

Logistics and Transport Management

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**Dynamic Development Strategy for Tamro and
Apoteket's Supply Chain**

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Preface

This Master Thesis has been one part of the program in Logistics and Transport Management at the School of Economics and Commercial law at Göteborg University.

The work has been totally based upon an assignment from Tamro. I will therefore thank all persons at Tamro that have helped me to get valuable information and answering all my questions and primarily the most important person, my supervisor Thomas Norstedt who initiated this project and has helped a lot during the working process.

I will also take the opportunity to thank Edit Szerző at Apoteket's logistic department, all the persons at different pharmacies that I met for interviews and also Carsten Christensen project-leader at Tamro's Danish daughter company Nomeco.

Finally I want to send my thanks to my examiner Professor Arne Jensen for the valuable support I have got, especially regarding details about different inventory control systems.

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Abstract

There is an increasing focus on supply chains in all types of businesses. This means that instead of optimising the own activities, companies work towards the best and most cost efficient solutions for the whole supply chain. One really important area to work with when companies are working with supply chain improvements is the inventory control system.

This paper is dealing with how an inventory control system should be designed to reach the biggest possible benefits to the lowest costs for a whole supply chain.

Tamro would through a better inventory control system, get the possibility to improve their internal organisation in their warehouses. But the first and most important factor is an improved general control and a more capital efficient business. Seen from Apoteket's point of view, this kind of improvement would reduce the daily physical handling of incoming products and the total ordering cost would most likely decrease with an improved inventory system.

The optimal inventory control system would be an implementation of an automatic replenishment system like VMI (Vendor Managed Inventory). To reach this goal I recommend that Tamro build up a more sophisticated co-operation with Apoteket. This could for example be through the following four steps, directive, co-operation, Base-stock system and finally VMI.

Keywords: Supply chain management, inventory control, co-operation, point-of-sale, automatic replenishment/ VMI.

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1 INTRODUCTION

This chapter will give the reader a good platform for the rest of my thesis. The chapter consists of background, problem, purpose, delimitation and interaction between the chapters.

1.1 Background¹

There is an increasing focus on supply chains in all types of businesses. Which means that instead of optimising their own activities companies work towards the best and most cost efficient solutions for the whole supply chain. One really important area to work with when one is working with supply chain improvements is the inventory control system

Inventory Management is a relatively broad area since it affects many other areas within a company. Such as for example the company's cost structure and its customer service. It is therefore important to study all causes and effects when one is working with an inventory control system.

Tamro is the leading pharmaceutical wholesaler, distributor and service provider in the Nordic- and Baltic regions and also in Northwest Russia. Tamro is active in eight countries and accounts for approximately 50% of the aggregate pharmaceutical demand on the Nordic market (www.tamro.com). In 1999 Tamro's market share of the pharmaceutical distribution in the Nordic countries was as the following numbers illustrate:

Sweden 53%

Finland 56%

Denmark 69%

Norway 11%

The four leading distributors in Europe- Alliance Unichem, GEHE, Phoenix and Tamro- have currently a market share of more than 50% in the EC countries, Switzerland and Norway.

¹ I have decided to keep the Swedish name of the central organisation of all Swedish pharmacies – *Apoteket*, but call its about 900 subsidiaries *pharmacies*.

Tamro is divided into two separate parts. Tamro MedLab specialised in sales, marketing and importation of healthcare and laboratory products and Tamro AB, the company that this thesis is written for, concentrated on distribution of pharmaceuticals, healthcare products and medical devices.

Tamro AB is organised into four business units, Tamro HealthCare, Nordic Central Warehouse, Health Care Distribution and Pharmacy Distribution. Tamro Pharmacy Distribution handles around 85000 order-lines/day and works as a “connection centre” between different product suppliers and the end consumer.

All Swedish Pharmacies get daily delivery from some of Tamro's four distribution-centres (DC) located in Gothenburg, Malmö, Stockholm and Umeå. The lead-time from order to delivery is up to maximum 24 hours. Apoteket AB has an ordering system that, a bit simplified, sends a new order to Tamro when their own inventory levels have reached a specific order point. This system can however lead to sub-optimisations for the system consisting of Apoteket AB and Tamro AB.

When it comes to distribution of pharmaceutical products to hospitals, it is in the Nordic countries in most cases done to hospital pharmacies from the wholesalers. In the rest of Europe it is usual that the pharmaceutical producers by themselves distribute to hospitals from their own warehouses. (essens, 1/00)

1.1.1 History

Tamro is a Finnish company that was founded by Finish pharmacists 1895, but the Group's Danish origins date back to 1801, and the company has all the time since it was founded been concentrated in the same core business.

In 1992 Tamro started its globalisation by taking small steps in the Baltic States and advanced to Russia in 1994. Giant strides where made between 1995 to 1998 when the company expanded to Sweden, Norway and Denmark. The first step was made when Tamro in 1995, bought the Swedish company ADA and reached a leading position on the Swedish market. (Tamro's Annual Report 1999)

The structure of the Swedish wholesaling market is a result of its history. In the 1970s the central organisation “Apoteksbolaget” was found by the Swedish

government, based on all private pharmacies in Sweden, today its name is Apoteket AB. In the same period Apoteksbolaget bought the biggest wholesaling company for pharmaceutical products ADA AB.

1.1.2 Pharmaceutical Market

An explanation to the structure of the Swedish pharmaceutical market is the “one channel distribution” system (EKD) that was introduced in the 1970's for pharmaceutical products. The one channel distribution system is characterised by the fact that the industry is negotiating about margins for distribution of parts or normally the whole assortment through one distributor. This has resulted in very cost efficient distributors and Sweden has currently the lowest distribution margins for pharmaceutical products in Europe. Sweden and Finland are the only countries in Europe with an EKD system, it is just Hong Kong, Indonesia, South Africa and a few more countries that uses an EKD system. This system should be compared to the “multiple channel distribution” system where all wholesalers in the market are keeping all products registered in the specific market in their warehouse.

A difference between the one- and the multiple channel of distribution is that in a multiple channel, the wholesalers compete forward in the supply chain. Which means that each and every pharmacy chooses which wholesaler they should buy from. In a one-channel-distribution system the wholesaling companies are competing backwards for the pharmaceutical manufacturers. Therefore the service to the pharmacies becomes even more important in the multiple distribution system. In countries using a multiple channel distribution system there are often many deliveries per day to one pharmacy hence the customer service department and the warehouses are often open 24 hours per day.

If one goes a step further from the two alternatives consisting of one- or multiple distribution systems, each country has its own system to organise its pharmaceutical distribution. Dependent on the country's laws and regulations, discount system, compensation system and so on. The result is that there does not exist any pure one- or multiple channel distribution system.

Positive sides of an EKD system are that it provides the best conditions for an effective and rational handling and logistics. The EKD system is tested in Sweden by "konkurrensverket" that have given their approval through a time limited exception.

1.1.3 Strategy

It is Tamro's mission to be the best, superior alternative in Northern-European pharmaceutical wholesaling and Tamro states that they should:

Deliver excellence in healthcare. (Tamro's Annual Report 1999)

Tamro's corporate vision is as follows:

"Our customer and partners ask for the highest quality, effectiveness and first class service through the whole supply chain in the healthcare sector. We shall full fill these needs in northern Europe".

The Swedish part of the company have set up the following vision:

"We shall be the leading distributor for the Swedish healthcare market"

The following six goals are set to reach the vision: (Internal company brochure, Vägbeskrivning)

1. To, on the present market lead the development of new distribution solutions for the healthcare market.
2. To all the time, be in the frontline regarding IT solutions and information management.
3. To be a cost efficient and high qualitative distributor.
4. To work for the lowest possible environmental influence.
5. To take responsibility for the role in the society.
6. To be an attractive employer with a challenging future.

1.1.4 Importance of pharmaceutical wholesaling

One way of describing the importance of an industry or a company is to describe the situation if the company did not exist. If the Swedish market did not have its two wholesaling companies Tamro and Kronans Droghandel (KD), the almost 900 pharmacies would have had delivery from about 500 different suppliers, instead of two. The suppliers would have got an impossible administrative task and the transport and handling costs would have been enormous. Another aspect is that Sweden only has one percent of world market for pharmaceutical products and if we had not had wholesaling companies, we as a country would have minor importance towards the big pharmaceutical producers. (Internal company brochure, Vägbeskrivning)

1.1.5 Future

It is most likely that the regulations of pharmaceutical products will continue to be strong even in the future, but the two wholesaling companies Tamro and KD have to be prepared for increased competition since there are many actors that want to take some part of the market. Examples are the Swedish Post, Schenker-BTL, ASG, ICA and mail order companies, to mention a few.

In 1998 an investigation called "Läkemedel i vård och handel"- Pharmaceutical products in healthcare and commerce- was delivered to the Swedish minister of social affairs, suggesting that Apoteket AB's monopoly for sale of pharmaceutical products should cease. The investigator's opinion was that it in the future should be possible to open private pharmacies to compete with service and prices. The investigation did not suggest that it should be any easier to sell pharmaceutical products that do not need prescription in a near future. All pharmaceutical products should be treated similarly and be sold at a pharmacy since these products need qualified handling and information. But on a longer term and if the establishment of private pharmacies will succeed, the investigator could see a future where it might be possible to sell some pharmaceutical products in a more free form.

