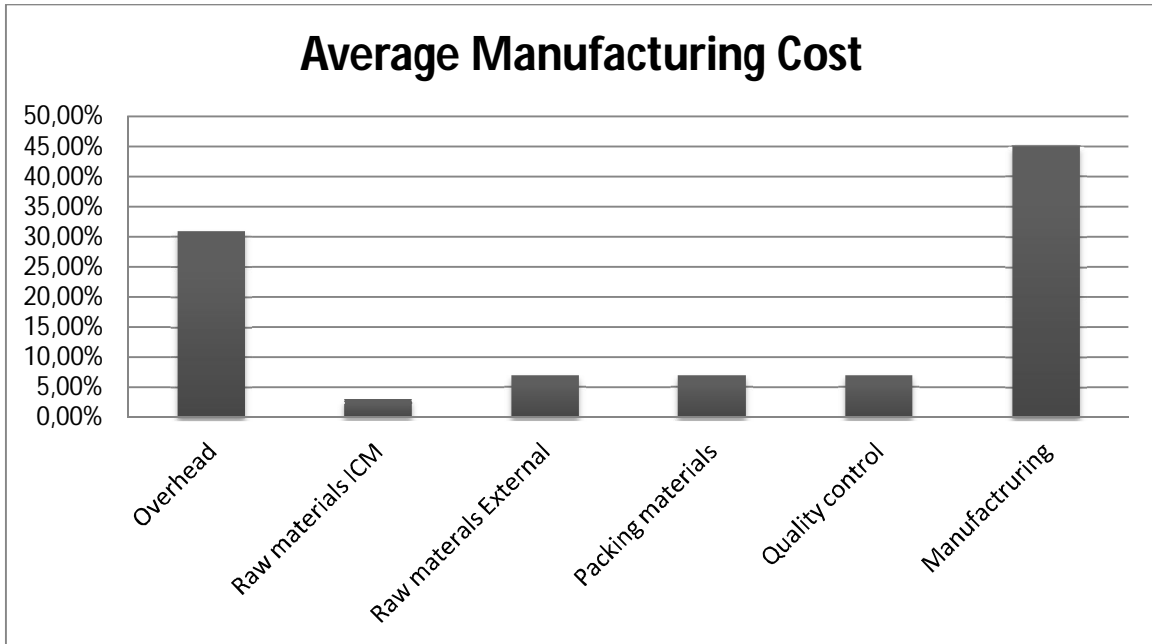


Figure 11, Average manufacturing cost of a medicine at AstraZeneca

As can be seen in Figure 11 the price of the materials is small compared to the Manufacturing and Overhead Cost.

5. Analysis

In this chapter the different research questions will be analyzed and connected to the theoretical framework in chapter 2. The research questions will also be connected to the empirical findings found at AstraZeneca to find a solution for the procurement process. The chapter will be structured as chapter 2 to get a clear view on what will be presented. Finally the analysis will be summarized in the end of this chapter where solutions are presented.

5.1 Organization of purchasing and supply

The analysis of the organization of purchasing and supply is divided into three sections, centralization/decentralization, planning of activities and the material flow. This analysis will be the basis for the solutions.

5.1.1 Centralization and decentralization of purchasing

The purchasing function at AstraZeneca is a combination of both a centralized and decentralized purchasing function. This is also described in the literature where big companies try to get the benefits from both approaches. At AstraZeneca the raw material such as the active substances are procured globally, due to the low prices associated with large volumes that AstraZeneca can get when they combine all the raw materials and procure them from a single supplier. This results in that it should be easier to negotiate the prices of the procured articles. The packing material is procured locally, which should give the departments at AstraZeneca bigger control over how much that is procured and when it is procured. The procurement department is negotiating the prices of the packing material but how much that is procured and when it should be sent to AstraZeneca is done by planners at each department. The combination of a centralized and decentralized procurement function allows for both the price reduction of procuring the large volumes of raw material centrally, and the control over the packing material which is procured locally. As can be seen from the cost structure of a medicine in the empirical findings the packing material is a small part of the total cost of a medicine. This is why AstraZeneca may not benefit from using a global function that procures the packing material. Instead it seems reasonable that the packing material is procured locally where the knowhow exists.

The purchasing function of production material at AstraZeneca is decentralized and a lot of the decisions are (as mentioned) done by planners. Each PET has its own planners, which allows for a lot of freedom on how to purchase material and plan the production. Each planner has a responsibility for the planning of a couple of medicines and this is done based on both experience and established procedures. When looking at the savings that can be done in the purchasing department of packing material it is a small part of the whole turnover of AstraZeneca. Since the biggest problem has been that the inventory of packing material gets full the focus of a possible solution is on reducing the pressure on the inventory rather than saving money. The best solution would be to both reduce the costs and also solve the inventory problem, as a lot of other problems are combined with the inventory problem, such

as extra work for both planners and personnel working in the inventory. Even if the cost for the material stays the same, total costs can be reduced by solving the issue of overstocking.

The structure of the purchasing function at AstraZeneca seems adequate for the company and is as the literature describes a mix between the centralized and decentralized structure. The company may benefit from the decentralized part having a more structured way of purchasing the material and not being so dependent on the experience of the individual planners. Currently the production regularity of medicines and procurement regularity of goods do not correspond. The production is well structured after the global ABC analysis, but the procurement on the other hand seems to be more focused on each individual article. If a more structured way is implemented it is important that all the PETs at AstraZeneca follow this way of purchasing the material. If the structured way of purchasing the material only is implemented at one PET it could result in that the space that is made free in the inventory only fills up by the other PETs when they see that the inventory gets free slots. This means that the issue of overstocking will continue to exist.