Tamro is, as all organisations, influenced by its history. The pharmacies have monopoly in their business and Tamro have been owned by Apoteket AB (and still are to some extent since Apoteket AB in 1999 owned 18% of Tamro) that

also owns the pharmacies that are Tamro's customers. The supply chain has therefore partly been very integrated. The ambition from Tamro has been to have a high service level, flexibility and a strong customer orientation.

The challenge for Tamro, like for most other companies, is to learn from its history, handle the present situation and to plan for the future. (Internal company brochure, Vägbeskrivning)

1.2 Problem

Figure one describes in general and broad terms Tamro's supply chain where the first level consists of the pharmaceutical producers. These can be divided into two groups those who use the central warehouses managed by Tamro and those, for example AstraZenica, that has its own production or warehouse on the Swedish market and therefore only uses the distribution centres. Tamro acts as a consignee for the pharmaceutical producers and buys products from the central warehouses for its distribution centres. From this point Tamro sells and distributes the pharmaceutical products to the almost 900 pharmacies all over Sweden.

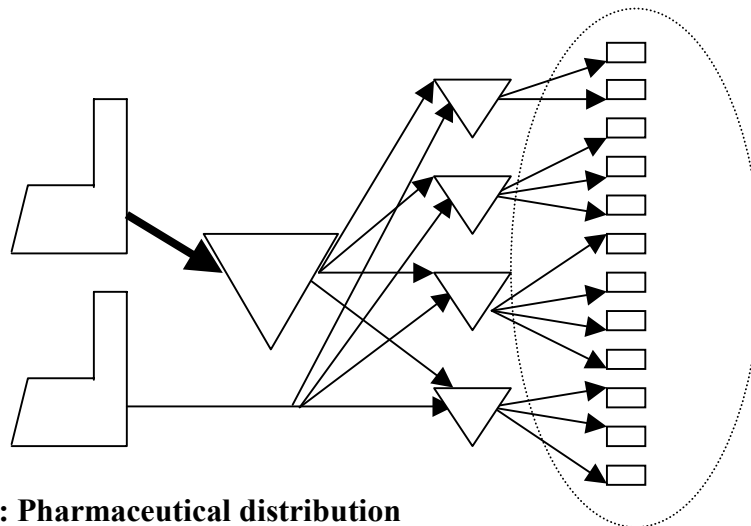


Figure 1: Pharmaceutical distribution

Source: Thomas Norstedt, Tamro Distribution

1.2.1 Problem specification

Tamro are the part in the supply chain with a broad logistic competence compared to other companies both upstream and downstream in the supply chain. Tamro's co-operation with Apoteket becomes more complicated than it is necessary to be since Apoteket do not have full control over its logistical

operations. This is especially true for order quantities, that if they were done in a more theoretically correct way would create the opportunity for more efficient operations both for Apoteket itself and for Tamro.

Tamro would through improvements in the ordering system from the different pharmacies, get the possibility to improve their internal organisation in their warehouses. But the first and most important factor is an improved general control and a more capital efficient business.

Seen from Apoteket's point of view, this kind of improvement would reduce the daily physical handling of incoming products. Another very important aspect is that the total ordering cost would be lower if a pharmacy ordered for example ten articles two times per month instead of ordering three items of the same product seven times per month. It should although be stressed that these are small products that do not take a lot of space since space is one limitation for the pharmacies.

Finally it should be emphasised that Apoteket AB and Tamro AB have an agreement that the orders from different pharmacies should be done at the lowest possible cost, and the highest effectiveness for the supply chain.

1.2.2 Problem-formulation

This study will answer the following question:

How should an inventory control system be designed to reach the biggest possible benefits to the lowest costs for a supply chain?

1.3 Purpose

The main purpose of this study is to introduce new ordering systems and parameters that will lead to lower cost and, at the same time improve the effectiveness of the part of the supply chain consisting of Tamro AB and Apoteket AB.

This specifically means that my thesis will:

- ◆ Investigate how the current ordering system between Apoteket and Tamro works.
- ◆ Evaluate how Apoteket's new inventory control system will affect Tamro's business.
- ◆ In a practical way connect the theoretical methods for an effective and efficient inventory control system with Tamro and Apoteket's business.
- ◆ Evaluate how Tamro should develop its services to the pharmacies.

1.4 Delimitations

I have in close co-operation with Tamro limited this master thesis to only specifically treat the Swedish pharmaceutical market. The reason for this is that there is, as I described previously, a big difference between the regulations of the pharmaceutical regulations in different countries. I have further limited my work to the part of the supply chain consisting of Apoteket AB and Tamro AB, since this is the part of the supply chain that most easily can be improved. The upper part of the supply chain is working like a push system, where the producer decides what inventory level should be placed in their three central warehouses, that Tamro is running for their account.

1.5 Interaction between the chapters

The work is disposed according to figure two, which shows that the some chapters are detached from the rest of the work. I have constructed this model since the first chapter introduction, chapter eight conclusions, chapter nine named future work and also chapter ten named reliability, in one way are independent chapters. Chapters eight and nine, conclusions and future work, are a result of the entire work and should therefore not be connected to any specific chapter, as figure two is illustrating. The same is also true for the reliability chapter.

The introduction consists of background, problem, purpose and delimitation, where I built up a platform for the further work. The background is the true introduction to my master thesis. It should give the reader an interest to continue his/her reading. It includes a presentation of the pharmaceutical industry and

specifically Tamro as a company. In the next subchapter called problem the goals that should be reached are presented and defined. The purpose states what I want to achieve and how the results are going to be used and finally the delimitation makes it clear exactly what my thesis will be about and what will be left out.

After giving a brief introduction to my subject in the first chapter, chapter two named Literature will explain all the theories, definitions and models that that I will use in my further work.

In the first chapter I introduced my problem to you as it have been given to me. After working with the problem I will be able to give my own analysis of the problem in the third chapter called Research question and information needs.

Figure two might at the first time look a bit messy with both “upstream and downstream” arrows from the forth chapter, Methodology and no clear input to the chapter. The reason for this structure is that within this chapter I will discuss both methods related to the Literature chapter, to the chapter Data collection, to my analysis and also to the chapter called Proposed research design for calculating the benefits of VMI (Vendor Managed Inventory). The only base for the methodology chapter is the introduction chapter and this is the reason that there are no arrows to this chapter in figure two. The chapter consists of a method discussion, where I present different possible methods for collecting data and a presentation of the methods I have chosen and why.

My actual case study that I performed at Tamro is presented in the fifth chapter called Data collection. After most of the subchapters I have chosen to have a discussion where I will have my own discussion around the collected information.

Chapter six is named Proposed research design for calculating the benefits of VMI and here I will present the calculation procedure for comparing the present inventory system with a VMI system. Since I most likely will not be able to perform these calculations in this thesis.

In chapter six Analysis I will discuss the problem formulation based on the previous chapter.

The final result of my work will be found in chapter eight called Conclusion and chapter nine Further work I have some comments on the result of my thesis. Finally I will have a Reliability discussion in chapter ten, where I will discuss the validity and reliability of my thesis.

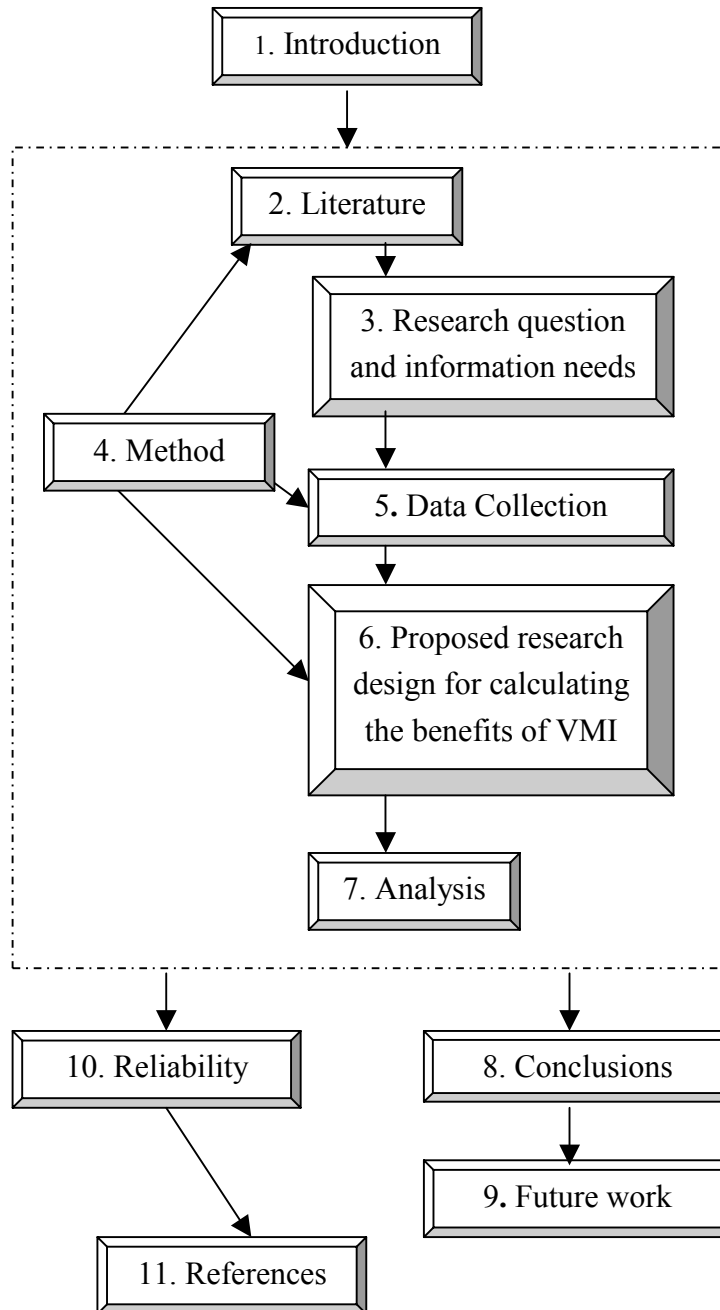


Figure 2: Interaction between the chapters

Source: Own construction

2 LITERATURE

This chapter will give a broad theoretical framework to the subject inventory control and its management. This is done to be able to see the inventory control system between Tamro and Apoteket in a correct way.

2.1 Introduction

The Council of Logistics Management has defined logistics in the following way: (Lambert, Stock, 1992, p. 4)

“The process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw material, in-process inventory, finished goods, and related information from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements.”

Since there are different views on the subject the previous definition should be compared to the mission of a logistican according to Ballou (1999, p. 6):

“...to get the right goods or services to the right place, at the right time, and in the desired condition, while making the greatest contribution to the firm”

2.2 Supply Chain Management

I started my thesis with saying that there is an increasing focus on supply chains in all types of business. Therefore I will explain the meaning of supply chain management.

Supply chain management and partnership relationships is according to Ellram and Cooper (1990, p.1f) a means of meeting the firm's customer service objectives while minimising the inventory and its associated costs through the supply chain. The attention of supply chains has occurred through the recognition of the fact that sub-optimisations of one company's activities will create problems for the rest of the supply chain. The concept has evolved to say that suppliers, customers, and third-party providers should share the information and plans necessary to make the channel more effective and competitive. In other

words, the channel should be viewed as a whole rather than a set of fragmented parts. The concept of supply chain management is valuable today due to the changing competitive environment and the need of new operating and competitive strategies that focus on better leveraging a firm's assets to achieve customer service goals. Supply chain management focuses on the control and management of inventory throughout the entire supply chain from the supplier to the final customer and it should involve trust and information sharing between the parties involved. In the traditional approach each company has optimised its own position by holding all the inventories that it needs or requiring other supply chain members to hold additional inventory. As a result the inventory level is often much higher than it needs to be.

Finally it should be noticed that the underlying concept of supply chain management is based upon similar concepts as a logistic partnership between for example a shipper and third party company where the partners are mutually dependent. (Ellram, Cooper, 1990, p. 4)

2.3 The importance of Inventories

Inventories are classified as one of the current assets of an organisation. Thus all other things being equal, a reduction in inventories lowers the assets relative to liabilities. The funds freed by a reduction in inventories are normally used to acquire other types of assets or to reduce liabilities. Such actions directly influence the current ratio, which is the most common measure of liquidity. Changes in inventory can affect both the left and the right side of the following equation:

$$\text{Operating profit} = \text{Revenue} - \text{Operating expenses}$$

Sales revenue can be influenced by the inventory allocation and operating expenses can be altered through changes in aggregate inventory levels since inventory-carrying changes represent a significant component of such expenses. More effective scheduling and control of inventories of individual items can also reduce the labour component of operating expenses. (Silver, Peterson, 1985, p.1ff)

Expectations of the future for a company or a supply chain depend according to Silver and Peterson (1985, p. 5) on the following variables:

- The trends of recent sales and new orders
- The volume of the infield orders
- Price pressures
- The level of inventories in the recent past
- The ratio of sales to inventories
- Interest rate on business loans
- The current level of employment
- The types of decision-making systems used by management

All of these variables are in one way or another related to the inventory system.

2.3.1 Overall control parameters

Silver and Peterson (1985, p. 59ff) have defined the following five broad decision categories for controlling aggregate inventories:

A. Cycle stock

Cycle inventories result from an attempt to order (or produce) in batches instead of one unit at time. The amount of inventory on hand at any point that results from such batches is called cycle stock

B. Safety or buffer stock

Safety stock is the amount of inventory kept on hand on average to satisfy an uncertain demand and supply in the short run. The level of safety stock is controlled in the sense that this investment is directly related to the level of desired customer service - how often customer demand is met from stock. I will go deeper into the aspects of safety stock in a later section of this chapter and also in the chapter called *Proposed research design for calculating benefits of VMI*.

C. Anticipation inventories

This type of inventory consists of stock accumulated in advance of an expected peak in sales. When the demand is regularly lower than average during some part of the year, excess inventory above cycle and safety stock can be built up so that during the period of anticipated requirements the extra demand can be satisfied from stock. Rather than from for example working overtime in the plant.

D. Pipeline inventories

Pipeline inventories includes goods in transit between levels of a multiechelon distribution system or between adjacent work situations in an assembly line

E. Decoupling Stock

Decoupling stock is used in a multiechelon situation to permit the situation of decision making at different echelons. Decoupling inventories allows decentralised decision making at warehouses without every decision at an industry having an immediate impact on the central operations of an organisation.

Senior management have to express an opinion of how much aggregate inventory is required in each of these broad categories.

The five categories described above are used to concentrate the attention on organisational purpose of inventories such as control and manageability rather than accounting storekeeping. These categories need further to provide an aggregate perspective for the control of individual stock keeping units' (s.k.u.). (Silver, Peterson, 1985, p. 61)

2.3.2 Lead-time

The replenishment lead-time (L) is defined as: the time that elapses from the moment at which it is decided to place an order, until the order is physically on the shelf for satisfying customer demands. It is convenient to think of the lead-time as being made up of the following five distinct components. (Silver, Peterson, 1985, p. 65f)

1. Administration time at the stocking point and order preparation time – this is the time that elapses from the moment at which it is decided to place the order until it is actually transmitted from the stocking point.
2. Transit time from the supplier – this may be negligible if the order is placed through EDI, telephone or Fax.
3. Time at the supplier – this time constitutes the primary variable component. Its duration is (primary) materially influenced by the suppliers stock situation when the order arrives.

4. Transit time back to the stocking point.
5. Time from order receipt until it is available on the shelf – this time is often neglected when it should not be. Contributing factors include inspection and cataloguing.

2.4 Inventory costs

The unit value or unit variable cost as it is also called, is for a merchant the price including freight paid to a supplier, ideally the value of an item should measure the actual amount of money that has been spent on the unit to make it available for usage. The total acquisition cost per year clearly depends on the unit value and so does the unit in inventory.

The cost of carrying items on inventory includes the opportunity cost of the money invested, the expenses incurred in running a warehouse, the cost of special storage requirements deterioration of stock, obsolescence, insurance and taxes. The most common convention of costing is to use carrying cost per year = Ivr . Where I is the average inventory in units, Iv is then the average inventory expressed in the currency chosen and r is the carrying charge – the cost in for example SEK of carrying a value of one SEK of inventory for one year. The largest portion of carrying charge is made up of the opportunity costs of the capital tied up that otherwise could be used elsewhere in the organisation and by the opportunity costs of warehouse space claimed by inventories. Neither of these costs is measured by traditional accounting systems.

The opportunity cost of capital can be defined as the return on investments that could be earned on the next most attractive opportunity that can not be taken advantage of because of a decision to invest the available funds in inventories. Theoretically this opportunity activity can change from day to day but the cost of capital is in most cases set to some level by decree and is changed only if major changes have taken place in a company's environment.

The value of carrying charge is not only dependent on the relative riskiness of the s.k.u, it also depends on the costs of storage that are a function of bulkiness, weight, special handling requirements, insurance, and possible taxes. To make

the inventory decision more manageable both from a theoretical and a practical point of view a single value r is usually assumed to apply to most items, r could depend on the total size of the inventory. (Silver, Peterson, 1985, p. 62f)

It should be stressed that the letter used here in the formulas and also later on can vary between different sources.