5.1.2 Planning activities at AstraZeneca

It seems as if the planners at the different PETs at AstraZeneca have considerably more authority when compared to purchasers. As is mentioned in section 4.2 the purchasers only place orders that have been reviewed and ratified by a planner. Apart from this their function seems mainly to negotiate prices with the suppliers and in the continuation to keep contact with the suppliers. Therefore any strategy for how to procure materials has to focus on how the planners should perform their activities.

How the planners plan and place orders into the production schedule can most likely continue in the same fashion. It is not in this part of the process that issues seem to occur which would suggest that this internal function is currently a well-functioning system. The only focus of the new strategy should therefore be for the placing of purchasing orders to the suppliers.

The planners have some degree of authority when it comes to the scheduling of orders in the MRP. The MRP can automatically arrange the orders for production according to different criteria. This can be arranged for the shortest change over time or the sequence in what the orders have been registered etc. The planner can choose any of these possibilities according to what is most suitable at the moment. Further they can also sequence it manually if deemed necessary. All this means that the planners have the opportunity to react to and anticipate issues in the schedule. It would therefore stand to reason that a new procurement process that focuses on how the planners should place orders has a reasonable chance of being successful. Further the planners currently have a good insight into how much to order for a given article of a specific medicine. This knowledge will be of great use when implementing the new strategy. Also the planners have the possibility to alter quantity of orders for articles that the MRP suggests. This can be an effective option during the transitional stage for the new strategy. Consider that there is a new purchase strategy, if the planners notice that the orders are too low or too high they can correct them and also send signals that there is a need for some alteration for a specific article. It could be for example that the article in question has

been categorized incorrectly. There exist a lot of articles at AstraZeneca and due to this each planner has the responsibility for a couple of medicines and the subsequent articles. By using the experience from the planners for their articles and by altering how they place orders a new purchasing strategy can hopefully be designed. This strategy would not increase the current workload to any significant extent for the planners, and would at the same time allow AstraZeneca to increase its efficiency.

5.1.3 The material flow

In section 4.3 a part of AstraZeneca's stock keeping policy is described, and as is stated the finished goods inventory is low. The reasons for this is connected with expiration dates for medicines and the cost of keeping finished medicines in stock as compared to the cost for the individual components. From a logical point of view AstraZeneca does not need a high level of finished goods, at least not at the facilities in Södertälje. Since all orders that are placed into the ERP system are customer specific order there is no need for a large finished goods inventory. Although some of the orders are from AstraZeneca's own distribution centers, these orders are not sent directly to the end customer. The regulations for expiration dates in this part of the chain are almost as strict as when shipping directly to the end customer from the facilities in Södertälje.

At the moment the material flow from warehouse through production and back to the finished goods inventory seems to be functioning well. Nevertheless there is a possibility that the issues of overstocking in the warehouse that has occurred could hide issues in this part of the flow. Therefore there could be a need to investigate this once the problem with material flow into the warehouse has been corrected.

Apart from the issue that the warehouse is at risk of being overstocked due to the current procurement process there are some issues that are in need of being resolved. The most important issue is probably the lack of process of what should be done with the goods that are obsolete. It has been estimated that around 2000, or ten percent, of the pallet positions are occupied by articles that will not be used due to them either being obsolete or damaged. Literature suggests that a warehouse should on average be filled up to 85 percent in order to function efficiently, so if this continues then AstraZeneca will only be able to use 75 percent of its warehouse effectively. Obviously a process for keeping better track of goods in the warehouse is needed. At the moment there is only one known signal from the warehouse that the goods in storage are obsolete and that is when a specific article has three months until it expires. Currently most articles are allowed to be kept in the warehouse for 36 months. Another issue that has arisen during the investigation is the process of handling damaged goods. There does exist a process at the moment though it does seem rather time consuming. Further there is the possible risk of these goods being forgotten and kept in storage for an unnecessary amount of time.

5.1.4 Cost for materials

The cost for the inventory of the packing material is not that big compared to the total cost of AstraZeneca's sales. But for the production unit the inventory costs can be seen as

relatively important and for the whole AstraZeneca all the money they can save from the production and inventory activities will show on the result.

To be able to get an understanding on how much AstraZeneca can save from improving the inventory management the average yearly cost for one pallet position needs to be calculated. This can be done in several ways and the point is not to show an exact number but an estimate of the cost. To estimate the cost of one pallet position the total cost for the inventory was retrieved, this was then divided by the total number of pallet positions in the warehouse, which gives an estimate of the cost for one pallet position during one year. The inventory consists of around 25 000 pallet positions and the total cost for the inventory during one year is 55 800 000 SEK. The cost for one pallet position then is around 2 232 SEK per year; this cost is not that big but in comparison to a box of packing which can cost around 500 SEK it can be seen as a lot of money.

One way of solving the problem that the inventory runs out of places could be to expand the inventory. The cost for the new places would not be that big as can be seen from the price above but it would need a big investment cost at the start when the inventory is built. This solution is a very easy way to solve the problem but not to recommend being implemented before a clear procurement process and an accurate estimate of investment costs for alternative issues is developed.