Speculation of a low carrying charge would generate a system with relatively large inventory investments, good customer service and low replenishment expenses. Alternatively it would create a system that encourage carrying less inventory, poorer customer service and higher ordering costs. The ordering quantity depends on the ratio of ordering cost/carrying charge, A/r . As A/r increases, the order quantity increases and the total number of replenishment per year decreases, as the figure below illustrates. (Silver, Peterson, 1985, p. 77)

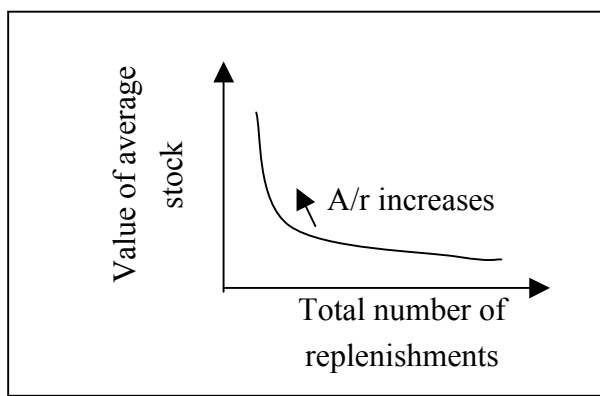


Figure 3: Exchange curve

Source: Silver, Peterson, 1985, p.77

The ordering or set-up costs (A) denotes the fixed costs - independent of the size of the replenishment. For a merchant this cost is called ordering cost and it includes the cost of order forms, postage, communication, authorisation, typing of orders, receiving, (possible) inspections, following up on unexpected situations, and handling of vendor invoices. (Silver, Peterson, p 1985, p. 63)

The cost of insufficient capacity in the short run can also be called the costs of avoiding stock-outs and those costs incurred when stock-outs take place. In the case of a producer the costs include the expenses that result from tearing down of existing production set-ups to run emergency orders and the attendant costs of expediting and rescheduling split lots and so forth. For a merchant emergency

shipment or substitution of less profitable items can contribute to these costs. The costs mentioned so far can be estimated reasonably well, but in addition there are costs that can result from not servicing customer demand. Will the customer be willing to wait while the item is backordered or is the sale lost for good? How much goodwill is lost as a result of the inability to be of immediate service and will the customer ever return? (Silver, Peterson, 1985, p. 64)

There are costs associated with the operation of the particular decision system selected, called system control costs. These include the costs of data acquisition, data storage and computation. In addition there are less tangible costs of human interpretation of results, training, alienation of employees and so forth. Although difficult to quantify, this category of costs may be crucial in the choice of one decision over another.

Other potential key variables can be cost factors such as space and expediting or supply situation including for example availability, flexibility and reliability. (Ibid. p. 65)

There are five fundamental categories of costs identified by Silver and Peterson (1985, p. 175)

1. Basic production or purchase cost
2. Inventory carrying costs
3. Cost of insufficient capacity in the short run
4. Control system cost
5. Cost of changing work force sizes and production rate.

Focusing on the part of the inventory control system that can be called order quantity system, the fourth category is not influenced by the exact value of the order quantity. In addition the fifth category is not relevant for item-by-item control. The only cost related to the third category, insufficient capacity in the short run, is caused when a decision maker chooses to run short of inventory before making replenishment. Therefore none of these three cost categories is needed when we are studying the economic selection of the replenishment quantity.

One is usually not looking for absolute optimisation in inventory management but instead for significant improvements over current operations. From this follows the development and use of heuristic decision rules. These are procedures of sound logic that are designed to yield reasonable and therefore not necessarily mathematically optimal answers to complex problems. Inventory planning decisions require the estimation of opportunity cost. Accountants are concerned with the historical costs and decision-makers need to anticipate future costs so that these can be avoided if possible. (Silver, Peterson, 1985, p. 71f)

When the cost per order is measured, the following three steps can be used as a guideline. (Jensen, 1991:123)

1. Describe the order cycle systematically
2. Estimate if different activities in the order cycle represent traceable costs
3. Measurement methods
 - resources for typical order
 - incremental cost of an hypothetical increase/decrease in number of orders
 - regression analysis of order and cost statistics

2.5 Order quantity

The order quantity can be calculated or determined in several ways. The figure below illustrates the alternative methods for different situations.

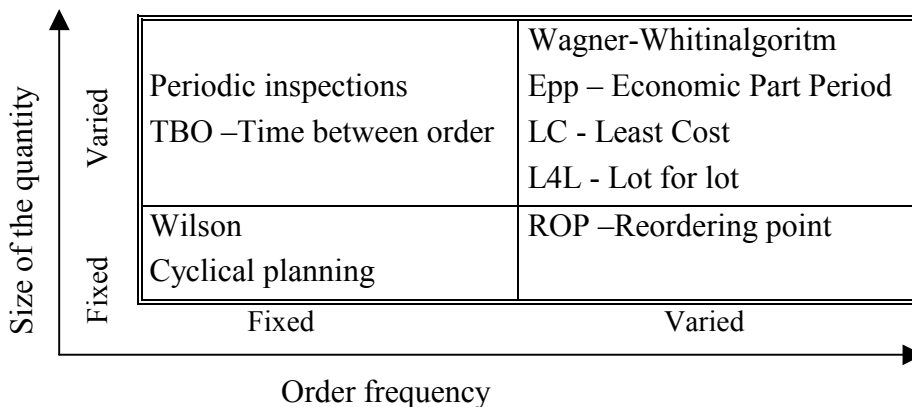


Figure 4: Comparison between different calculation methods

Source: Lumsden, 1998, p. 334

Some of these methods, like for example the periodic inspections and reorder point, will be discussed in a later section of this chapter. The least cost (LC) method means that the time between orders is increased so the average cost per item for the quantity ordered is minimised for this specific time interval.

2.5.1 Economic Part Period

In an Economic Part Period (EPP) a key figures is determined for every product category in the assortment. This parameter is fixed until some type of change occurs regarding the order quantity. The key figure is not influenced by a varied demand. The figure describes the optimal inventory time the items in product category should have, based on their demand.

2.5.2 Lot-For-Lot

As its name implies the Lot-For-Lot (L4L) method means that every item that is sold is immediately replaced by a new one. This is done to be able to provide a high service level. If there is a fixed size of order quantity, the supplier can in a more simplified way plan its business for every order. The problem with a cyclical planning system where both the order quantity and its frequency can be fixed, is that the order quantity varies. (Lumsden, 1998, p. 311ff)

2.5.3 The Wilson formula

The Wilson formula, or square root formula as it is also called, is the basic method for optimising the order quantity and more developed theories are almost exclusively built upon this formula.

The Wilson formula takes two types of constants into consideration, the cost for keeping inventory and the ordering cost. When the economic order quantity (EOQ) is calculated through the Wilson formula the total relevant costs are minimised under a given set of circumstances. The best way to do this is to first minimise the fixed cost or the carrying charge. This idea is also one part of the Japanese JIT (Just In Time) philosophy. (Silver, Peterson, 1985, p. 179)

The Economic Order Quantity, EOQ or simpler Q, is calculated through the following formula:

$$Q = (2RS/IC)^{1/2}$$

Q = the replenishment order quantity, in units

S = the fixed cost component incurred with each replenishment

C = the unit variable cost of an item, not the selling price but the product's value

I = the carrying charge, interest rate

R = the demand rate of the item, usage over a period of time

The time between replenishment is given by Q/R which means that the number of replenishments per unit time is given by R/Q . Associated with these calculations is the replenishment cost given through $S + QC$ (where C has to be independent of Q)

All the variables used in the Wilson formula reflect only financial considerations, but there are some so-called "softer variables" that need to be studied. Examples of such variables are the shelf life, storage capacity limitations and the fact that a very long time supply may be unrealistic. (Silver, Peterson, 1985, p. 194f)

Certain commodities are sold in pack sizes containing more than one unit. Therefore it makes sense to restrict a replenishment quantity to be limited to the different packaging sizes and its multiples. (Ibid. p. 196)

Internal efficiency can be described in forms of service costs and the amount of tied-up-capital. The problem is that different actions that have the purpose to improve specific parts of the business can result in negative synergies for the business as a whole. (Lumsden, 1998, p. 225)

2.5.4 Safety stock

The safety stock is a security for a company's ability to deliver in an insecure environment. It is caused by insecurity in the length of the lead-time, the demand under the lead-time and in the inventory balance. (Lumsden, 1998, p. 240)

The different methods for calculating the safety stock is discussed in a later chapter called *Proposed research design for calculating the benefits of VMI*.

The safety stock can be reduced by the following factors: (Lumsden, 1998, p 265ff)

- ◆ The service level can be reduced, which will result in a lower safety factor. This should not be based on an internal decision since the overall relation to the customer must be considered and it is therefore preferred to make this type of change in close co-operation with the customer.
- ◆ Reduction of the length of the lead-time, by reducing the variance of the length of the lead-time the safety stock at the customers' plant can be reduced, or even eliminated.
- ◆ The variance of demand is reduced through communication with the customer. The customer can either reduce its variation of demand or the information between the companies can be further developed so the supplier can adjust its normal production and in that way avoid safety stock.

The stock should be controlled according to the customers requirements, or what the customers demand should at least be investigated. (Lumsden, 1998, p. 250)

2.6 Inventory control system

When an inventory control system is designed should answer the following three questions: (Silver, Peterson, p. 256)

1. How often should the inventory status be determined?
2. When should the replenishment order be placed?
3. How large should the replenishment order be?

There exist a lot of variances between differences in inventory control systems, but there are three basic systems, as I will describe here. (Silver, Peterson, p. 256ff)

A. Order-Point, Order-Quantity System (s,Q)

This system involves continuous review. A fixed quantity Q is ordered whenever the inventory position drops to the reorder point s or lower, where it is the inventory position and not the net stock that is used to trigger an order. The (s,Q) system is illustrated in the figure below.