The transportation of the packing material sometimes results in that some of the goods get damages. This results in an extra handling cost for AstraZeneca and also takes time from the personnel working in the inventory. When the material gets damaged an investigation starts to examine where the goods got damage and who is responsible. Sometimes it is the supplier who should take the cost for the specific damaged goods and other times AstraZeneca needs to take the cost. This process can take several months and during that time the damaged products are positioned on a pallet that is placed in the inventory. This takes space from the inventory and sometimes it is only a small box that takes a whole pallet position. The quality department is responsible for making the decision whether the damaged goods should be scraped. As shown with the calculation the average cost for a pallet position during one year is 2 232 SEK. Some of the material that is positioned in the inventory can be seen as relatively cheap and when this material is damaged and the personnel in the inventory knows that this material cannot be used it may be good to have a process where the inventory staff themselves can scrap this material. This would result in an easy and cheap way to get extra space in the inventory. If for example a box of material that is damaged is worth 200 SEK and this box is positioned on a pallet position that costs 2 232 SEK per year it does not take many months before the cost of storage of the goods is more expensive than the goods itself.

One solution to this problem could be to make the personnel in the inventory in charge of making the decision on when to scrap the material directly when they notice that it is damaged. They could be given a small account where they can take the losses and if the damaged goods are worth less than a specific amount of money they could be allowed to make the decision themselves. This would result in that the handling of broken goods would go faster and also give extra space in the inventory that can be used for the material that is going into the production. However there has not been a thoroughgoing investigation in this

area so there may be cases where AstraZeneca takes the losses when the supplier should have taken the losses. This is why the amount that is allowed to be scraped should be low so that only the really unnecessary boxes that take place in the inventory are removed.

Together with the other options some small changes will be proposed that is relatively easy to implement and will make some improvement to that the inventory gets full. In the inventory there is damaged goods that take up space during an investigation telling what to do with the damaged goods. This investigation sometimes takes up unnecessary time and to solve this problem a new process could be implemented where the warehouse manager is allowed to scrap material that is damaged. To make this a safe and secure option it would be good to have some restrictions to this process. The process can look like following:

- If the goods worth less than 500 SEK they are allowed to make the decision themselves.
- To be able to be allowed the goods needs to have clear damages.

Since a pallet position costs a certain amount of money each year it is not defendable to have a box of material that is under investigation taking up that space if the cost of the material is low. This may be an alternative if there is a lot of space free in the inventory but not when the inventory gets full which later results in bigger losses than scraping some material.

There are other solutions for AstraZeneca to procure their material than dividing the inventory after an ABC analysis. As was shown in the theoretical findings the total inventory cost can be described by the inventory carrying cost and the ordering cost. This would result in that the procurement of material was done to get the total cost of the inventory as low as possible. From one aspect this solution sounds as a good way to procure the packing material but the problem at AstraZeneca has also been that the inventory gets full. This method would not consider any other parameters than the inventory carrying cost and the ordering cost, which could result in that the inventory gets even fuller. One scenario could be that an article that has relatively large volume also has a cheap price. This would mean that every time this article is procured a large amount would be ordered. This in turn would then result in that a large space in the inventory would be needed to be able to take care of the order. The main problem at AstraZeneca has been that the inventory gets full and when analyzing the cost structure of a medicine it is easy to see that the material cost is only a small part of the total cost of the medicine. On top of this cost structure described in section 4.4.2 cost there is also a big margin, which makes the savings from procuring the material after the Wilsons formula only a small percentage of the total earnings on a medicine.

5.1.5 Safety stock

The safety stock situation at AstraZeneca for the duration of this investigation has been in a state that is not to be considered normal. The levels of safety stock have been exaggerated in order to reduce the risk of shortages due to the implementation of the new MRP system. It is therefore not of interest to focus the analysis on the situation as it is now since this may lead to suggestions that are of no use when the new system is stabilized. Indeed it may be more

beneficial for AstraZeneca to analyze the safety stock once this has occurred. However some analysis can be done from the literature and how AstraZeneca currently envisions its safety stock policy.

AstraZeneca uses a form of safety stock that it refers to as days' coverage. Since goods have different demands in terms of quantity what one day actually covers depends on the specific article, so articles can have the same number of days' coverage but the actual quantity can be different. The days' coverage for each article is dependent on the demand, and the demand is in this case dependent on what is planned in the MRP. If for a certain period of days there are no orders that require the article then the demand is zero, meaning that a day's coverage will be zero. Hence there should be no physical safety stock at AstraZeneca. This should, at least in theory, help in keeping down stock levels and at the same time not increase the risks for shortages to any significant extent. So although there does not exist a physical safety stock it exists in the system. And once an order for an article is within the set coverage a physical safety stock will be created, with the system automatically adjusting for the supplier lead times. This is furthermore a method that is well suited for the rules and regulations that AstraZeneca has to abide. This is exemplified by that a change in a design of a package often leads to that the old design is not allowed to be used anymore, which means that it has to be scrapped. By trying to only have physical safety stocks of goods that are to be used in the very near future, typically one to two months, the risk of having to scrap goods can be reduced. However there are some drawbacks with relying too heavily on a safety stock related to days' coverage. For medicines that are only produced a couple of times per year, like the medicines in category C and D, issues may arise if only day's coverage is considered. Figure 13 will illustrate the possible issue with this method.

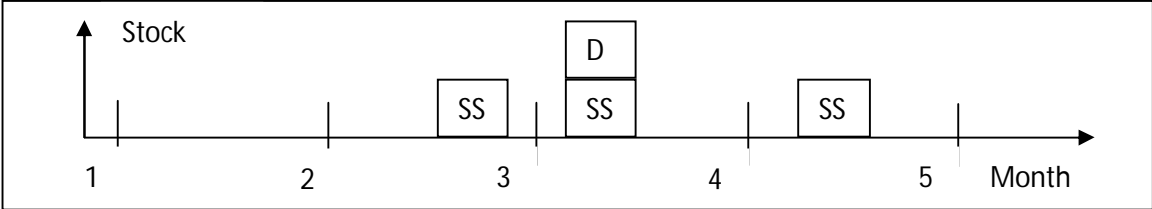


Figure 12 The issue with days cover for articles with low demand

As is illustrated in Figure 13 a production order is generated for a C medicine in month 3, currently there is no stock on hand of the articles needed for production. If the order lead time from suppliers is one month then the purchase order is released in month 2. But there is also a need for a safety stock in terms of days covered, which has to be present x days ahead of the starting point of the production. This means that before start of production there should be an inventory of the needed articles for production plus a safety stock. However after production, assuming it went to plan, there will still be a safety stock left, which is unnecessary for at least a couple of months. An alteration in the practice for these medicines should be considered since there is the issue of overstocking.

There are still issues that should be dealt with one is the data for purchasing quantities that has been put into the MRP. Another is the calculations of the necessary safety stock runs at a risk of being outdated. Though there do exist clear methods for deciding the amount as is presented in section 4.5 it is somewhat unclear how often these calculations are performed in

order to update the information in the MRP system. Due to the fact that the demand figures are in part based on historical data and old calculations the issue that arises is that the safety stock levels are not accurately modelled to fit reality. This means that there is a possibility that the safety stocks are too high, which is an unnecessary cost, or that they are too low, which increases the risks of shortages to a level that AstraZeneca is unwilling to accept.

5.1.6 Expand the warehouse

One solution to the core problem that the inventory gets full could be to expand the warehouse. This is a solution that does not consider how the procurement of material is done and only focuses on the problem that the inventory gets full. As shown in section 4.4.2 with the cost calculations the cost for the inventory is relatively low in comparison to the cost of the finished medicine. To be able to execute this solution it is necessary to take a big investment for the construction of the new inventory

This solution seems as an easy way to go but it does not solve the problem of how to procure the packing material. Since the problem still exists after the inventory is built it may result in that this new inventory also gets full. Therefore it would be better for AstraZeneca to first implement the new way of procuring the material. If this solution is not enough there are strong reasons for expanding the inventory. This may not be that strange since the production volumes at the sites in Södertälje have increased.

5.2 The ERP system

The literature review reveals that a MRP system is well suited for production environments where there exists dependent demand. AstraZeneca production process for most of its medicines is from raw material to finished product, hence there is a lot of dependent demand. Therefore the choice of utilizing a MRP system is a logical one. Further as illustrated in section 4.2 the MRP at AstraZeneca follows the general principles for such a system. Even though it is appropriate there are still difficulties with using MRP solution at AstraZeneca. One issue is that the MRP is dependent on the input data to generate the schedule, meaning that inaccurate data will lead to an inaccurate MRP. For the finished medicine the data is fairly accurate. It is for the components of the medicine, like raw material and packaging that problems arise. A placed order for a medicine automatically generates, through the bill-of-materials, the demand for the components that are needed. This demand is checked against the stock on hand to determine if supplier orders need to be placed. If there is need for a supplier order the MRP will generate a suggested order quantity. It is here that issues arise, the suggested order is based on figures that have been put into the system. These figures are in part based on calculations done some time ago, with the help of Wilson's formula, and in part based on historical data. The figures however have not been updated to any significant extent to match the current customer demand. This means that while the demand for finished medicine is continually updated the demand for the articles is not updated in a similar manner. This means that AstraZeneca procurement process lacks connection with the actual sales.

However at the same time it would require a lot of work to continually update component figures in a similar fashion as for the finished medicine. Such work would most likely have to

be undertaken by the planners at each PET, where they would then have to keep track of updating the medicine components that they have responsibility for. But this would as stated very likely require a lot of time of the planners, time they may not have in order to fulfill their other responsibilities. Still there is certainly a requirement to update the figures in the MRP to more accurately model reality. A possibility could be to categorize the components into groups, by for example an ABC analysis, and then the procurement for each group can be put into the MRP. This could possibly make it easier to update the component demand on a more regular basis.

Another problem with the MRP at AstraZeneca is that the only major constraint that is considered is the production capacity and this is only once orders are planned into the actual production. This means that the MRP will suggest orders as long as there is production capacity to match it. Hence it is understandable that the inventory at AstraZeneca becomes overstocked since there does not exist any mechanism to alert about it until the inventory is full, apart from the personnel in the warehouse actually telling every planner that such is the case. While it may be possible to add the constraint of inventory capacity to the MRP it may create more problems than it solves. First adding this constraint to the MRP will increase the complexity of an already quite complex system. Further if the planners are disallowed to place orders if the inventory is at risk of being overstocked than the orders will not be delivered as promised. This would be a major issue for AstraZeneca since if they do not deliver as promised the company may lose customers. However some sort of warning signal from the system to the planners should be issued so that they at least are aware of the problem. A step that then could be taken is to check the inventory for goods that are obsolete and consequently to scrap them to make room. It may be too much for the planner to check all goods in the inventory but they could possibly check the components that they are responsible for. This would at the very least help in a transitional period when this procedure would be implemented. At the same time they would gain a procedure for checking the inventory for which there currently exists none.

5.3 ABC analysis

The thought behind using an ABC analysis in procurement process is to make it clearer for the management what they are working with. This can be done in several ways and as the literature proposes it may be more than the annual dollar usage that is important for the company. Other criteria that can be important are obsolescence, lead times, substitutability, reparability, criticality and commonality. These different criteria can be weighted together with the annual dollar usage to give a better picture of what is important for the procurement process. For AstraZeneca the ABC analysis is not a tool to sort the articles after how important they are since all the articles need to be delivered to the customers. Instead it is more of a tool to keep track of all the articles and how often they should be produced.