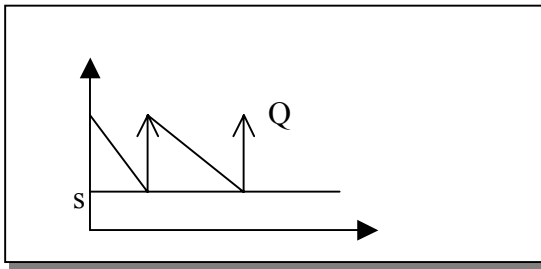


Figure 5: Order-Point, Order-Quantity System

Source: Own construction

This is a simple system. The fixed order quantity has the advantage of less likelihood of errors. One disadvantage is that in its unmodified form it may not be able to effectively cope with situations where individual transactions are of appreciable magnitude.

The inventory level should be big enough to satisfy the expected demand under the lead-time and a possible divergence in the safety stock level. (Lumsden, 1998, p. 269f)

B. Periodic-Review, Order-up-to-Level System (R,S):

Another name for this system is replenishment cycle system and this is a system commonly used in companies that do not utilise a computer controlled system. For co-ordination between different related items the (R,S) system is a preferred method. The system offers a regular opportunity to adjust the order-up-to-level S , which is a desired property if the demand pattern is changing with time. The main disadvantage of the (R,S) system is that the carrying costs are higher than in a continuous review system. The system is illustrated in the figure below.

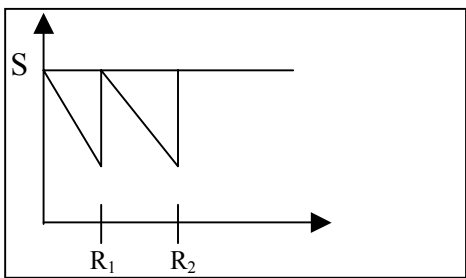


Figure 6: (R,S) System

Source: Own construction

There are according to Lumsden (1998, p. 272) three distinct negative sides with the Periodic Review system. First the size of the order can and will vary. A consequence is that the supplier can be forced to change the efficient and effective sizes from for example complete secondary packages. Secondly the order quantity can be much lower than the economic order quantity. The last negative side with this system is the increased safety stock followed by the increased insecurity in the system.

An alternative to the Periodic-Review Order-up-to-Level is to use a system where the replenishment quantity is fixed. This system is seen as an improved development of the (R,S) system and one of its ideas is to not order too small quantities since just quantities over a specific size are ordered.

C. (R,s,S) System:

The idea behind a Periodic-review, Order-point, Order-up-to-level system is that every R unit of time the inventory position is checked. If the inventory position is at or below the reorder point s, enough is ordered to raise it to S. If the position is above s, nothing is done to raise it until at least the next review instant. As the figure below illustrates the (R,s,S) system has an (extra) ordering point that is used if the inventory level falls between the periodic reviews.

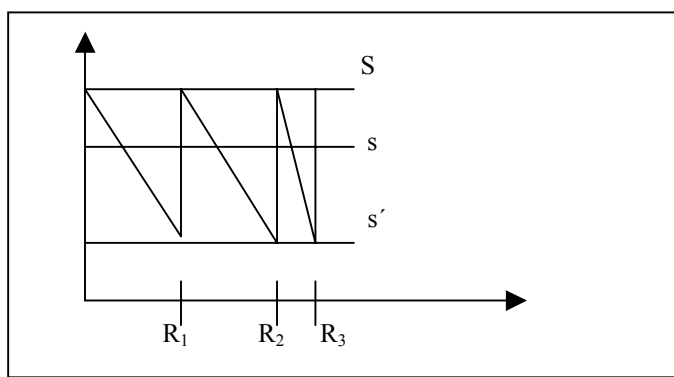


Figure 7: (R,s,S) System

Source: Free from Lumsten, 1998, p. 274

The best (R,s,S) system produces a lower total of replenishment, carrying and shortage costs than any other form of system. The (R,s,S) system is however

more difficult for a clerk to understand than some of the previously mentioned systems.

One Positive side with a system with fixed order intervals is a reduced safety stock since the insecurity only relates to the lead-time.

2.7 Classification of products

There is a theory saying that all articles kept as inventory could not be treated in the same way. Therefore some classification methods have been developed. These can for example be groups based upon volume, weight or volume-value. The meaning with the classification is to concentrate the reduction of lead-time, order costs and insecurity primarily to the most important items – the A articles, to increase their inventory turnover. For items not that important, C articles, it is according to this view enough with more simplified routines to keep an acceptable service at a minimal cost.

One method of classifying the products is through the 60-30-10 limitation. This means that the A-class will represent of 60% of the volume value and it consists of 10% of the total amount of articles and so on. (Lumsden, 1998, p. 385ff) The ideas behind ABC analysis were introduced in the 18th century by Vilefredo Pareto and are therefore also called Paretos principal. (Lambert, Stock, 1993, p. 426)

According to the classification theories, many inventory management systems can be significantly improved by adopting decision rules that do not treat all s.k.u, or all inventory investments equivalently. It is common to use three priority ratings: A (most important), B (intermediate in importance) and C least important. (Silver, Peterson, p. 64ff)

The number of categories appropriate for a particular company depends on its circumstances and the degree to which it wishes to differentiate the amount of effort allocated to various groupings of Stock keeping units.

There are theoretically both positive and negative sides to the classification system described here and according to Professor Arne Jensen the categorisation

into A-B-C items is not needed at all in a good computerised inventory control system.

Another aspect of product classification is to differentiate the inventory availability for different product categories. One way is to take both the profit contributions, the individual product demand into consideration. This is illustrated in the figure below. (Christopher, 1998, p. 58f)

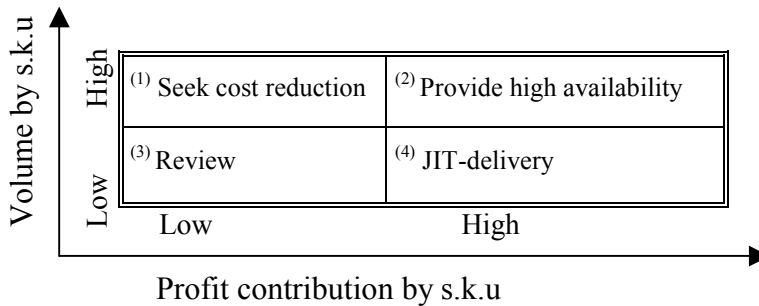


Figure 8: Managing product service levels

Source: Christopher, 1998, p. 59

Cost reductions is the method for products that have a high volume but low profit contribution, the priority should be to re-examine product and logistics cost to see if there is any scope for enhancing profit.

Products that are profitable and have a high frequent demand should have the highest service availability.

If the products that fit into the review group do not play a strategic role in a firm's product portfolio, there is a strong case for dropping or at least minimising the occurrence of these products.

Products that are highly profitable but not so frequent in demand are candidates for the JIT-delivery group.

In these aspect it is interesting to compare the previously described with the Boston Matrix illustrated below. The Boston Matrix analyses the balance of an organisation's strategic business units.

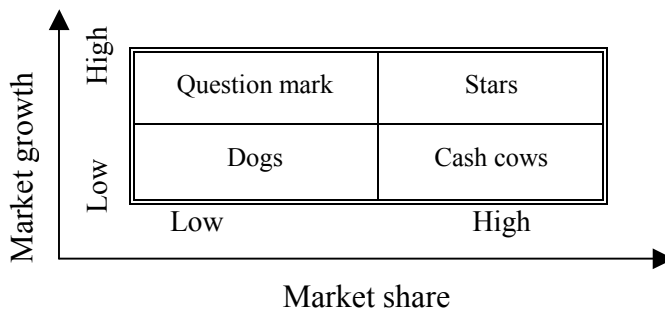


Figure 9: Boston Matrix

Source: Freely from Johnson, Scholes, 1999, p. 187

Briefly, in this model the question mark represents the new products with growth potential but not sufficient market share. Stars represent business units (or products) with high market share in a growing market. A cash cow has a high market share in a mature market and a dog has low market share in a static or declining market. (Johnson, Scholes, 1999, p. 188)

2.8 Customer service

A primary goal of inventory management is to achieve an optimal balance between Inventory carrying costs and customer service. The inventory policy in a supply chain will therefore affect the customer service. Customer service is according to Lambert and Stock (1993, p. 111) defined as:

...The measures of how well the logistic system performs in creating time and place *utility for a product, including post-sale support.*

It has been stated that in today's marketplace the order-winning criteria are more likely to be service-based than product-based, therefore it is very important to recognise the customer service elements.

Some of the elements included in customer service are explained in the following points. (Lambert, Stock, 1993, p. 113)

1. Availability of the item – availability of the supplier to satisfy customers order within a time limit
2. After sales service and backup – speedy and ready replenishment of defective or damaged items

3. Efficient telephone handling of orders and queries - availability of personnel within the organisation who can be quickly accessed for intelligent handling of customer queries.
4. Order convenience- efficiency, accuracy and convenience of the daily work.
5. Competent technical representatives
6. Delivery time
7. Reliability
8. Demonstration of equipment
9. Availability of published material

There are according to Christopher (1998, p 41) three distinct stages in the area of customer service called pre-transaction, transaction and post-transaction. Examples of the activities within the different stages are:

Pre-transaction: inventory availability, target delivery dates, response time to queries.

Transaction: order fill-rate, on time delivery, product substitutions, handling of back ordered items, shipment delays.

Post-Transaction: First call fix rate, customer complaints, invoice errors and service.