AstraZeneca is a big company with a lot of different products. An ABC analysis can help the management since it is impossible to keep track of all the articles at once. As described in the empirical findings there is an ABC analysis for the finished goods inventory that is based on annual dollar usage. Since the value of the finished medicine is relatively high compared to

the parts that it consist of an ABC analysis that is depending on the annual dollar usage seems understandable. This will result in that the company keeps the tied-up capital as low as possible in the finished goods inventory without risking the late delivery to customer. For the packing material it is also good to get the tied-up capital as low as possible but here it may be other criteria that are also central for the company. Since the packing material is a relatively small part of the total cost of a finished medicine other criteria than the annual dollar usage can be important. The different criteria proposed by the theoretical framework will be analyzed separately to get an understanding if they fit the ABC analysis of the packing material.

Annual dollar usage is one of the most important criteria for the packing material since it will help the company to keep the tied-up capital as low as possible. *Obsolescence* can be important for the ABC analysis of the packing material. As described the design of the packing material is changed from time to time and in some countries the old designs are not allowed to be sold. This results in that AstraZeneca needs to scrap the material in inventory. One way of handling this problem could be to put bigger weight on the products and countries where there can be problems with old designs and try to have as few of them in inventory as possible. *Lead times* can be one way of dividing the ABC classification but in AstraZeneca's case this does not seem as a way to go for the packing material. All the suppliers of packing material have specific lead times for their products. *Substitutability*, *Reparability*, *Criticality* and *Commonality* are not that important in AstraZeneca's case for the packing material since the products that are procured are not made out of any special material or hard to find on the market. This results in that finding the suppliers for these parts if needed should not be that hard. Therefore this is something that does not have to be weighted in the ABC analysis.

As mentioned above the tied-up capital seems as a crucial criterion both for the finished goods inventory of medicine and also for the packing material. But for the packing material the criteria obsolescence also seems important since some packing material can get old. This will result in both a scraping cost and it will also take unnecessary space in the inventory. Other things that are more important for the packing material is that there should always be material present when the production starts. If the case is that there is no material when the production starts, the company cannot produce and will both loose the sales and have to reschedule the production. It is hard to put a specific number on the losses in this case but it can be seen as large compared to having the packing material in inventory. One way of handling this problem is with safety stock and safety lead times, which will be analyzed separately in another section of this chapter.

One way of dividing the packing material could be to use the global ABC analysis for the finished goods. Since the products in the finished goods inventory are produced with different frequency based on the ABC analysis it could then be a good idea to procure the packing material in the same manner. This will enable the management to continuously keep track of the products that are produced every week and spend less time on the products that are produced only a few times per year. It would be possible to make a new ABC analysis for the packing material based on the annual dollar usage. But this would result in that some parts of the medicine that are expensive would be categorized as A articles while, boxes and labels that are really cheap to produce would be placed in the less significant class. To produce the

finished medicine all the parts are needed and not only the expensive parts which could make this solution unsustainable. The cost of not being able to produce is really large compared to the cost of the packing material and the cost consist of both loss in sales and, unutilized capacity of the labor force in the production (which loses time when they are not able to produce).

The second ABC analysis that has been proposed is based on the volumes that are produced each year, which could also be used for procuring the material. This would result in that the material that is produced in large volumes will be procured more often which is closely related to the global ABC analysis. The difference is that while this solution categorizes the articles after the yearly volumes, this classification does not necessarily have to be the same as for the global ABC analysis. However a lot of the articles should be classified similarly since the medicines that are produced in high volumes are produced with high regularity. The global ABC analysis is also divided into four different classes while the proposed ABC analysis only has three classes. By keeping the number of classes in the ABC analysis as low as possible it should be easy to understand and keep track on how to classify the articles. But for some articles that are only produced a few times per year it may be necessary to have a specific class.

To make the ABC classification understandable and not too hard to implement there should not be too many criteria to follow. For the same reason there should also be as few classifications as possible. The planners at each department should easily be able to update the articles and sort them into different classifications and since the number of articles at AstraZeneca is large this could be very time consuming for the personnel if the process is too specific in this regard.

5.3.1 Procurement based on global ABC analysis

One possible method for designing a procurement process is to utilize the existing global ABC analysis. The global ABC analysis is used in order to determine how often different medicines should be produced. As previously described there currently does not exist a clear connection between the procurement of articles and the ABC classification of the medicines. This is exemplified by the fact that there are medicines classed as A, meaning that there are production orders every week, while the articles for these medicines are procured a couple of times per year. This means that there are probably high stocks of these articles in the inventory. This is an issue when considering that the inventory is running the risk of overstocking. By purchasing the articles according to the ABC classification the stock levels should be reduced, which should be the case at least for A and B articles. The production of C and D medicines and the subsequent procurement of articles are already quite similar, as the number of production orders and procurement orders are the same, meaning that the effect would be limited. For the A and B medicines the potential reduction is significant. Table 10 shows a comparison of the number of labels in stock on hand between the current situation and how large the average stock on hand would be if the global ABC classification was followed for the procurement.