Before a transaction takes place the following pre-transaction elements should be discussed:

- ◆ Written statement of customer service policy
- ◆ Organisation structure
- ◆ System flexibility
- ◆ Management service

Just-In-Time purchasing requires frequent releases of orders and frequent deliveries of products. For this to work, purchasers and suppliers must develop long term relationships rather than use the multiple sourcing practice. (Lambert, Stock, 1993, p. 498)

An Inventory system can, according to Lambert and Stock (1993, p. 539) be divided into a strategic and an operational part. The strategic part consists of

replenishment system and decided safety stock level. While operational decisions relate to forecasting, inventory tracking, carrying cost measurement and inventory turns.

2.9 Inventory policy

An inventory policy consists, according to Bowersox (1996, p. 250) of guidelines concerning what to purchase, when to take action and in what quantity. It also includes decisions regarding inventory position and placement at plants and distribution centres. Secondly the inventory policy concerns management strategy involving co-ordination and communication.

On the other hand Inventory control is a mechanical procedure for implementing an inventory policy and the primary differentials are speed, accuracy and cost. To implement desired inventory management policy, the following control procedures must be devised: perpetual review, periodic review and modified control system. (Ibid. p. 282)

Bowersox (1996, p. 305f) have identified the following three methods for improvements of inventory management:

- ◆ Policy definition and refinement
- ◆ Information integration
- ◆ Expert system applications

It should in relation to these three methods be recognised that logistic competency is achieved through co-ordination of the following areas: Network design, information, transportation, inventory, material handling and packaging. Bowersox (1996, p. 25)

Stern, El-Ansary and Coughlan (1996, p. 27) have in their book *Marketing Channel* described the paradigm shift from a push to a pull philosophy. Where the push system forces products through a pipeline based on the production capabilities while in a pull system the most important factor is to listen to the customer and respond to changes in their demand. Example of changes for a retail distribution centre and a retail store are illustrated in the table below.

PUSH	PULL
RETAIL DISTRIBUTION CENTRE	
Order point based upon safety stock level and historical forecasts	Automatic replenishment
Deals, promotions	EDI services
Forward buying	Cross-dock receiving
Manual purchase orders, information entry and output	
RETAIL STORE	
Order point based upon safety stock and forecasting	POS data collection
Promotions	Micro market driven
Manual entry of items to be reordered	Automatic replenishment EDI services

Table 1: Push verses Pull strategies

Source: Stern, El-Ansary and Coughlan, 1996, p. 27

It is here important to understand that a completely automated replenishing system is not by itself always the best alternative. A manual override is essential for several reasons, as exemplified in the following two points. Silver and Peterson (1985, p. 172)

- A. Provisions for the incorporation of factors not included in underlying mathematical model.
- B. The cultivation of a sense of accountability and reasonability on the part of the decision-makers.

2.10 Inventory system

Recently new popular approaches to inventory management have popped up that aim to improve system wide efficiency. A number of different terms are used to designate these programs, but all these programs can be brought together under the term automatic replenishment programs (ARP).

The term ARP:s are used to signify an exchange relationship where the seller replenishes or restocks inventory based upon the actual usage and stock level information provided by the buyer in the supply chain.

The background to the automatic replenishment programs is to make inventory commitment more efficient without jeopardising sales or customer relations. The overall solution for these programs is therefore to substitute information for inventories, which requires a close co-operation in the supply chain and it can not be emphasised enough that these inventory systems must involve trust in the supply chain and willingness to share proprietary and confidential information.

The usage of a ARP system will most likely give benefits like increased sales for the retailer due to more efficient stocking and more frequent deliveries, higher selling space productivity since there will be fewer stock-outs and there will be a decreased need for storage space for safety stock. The safety stock will in these inventory systems be dramatically reduced and sometimes even totally eliminated. Manufacturers will benefit from lower distribution costs through better matching of supply to demand.

Popular ARP's are continuous replenishment planning (CRP) and vendor managed inventory (VMI). These programs are very similar but in a VMI program the vendor takes responsibility for deciding when and what to ship. (Daugherty, Myers, Autry, 1999, p.63f)

Industry specific programs have developed in this new pull paradigm. Examples are efficient consumer response (ECR) that is widely used in the grocery industry and quick response (QR) common in the apparel industry.

The table below illustrates the most common automatic replenishment programs and their frequency (multiple responses were possible) according to a study performed by Daugherty, Myers and Autry (1999, p. 68).

TYPE OF PROGRAM	FREQUENCY (%)
Vendor-Managed-Inventory	45
Continuous Replenishment	36
Supplier-Managed-Inventory	16
Quick Response	12
Co-Managed Inventory	10
Efficient Consumer Response	9
Distributor Managed Inventory	4

Table 2: Involvement in automatic replenishment programs

Source: Daugherty, Myers and Autry, 1999, p. 98

The respondents in this study were from different industries, examples are food and beverages, electronics, pharmaceutical and medical equipment.

2.10.1 *Vendor Managed Inventory*

In a VMI system the vendor manages the demand by sharing information with the customers. The supplier takes responsibility for replenishment of the customers' inventory. This is handled through information of the actual usage of the products, the customers' current level of inventory and details of any planned marketing activities. The customers give their supplier an indication of the upper and lower limits of the stock that they want to have.

A VMI system will reduce the customers inventory levels simultaneously as the out of stock situations is decreased. Another benefit for the customer using this system is that they, in most cases, do not pay for the inventories until after they have been sold. The customer can in this way reduce their cash flow considerably. (Christopher, 1998, p. 195f)

VMI is one of the most common types of automatic replenishment systems currently in use and the following quotation describes this system. (Daugherty, Myers, Autry, 1999, p.63f)

...Suppliers assume the responsibility for managing inventories at customer locations through the use of highly automated electronic measuring systems. Detailed sales and demand data are exchanged

between vendors and customers, and the information is used to plan and implement product replenishment and sales strategies.

The supplier will through the improved information situation be able to plan and schedule their production and distribution. This will improve the capacity utilisation and reduce the requirement for safety stock considerably. (Christopher, 1998, p. 195f)

2.10.2 Co-managed Inventory

Co-Managed Inventory (CMI) involves a more actively collaborative approach between supply chain partners than VMI, which is only handing over responsibility for inventory management from the customer to the supplier. CMI is characterised by the sharing of responsibility for inventory management, in a way that maximises supply chain efficiency, supposedly to the mutual benefit of all parties. (Peck, p. 1)

General benefits of a CMI strategy is secured loyalty from customer since closer relationships can secure market access and through information it might be possible to minimise inventory holdings and other distribution costs. Non-mutual sharing of savings in the supply chain is one potential risk with CMI together with the ability to manage the system. Potential obstacles when implementing a CMI system could be cultural differences between organisations, new type of resources like good IT systems and reorganisations since for example the order processing might disappear. (Jensen, 991126)

2.10.3 Efficient Customer Response

ECR has according to Stern, El-Ansary and Coughlan (1996, p. 174ff) become the code word for how a consumer channel will work in the future, with continuous replenishments of inventories through the channel in response to end customer demand. The idea behind ECR encompasses the following six activities: (1) Integrated EDI, (2) continuous replenishment, (3) computer assisted ordering, (4) through distribution, (5) ABC Costing and (6) Category management.

The retailer benefits from ECR through increased sale, higher productivity and the need for less room for keeping inventories. The wholesaler can continue to upgrade services to retailers such as inventory management, replenish management and assortment planning – freeing them to focus on relationships with consumers. An ECR system has the potential to improve the efficiency of delivery, stocking and replenishment of inventory in a distribution channel. The availability of inventory at the point of purchase should be matched as closely as possible to the time at which the product will be bought rather than holding safety stocks of inventory on the chance that products will be demanded, or stocked out because of under-forecast of demand. (Stern, El-Ansary, 1996, p. 476)

2.10.4 Components

To support the automatic replenishment systems discussed previously the programs need to be built up of different components. These components can for example be EDI, bar coding and point-of-sale data. The table below illustrates frequently used components in an automatic replenishment system. (Daugherty, Myers and Autry, 1999, p. 69)

- ◆ EDI
- ◆ Cross-functional Teams
- ◆ Bar-coding
- ◆ Electronic-payment
- ◆ Point-of-sale

The Importance of most of those components is quite obvious but the need of Point-of-sales data will be more detailed described. Another area related to the automatic replenishment systems that I will describe later is category management.

2.10.4.1 Point-of-sale

The costs of ordering and inventory replenishment will be reduced through effective use of Point-of-sale (POS) data. As each item is sold the information is captured on the retailers POS system, permitting instant updating of its inventory position. Replenishment orders can be issued in one of the following three ways.