Label	ABC Classification	Current average stock	ABC average stock	Difference %
ETIK NAROPIN 10MG/ML PPAF 10ML CN	A (Produced once per week)	191 000 (12 separate orders)	44 000 (52 separate orders)	76
ETIK NAROPIN 2MG/ML PPAF 10ML DE	B (Produced once per month)	56 000 (9 separate orders)	42 000 (12 separate orders)	25
ETIK NAROPIN 5MG/ML PPAF 20ML CA	C (Produced three to five times per year)	30 000 (2 separate orders)	15 000 (4 separate orders)	50
ETIK NAROPIN 2MG/ML PPAF 20ML HU	D (Produced one to two times per year)	7 000 (1 separate orders)	3 500 (2 separate orders)	50

Table 10 Possible reduction for the new procurement strategy

The A classified label in Table 10 shows a significant reduction by more than 75% which could possibly have a large impact on the warehouse situation. Further this is just for one article (for one medicine), which could then possibly be extrapolated for the other articles for the same medicine. The table also shows significant reduction potential for the B, C and D labels in terms of percent but in terms of actual quantity reduction the figures are not as significant. It should be noted that following the ABC classification this strictly may not be possible. Placing purchase orders for the A articles every week may be time consuming for the planners and it may be that the quantities are not acceptable for the suppliers. But it should be plausible to place orders once or two times per month for all articles that would be classified as A. Table 11 illustrates the reduction that could be attained for two different A labels.

Label	Currently	12 orders/year	24 orders/year	52 orders/year
ETIK NAROPIN 10MG/ML PPAF 10ML CN	191 000	191 000	95 500	44 000
ETIK NAROPIN 2MG/ML PPAF 5X20ML AU	14 000	8 000	4000	1800

Table 11 Average stock depending on number of orders per year

The table illustrates that there seems to be potential for reducing the pressure on the warehouse by utilizing the global ABC analysis to create a purchasing strategy. It should be noted that this thesis has not investigated how many labels that would fit in one pallet space. So it is not possible to determine if this would reduce the number of pallet space required for labels. However as the figures presented here are just for labels, which are attached to each and every medicine, the same reductions should be acquired for the rest of the articles that are used to produce the medicine. It is therefore likely that this purchasing strategy, if used for all articles, could reduce the risk of overstocking the warehouse.

Apart from the issue of the suppliers there are some other points that will have to be taken into consideration if this strategy is implemented. One such issue is that by increasing the number of separate orders the number of trucks that come to the warehouse will also increase and probably the transportation costs. This will increase the workload on the unloading part of the warehouse operations. For instance instead of a truck coming with goods of a specific label once per month there could be a truck arriving four times per month. There will be a significant increase in trucks if the system is used for all of the incoming goods. An investigation of how many trucks that the warehouse can handle on a daily/weekly/monthly basis may be needed. The increase in transportations will also lead to an increase in this type of costs as well as that it is not an environmentally friendly strategy. Calculations for the transport cost are needed to get a clearer picture of utilizing this procurement strategy, as well as investigating how the procurement strategy corresponds with AstraZeneca's environmental strategy.

5.3.2 Procurement based on proposed ABC analysis

Similar to the procurement strategy presented in section 5.5.1 this procurement strategy will be based on an ABC-analysis. This strategy will be based on the proposed ABC analysis for the inbound flow of articles. Using this strategy should give similar reductions in average stock on hand as the previous strategy. The drawback of using this method is that it will probably require more work to be implemented. In order to implement this strategy the proposed analysis has to be accepted as the standard. The quantity figures presented in section 4.3.3 probably need to be verified to insure that the classification is appropriate. Also there could be a need to check if using the proposed ABC analysis causes conflict with the existing global ABC analysis for the finished medicines. A possible benefit is that since the proposed ABC analysis is focused on the annual volume of articles, it could lead to a higher overall reduction in the needed warehouse space. In Table 12 the difference in average stock for the two procurement strategies are presented, the labels and their corresponding ABC class is presented in Table 12.

Label	Current average stock	Global ABC average stock	Proposed ABC average stock	Difference
ETIK NAROPIN 2MG/ML PPAF AU	6 500 (4 separate orders)	500 (52 separate orders)	6 500 (4 separate orders)	+ 6000
ETIK NAROPIN 7.5MG/ML PPAF 20ML NRC	13 800 (5 separate orders)	5 750 (12 separate orders)	17 250 (4 separate orders)	+ 11 500
ETIK NAROPIN 7.5MG/ML PPAF 5X20ML AU	43 000 (9 separate orders)	96 750 (4 separate orders)	32 250 (12 separate orders)	-64 500

Table 12 Actual difference for three labels between two ABC analyses

The table shows that there are significant differences between using the two different purchasing strategies. Though it should be noted that this difference is due to that for these specific labels the ABC classification are different between the Global and Proposed analysis. For the labels, and other articles, that are classified in the same group by the two analysis there will be no difference.

6. Discussion and conclusions

In this chapter the analysis in the previous chapter will be discussed in regard of the research questions that are presented throughout chapter 2. The goal of the discussion is to give clear answers to these questions so as to illustrate their relevance in regards to the thesis as a whole. Further the proposed solutions for the issue of overstocking in the warehouse are compared with each other. The following research questions were raised in chapter 2.

Q1 – How is the finished goods inventory affecting the procurement process of the packing material?

Q2 – What criteria are the supply and demand conditions putting on the procurement process for AstraZeneca?

Q3 – How is the current procurement process handling these criteria?

Q4 – Does the MRP at AstraZeneca take capacity constraints into consideration?

Q5 – Should the safety levels be dependent on the ABC-analysis?

Q6 – How should safety levels be determined when faced with overstocking?

Q7 – How is the ABC classification in the finished goods inventory affecting the classification in the warehouse where the packing material is located?

Q8 – Should other criteria than the annual dollar usage be considered when doing the classification and how could this be done in the most effective way?

It has hopefully been made clear that the strategy for the finished goods inventory has an impact on the current procurement process at AstraZeneca. The global ABC classification determines how often different medicines should be produced and this affects the procurement of the articles needed to produce it. Though the procurement at the moment does not follow the ABC analysis completely, articles are not procured with the same regularity as the medicines are produced. Nevertheless it is still the demand for the finished medicine that governs the procurement of the articles. This could be affected by the fact that there is both a centralized purchasing function and a decentralized purchasing unit. By this could follow that the articles that are to be used in production of the same medicine could be procured in differently. Some of the components are procured so as to cover one order at a time. While some of the components are procured to cover several production orders. The difference of procuring both centrally and locally increases the difficulty of implementing a new unified purchasing strategy, though the combination seems to play well to the strength of a company such as AstraZeneca. Further regardless of the procurement strategy that AstraZeneca chooses to utilize it will continue to have an impact on the procurement of articles. One specific condition concerning supply and demand at AstraZeneca is that the company has to be able to provide all medicines regardless of the ABC analysis. It is a key aspect that the ABC analysis is not used to categorize one medicine as more important than another since it is medicines that are being supplied. One patient cannot be considered more important than another in this aspect. It is these conditions that determine how often the medicines should be produced not

its importance from an economic viewpoint. Therefore securing supply of articles for each medicine is equally important. Currently the procurement is working to fulfill the specific criteria of the supply and demand situation. However the lack of an appropriate procurement strategy has at a couple of points put it at risk since there has been the issue of overstocking in the warehouse. This means that there exists a possibility that AstraZeneca is in risk of not being able to fulfill these criteria, since if there is no space to store the goods in the warehouse it is not possible to receive articles that are needed for production of medicines. It would then be possible that AstraZeneca is unable to meet the demand in time.

AstraZeneca has implemented a new ERP system, which includes a new MRP. Currently the only real constraint on the system is the production capacity for different medicines. However it should be noted that this constraint only comes into effect when the planners are releasing actual purchase orders for the needed articles for production. Before the planners release the orders the MRP schedules and suggests purchase requisitions for all the orders that are placed by the customers. It is the planners who then have to review if it is possible to produce the desired quantities. Particular consideration is given to those medicines where the demand is much higher than the production capacity. The planners make sure that the orders for these medicines fall within the quantities that have been allocated to each customer.

AstraZeneca does not classify their articles that go into the warehouse with consideration to the global ABC analysis of the finished medicines. As has been described previously in this thesis this lack of classification can be a reason for the overstocking in the warehouse. The main reason for the ABC analysis that has been performed at AstraZeneca is to determine how often different medicines should be produced. ABC analysis is not used to find which medicines should be considered the most important. Therefore using other criteria than annual dollar usage could be done but there would probably be no significant benefit or drawback. It would only change the regularity of production for some medicines, as can be seen in section 4.3.3 where a proposed ABC analysis based on volume and not annual dollar usage is presented. Procurement for some medicines, and their subsequent components, could possibly benefit from using other criteria.

While it could be a possibility to use the global ABC analysis, or an ABC analysis with different criteria, to determine the safety stock level it is difficult to determine if such should be the case. There already exists a clear method for determining the safety stocks at AstraZeneca that should be well functioning once the new ERP system has been implemented. However an issue that should be taken into consideration is how to handle safety stocks for the medicines that are only produced a couple of times per year. Here there is a possibility that due to the irregularity there is safety stock that is kept in storage where there is no need for one. This could possibly be taking up space in the warehouse that is needed for other articles. Therefore there could be a need to alter the method used for determining safety stocks for the articles that are used infrequently.

To use an ABC analyses upon which to base a procurement strategy seems to be a method that would help in reducing the pressure on the warehouse at AstraZeneca. It would especially seem that the quantities of articles used for medicines categorized as A medicines could be reduced significantly which would in turn reduce the risk of overstocking in the warehouse. It

is indicated in the section 5.3.1 that it may not be possible to procure the articles with the same frequency as they are produced. The reduction in terms of quantities would seem enough that a shift towards procurement of smaller and more regular batches could significantly reduce the risk for overstocking. Also there is an issue that can be derived from the difference between using the global ABC analysis and the proposed ABC analysis. The quantity that would be kept in storage for some articles would see different reductions depending on which analysis is used. This means that the potential benefits with using the strategy is dependent on what criteria the ABC analysis is based on. Regardless of criteria there will probably always be articles that will be affected negatively by a specific ABC analysis. Therefore a thorough investigation of how all the articles are affected by this change should be performed before going ahead with the strategy.

6.1 Recommendations

We believe that using the current global ABC analysis in order to determine the quantity that should be procured for each article is the appropriate method to use to formulate a new procurement strategy. The main goal of this strategy should be to reduce the quantity of goods that are kept in storage while at the same time keeping or improving the current customer service level. As has been explained previously it may not be possible to procure the goods exactly according to the ABC classification. We would propose that to start AstraZeneca should try to procure the articles with the following regularity seen in Table 13.

ABC Classification	Procurement regularity
A articles	12-24 times per year
B articles	6-12 times per year
C articles	3-5 times per year
D articles	1-2 times per year

Table 13 Procurement regularity depending on ABC classification

Both the A and B articles will be procured less regularly than what a strict adherence to the ABC classification would suggest while the C and D articles would follow the ABC classification. The reason for the more infrequent procurement, and hence larger batches, is due to that AstraZeneca has to in this case work with its suppliers. The suppliers will have to have their say in this. It may not be possible at the moment to procure the articles with such high regularity or so small batches as the ABC analysis would suggest. Also a risk with procuring with higher regularly is that it increases the possibility for there to occur shortages since there are more times when the stock on hand reaches the set safety stock. Further the reason for the ranges is due to that currently the production for each medicine is not strictly following the current ABC classification. Currently an A medicine should have a production order every week, but it could be every other week meaning that the current analysis is used as a guideline. This suggests that AstraZeneca is capable of adjusting their production after

the demand of each individual medicine. It should therefore be possible to tailor the procurement for each medicine. As has been stated previously the focus of this thesis has been specifically on the labels since more or less all are not supplied via SMI. The strategy should therefore be applicable on all labels at AstraZeneca. It would further be advisable when going forward with the implementation to first look at those article groups where there are few SMI articles. This raises a question that will have to be investigated and that is how this strategy would effect, or be affected by, the SMI articles. This thesis has not investigated how this strategy would work with the current SMI agreements or if it is possible to alter the agreements to fit with the new procurement strategy.