(1) The retailer gives the supplier a blanket authorisation to ship orders without

the buyer's review of individual orders. (2) The supplier prepares an order and sends it to the buyer as a recommended order, with the buyer reviewing and authorising the order. (3) The retailer prepares replenishment orders and transmits them to the supplier through EDI. (Stern, El-Ansary, 1996, p. 416)

A Point-of-Sale system is more appropriate for some types of industries/products. Fashion and seasonal goods are both difficult and risky to project in advance. While products with more predictable sales patterns are more appropriate for automatic replenishment and longer range projections. (Daugherty, Myers and Autry, 1999, p. 70)

2.10.4.2 Category management

Retailers are more and more starting to measure the profitability of their shelf-space, particularly as they move towards a strategy in which products are grouped into categories and those categories are then managed against profit goals. (Christopher, 1998 b, p. 51)

The suppliers are usually best placed to be the category expert as they only tend to compete in a limited number of categories whilst the retailer of necessities will be concerned with several hundred of categories. (Christopher, 1998 b, p. 63)

2.10.5 Base Stock Control System

A Base stock control system can strategically be placed between the complete automatic replenishment systems and the "normal" inventory control systems. The base stock system is related to the POS theory and it is one way to solve the problem when organisations in the supply chain, place their orders only on basis of the demand from the next part in the supply chain. The key is to make end item demand information available for decision-making at all stocking points. The technical need for this system is an effective communication/ information system.

The most common type of base stock system is a variant of the order-point, order-quantity system previously mentioned. (Silver, Peterson, 1985, p. 476)

The figure below illustrates the Information and physical Stock Flow in a Base Stock System.

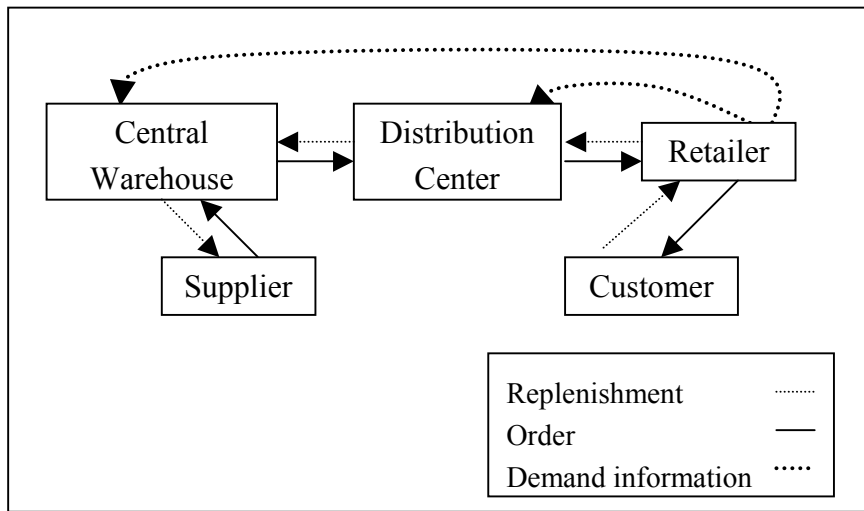


Figure 10: Base Stock System

Source: Freely from Silver, Peterson, 1985, p 477

For each stocking point treated independently, an order quantity (Q) and a reorder point (s) is established. The reorder point is decided through end-item demand forecast over the replenishing lead-time for the level under consideration. The Base Stock level (S) is explained through the following function:

$$S = s + Q$$

The inventory position at each level monitored through the following function.

$$\text{Echelon inventory position} = (\text{Echelon stock}) + (\text{On order})$$

When the inventory position is known, it is compared to the reorder point s, when it is equal to or less than s the order quantity is enough to raise the position to the base stock level S.

Since there is much more variability in the orders from the next coming level in the supply chain compared to the end-item demand, there will be significantly lower safety stock levels when a supply chain is using a base stock system. (Silver, Peterson, 1985, p. 476ff)

2.10.6 Goals

To be able to determine how well an automatic replenishment program is performing Daugherty, Myers and Autry (1999, p. 72) asked respondents in their

study of Automatic replenishment programs, to rank eleven goals connected to the ARP systems. The list below illustrates the result.

1. Improved/increased customer service
2. Fewer stock-outs
3. Improved reliability of deliveries
4. Faster inventory turns
5. Reduced inventory
6. Reduced over-stocks
7. Reduced returns and refusals
8. Reduced costs
9. Reduced handling
- 10.Reduced product damage
- 11.Reduction of discounting

As the different inventory strategies described above indicate, information has become very important in recent years and without investments in information systems, a channel can not hope to remain competitive in today's market since the information technology is revolutionising the way distribution is organised and co-ordinated as well as its related costs. (Stern, El-Ansary, 1996, p. 401f)

The full benefits of what a channel information system has to offer can only be enjoyed if the members involved co-operate with each other in the best interest of the whole channel. (Stern, El-Ansary, 1996, p 428)

I will end this chapter with a statement from Christopher, (1998 b, p 74) saying that if supply chains are to operate as seamless processes then they require openness, trust and willingness to share information.

3 RESEARCH QUESTION AND INFORMATION NEEDS

After having worked with the theoretical part I have got new ideas around my subject. This chapter will therefore specify the problem that should be solved within this thesis. I will also specify some research questions for my further work.

3.1 Analysis of my problem

My theoretical study has increased my knowledge around inventory control and how to apply these theories. At this stage of my thesis, I have also discovered important knowledge about Tamro and their business. Therefore I have decided to divide my study into the following four stages:

1. Present development areas
2. Adjustment in the Supply chain
3. Improvement of Tamro's inventory control system
4. Implementation of a combined inventory control system between Tamro and Apoteket

The two first stages will be identified through interviews with pharmacies together with written information. My initial idea was to calculate the difference between the present inventory control system and a future VMI system between Tamro and the pharmacies. After some struggling I realised that a complete comparison is not possible to perform within this report, since some of the data needed are very hard to get. I will therefore theoretically describe how the comparison should be performed. Finally Tamro's inventory control system might be improved through a Base stock system where Point-of-Sale data are used. These improvements will therefore be perspicuously determined.

Inventory control is a broad area and my initial view of the subject was to perform both a quantitative and a qualitative study but during the work I realised that I had to have a comprehensive view of the inventory control system to get the desired results. Therefore my thesis has the title *Dynamic development strategy for Tamro's and Apoteket's Supply Chain*, and the results are mainly based upon qualitative data. A combination of a suitable inventory system,

described in chapter two, and the right control parameters, see for example section 2.5, will according to my opinion create a good inventory system. A presumption for such a system is, as I also mentioned in the theoretical part, a close collaboration between companies in a supply chain.

The information I will need to be able to come to a conclusion in this investigation will be based upon both primary data and secondary data, as will be further described in the methodology chapter.

3.2 Research questions

I have formulated my initial problem that I got from Tamro, in the following way:

How should an inventory control system be designed to reach the biggest possible benefits at the lowest costs for a system?

This question is a general formulation which, through my new insight to the subject, is specified into the following research questions:

- ◆ Compared to the theoretical models of both inventory control systems and Inventory systems, what are Tamro and Apoteket's positions today and how does a possible future look?
- ◆ How and in what way does a pharmacy place orders in the current inventory control system?
- ◆ What will the new planned inventory control system, that Apoteket AB are purchasing look like?
 - What are the expectations of the new inventory control system?
- ◆ In what way will the planned inventory control system affect Tamro's business?
- ◆ How can the co-operation in the supply chain between Tamro and Apoteket be further developed?
- ◆ How can Tamro develop its business to become more competitive?

To be able to answer these, more detailed research questions, I need help from Apoteket and also some kind of “inside information” from different pharmacies to understand their daily work.

4 METHODOLOGY

In this chapter I will present different research methods theoretically together with the methods I have employed in my research.

4.1 Scientific Methods

There are a lot of scientific methods that have to be applied when one is writing a Master thesis, if the result are going to be a paper with a common theme.

The overall methodology consists of the research design that according to Yin (1994, p. 19) is an action plan for getting from here to there. A summary of my overall action plan will be found in the last section of this chapter.

The methods described in the figure below illustrate different approaches for conducting research. There is never a single correct method of carrying out research since there are many ways to tackle the same problem. (Churchill, 1995, p. 145) Therefore it is common to mix the three basic strategies.

I have chosen to mix the three approaches in my thesis since I started with an exploratory way of working. Meaning that I started with a phase of getting new ideas and deeper insight to my problem, since I did not have a deep insight into the pharmaceutical industry and its regulations. As a second step I had a descriptive view to my problem when I built my own hypothesis around the problem I got from Tamro. Finally I will use a causal strategy where I will determine cause-and-effects by testing the hypothesis I decided to investigate.