6.2 Further research

Looking into the future there are a couple of areas that we believe that AstraZeneca should investigate with regards to the new procurement strategy. The following areas should be looked into.

How does the change towards more frequent purchasing orders effect AstraZeneca as a whole? There are a number of effects such a change will have on a number of different areas. It is likely that the number of trucks coming to AstraZeneca will increase which will affect the warehouse operations. How many trucks per day/week is it possible for the warehouse to handle? Also an increase in truck transports can have impact on an overall environmental strategy that AstraZeneca wants to promote.

Increasing transports, purchasing smaller batches and purchasing more frequently will have an effect on the costs, most likely increasing them. Investigating exactly how much the cost will change should be done in order to minimize total costs, before going ahead with any implementation. Further as has been described AstraZeneca combines both traditional purchasing and procurement via SMI agreements. In the current situation this combination seems to work well. But will a change lead to issues between the two? It is possible that the benefits from the new purchasing strategy could be negated by the SMI agreements. Exactly how these two procurement strategies affect each other needs to be investigated.

Finally as has been stated numerous times in this thesis the suppliers have not been a part of this investigation. It is important to determine how the suppliers react to changes in procurement and if it is possible to go through with the changes. AstraZeneca cannot just implement a new purchasing strategy and expect the suppliers to be on board without being part of the process.

Works Cited

- AstraZeneca Responsibility Report, 2011. *AstraZeneca*. [Online] AstraZeneca (1) Available at: <http://www.astrazeneca.com/Investors/Annual-reports> [Accessed 15 March 2012].
- AstraZeneca, 2011. *AstraZeneca*. [Online] AstraZeneca Available at: http://www.astrazeneca-annualreports.com/2010/financial_statements_downloads/build-your-own-report-english.htm [Accessed 15 March 2012].
- Axsäter, S., 1979. *Produktionsplanering och - styrning*. Lund: Studentlitteratur.
- Axsäter, S., 1991. *Lagerstyrning*. Lund: Studentlitteratur.
- Björklund, M. & Paulsson, U., 2003. *Seminarieboken: att skriva, presentera och opponera*. Lund: Studentlitteratur.
- Bryman, A. & Bell, E., 2011. *Business Research Methods*. 3rd ed. Oxford: Oxford University Press.
- Carlsson, I., 2011. *Sweden Operations / PET Supply*. PowerPoint. Mikael Ericson.
- Dubois, A. & Gadde, L.-E., 2002. Systematic combining: an abductive approach to case research. *Journal of Business Research*, 55, p.553–560.
- Dubois, A. & Gadde, L.-E., 2002. Systematic combining: an abductive approach to case research. *Journal of Business Research*, 55(7), pp.553-60.
- Eisenhardt, M., 1989. Building Theories From Case Study Research. *The Academy of Management Review*, 14(4), pp.532-50.
- Flores, B.E., Olson, D.L. & Dorai, V.K., 1992. Management Of Multicriteria Inventory Classification. *Mathl. Comput. Modelling*, 16(12), pp.71-82.
- Flores, E.B. & Whybark, D.C., 1993. Multiple Criteria ABC Analysis. *International Journal of Operations & Production Management*, 6(3), pp.38-46.
- Gadde, L.-E., Håkansson, H. & Persson, G., 2010. *Supply Network Strategies*. 2nd ed. Chichester: John Wiley & sons Ltd.
- Hair, J.F. et al., 2011. *Essentials of Business Research Methods*. 2nd ed. New York: M.E.Sharpe.
- Jonsson, P. & Mattsson, S.-A., 2009. *Manufacturing, Planning and Control*. 1st ed. Berkshire: McGraw-Hill Education.
- Lumsden, K., 2007. *FUNDAMENTALS OF LOGISTICS*. Göteborg: Chalmers University of Technology.
- Ng, W.L., 2007. A simple classifier for multiple criteria ABC analysis. *European Journal of Operational Research*, 177(1), pp.344-53.
- Partovi, F.Y. & Burton, J., 1993. Using the Analytic Hierarchy Process for ABC Analysis. *International Journal of Operations & Production Management*, 13(9), pp.29-44.

Shah, N., 2004. Pharmaceutical supply chains: key issues and strategies for optimisation. *Computers and Chemical Engineering*, (28), pp.929-41.

Waller, M., Johnson, E.M. & Davis, D., 2001. VENDOR-MANAGED INVENTORY IN THE RETAIL SUPPLY CHAIN. *Journal of Business Logistics*.

Weele, A.j.V., 2005. *Purchasing & Supply Chain Management*. 4th ed. London: Cengage Learning EMEA.

Yin, R.K., 2009. *Case Study Research Design and Methods*. 4th ed. Applied social research methods series.

Zizka, M., 2005. The Analytic Approach Vs. The Simulation Approach to Determining Safety Stock. *Problems and Perspectives in Management*, (3), pp.119-28.

Appendix A

A1. Costs for warehouse