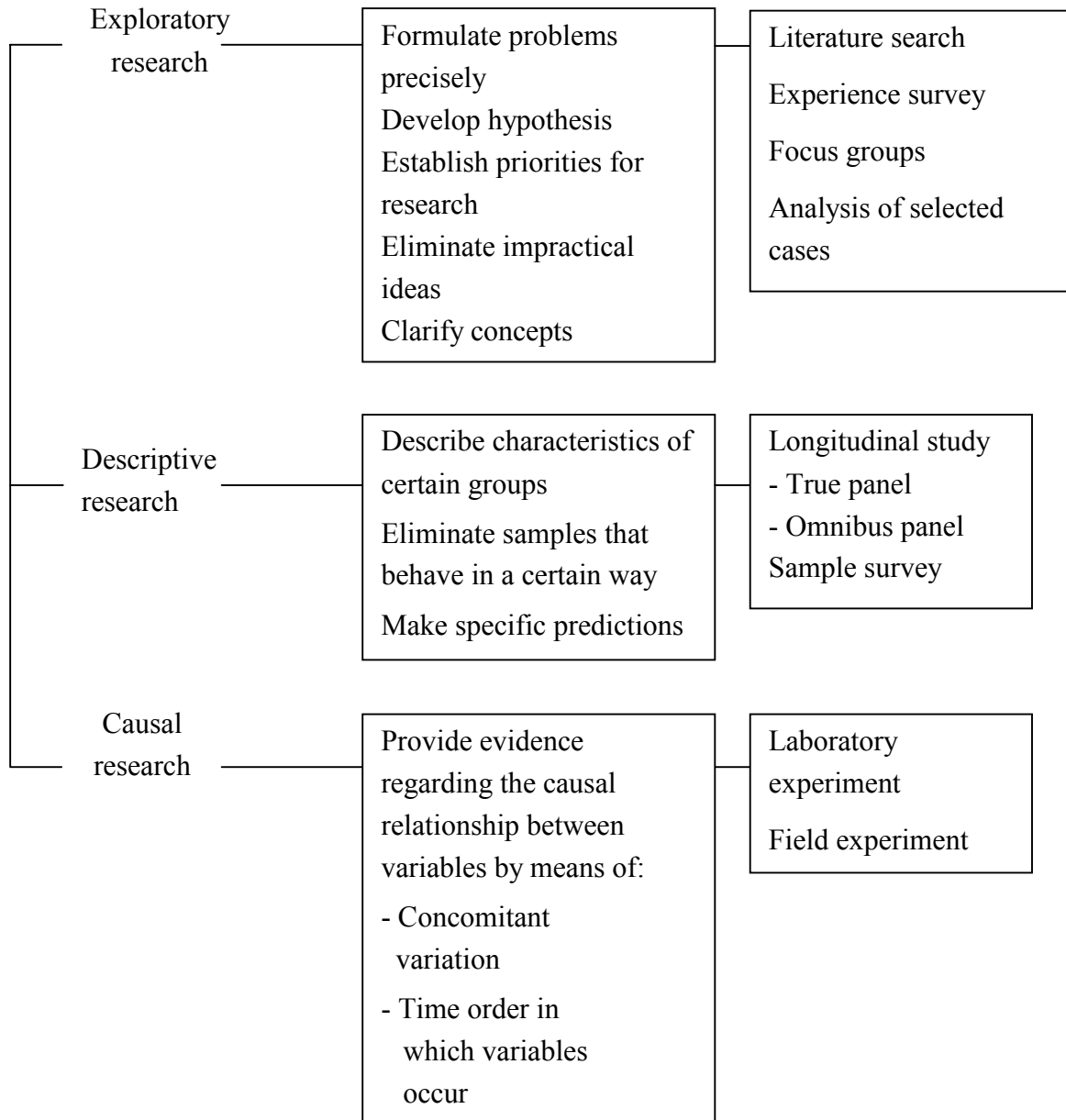


Figure 11: Types of research design

Source: Churchill, 1995, p. 182

4.2 Research strategy

For conducting research according to the approaches described in last section a research strategy is needed. According to Yin (1994, p. 7) there are five different research strategies, as the table below illustrates.

Experiments are done when the investigator can manipulate the behaviour. Surveys and archival analysis are more likely to identify the outcome of research when research questions such as how many and how much are asked. The difference is that the survey deals only with contemporary events while an archival analysis deals with both contemporary and historical events. The later is a preferred strategy when there is virtually no access or control and it is only used for historical events.

A Case is according to Yin (1994, p1) the preferred method when the study is going to answer how and/or why questions and when there is little or no control over events.

The case study is further the right method when contemporary events are going to be examined and the behaviour cannot be manipulated. The historical study and the case study are related to each other but the difference lies in the case study's direct observation and systematic interviewing. (Yin, 1994 p. 8)

RESEARCH METHOD	FORM OF RESEARCH QUESTION	CONTROL OVER BEHAVIOURAL EVENTS	FOCUS ON CONTEMPORARY EVENTS
Experiment	How, Why	Yes	Yes
Survey	How, what, where, How many, How much	No	Yes
Archival Analysis	How, what, where, How many, How much	No	Yes/No
History	How, Why	No	No
Case study	How, Why	No	Yes

Table 3: Relevant situations for different Research Strategies

Source: Yin, 1994, p. 6

Although there are distinct differences between the strategies in the table above one strategy could be used within another, in the same way as the approaches for conducting research.

4.2.1 Action research

Action research is an additional research method where the researcher acts upon his/her beliefs and theories. The researcher using this method does not only intend to contribute to existing knowledge but also to help to resolve some of the practical concerns of the client who is trying to deal with a problematic situation. The following is a definition of action research. (Gill, Johnson, 1997, p.59ff)

“Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework”

Another view is that that action research has been regarded by social scientists to be “primarily concerned with problem solving for clients and not necessarily with testing theory” (Ibid. p. 72)

Finally by the definition most action research projects are pursued through the medium of case study. (Ibid. p. 64)

4.2.2 My position towards the theories

My theses is completely based upon the assignment I got from Tamro and the case study and will therefore be the most appropriate research strategy even through it is a special form of it, close to action research.

4.3 Case study design

A case study design is needed to gain in-depth understanding of the situation and the meaning for those involved. The interest is in process rather than in outcomes. Insights glanced from a case study can directly influence policy, practice and future research. (Merriam, 1998, p. 19)

The purpose of the case study design is to help me identify evidence, which is relevant to my main problem. Four major types of designs are relevant for a case study. The first pair of categories consists of single case and multiple case design and the second pair consists of holistic and embedded designs, as the figure below illustrates.

	Single case design	Multiple case design
Holistic (Single unit)	<i>Type 1</i>	Type 3
Embedded (Multiple units)	Type 2	Type 4

Figure 12: Type of Case study design

Source: Yin, 1994, p. 39

4.3.1 Single Case design

The single case design is used when a case for example represents a critical case in testing a well- formulated theory. Another situation where a single case will be a good method is when the case represents an extreme or unique case. A Third reason for using a single case study is for a revelatory case. (Yin, 1994, p. 38ff)

4.3.2 Holistic or Embedded case studies

One case study can involve more than one unit of analysis. This occurs when attention is given to subunit(s) – type 2. The holistic approach (type 1), single unit of analysis, has an advantage when the case study itself is of holistic nature. (Yin, 1994, p. 41f)

Multiple case designs are used when the case study involves multiple experiments that are co-related to each other.

Even through I am studying a part of a supply chain, Tamro and Apoteket, a single case design with a holistic view is the most appropriate design for my study. I will study the two companies to be able to suggest improvements, and also study one comparable example in the pharmaceutical industry, but this is not enough to motivate a choice of a type 3 design. My findings can on a general basis be applicable to other companies but since the pharmaceutical industry is so special my work will be very specific for Tamro.

4.4 Qualitative or quantitative research

A study can be of qualitative or quantitative nature. The following table illustrates the characteristics of the two different ways of working.

	QUALITATIVE	QUANTITATIVE
Focus on research	Nature, essence	How much, how many
Philosophical roots	Phenomenology, symbolic interactions	Positivism, logical empiricism
Associated phrases	Fieldwork, ethnographic, naturalistic, grounded constructivism	Experimental, empirical, statistical
Goal of investigation	Understanding, description, discovery, hypothesis generating	Prediction, control descriptions, hypothesis testing
Design characteristics	Flexible	Predetermined structure
Sample	Small, non-random, powerful theoretical	Large random representative
Data collection	Researcher as primary instrument, interviews, observation and documents	Inanimate instruments, scales, tests, surveys, questionnaires
Mode of analysis	Inductive- by researcher	Deductive- by statistical methods
Findings	Comprehensive, holistic, expansive, richly descriptive	Precise, numerical

Table 4: Characteristics of qualitative and quantitative research

Source: Merriam, 1998, p. 9

Qualitative case studies are limited by the sensitivity and integrity of the researcher and the investigator is the primary instrument of data collection and analysis. There are both advantages and disadvantages with this view on a problem. One thing is that the researcher is left to rely on his/her own instincts and abilities throughout most of the research effort. (Merriam, 1998, p. 41 ff)

I will have a mix of both quantitative and qualitative approaches in my study. The quantitative approach is used for my comparison between the present inventory system and future VMI system. The absolute majority of my study will have an inductive approach. Meaning that I will have the reality as my first step and from these observations I will be able to generalise the reality which together with my theoretical findings I will be able to draw some conclusions. The qualitative elements of my problem are used to determine how the qualitative findings are going to work in reality, but also through interviews with pharmacies to create new ideas about the future development in the supply chain between Tamro and the pharmacies.

4.5 Data collection

Data can be collected through either primary or secondary data. Primary data is originated by the researcher for the direct purpose of the investigation and secondary data consists of for example statistics not generated for the immediate study at hand but for some other purpose. (Churchill, 1995, p. 270)

My theses will have a mixture of both primary and secondary data. The qualitative information consists of primary data through interviews and secondary data through written material. The description of the present inventory system compared to a VMI system is, to the extent that this will be possible to perform, generated with help from Tamro's statistical information of their sales to pharmacies.

The data needed for all types of research can be collected through archival records, direct observations, documentation, interviews, participant observation or physical artefacts. (Yin, 1994, p. 78)

Secondary data can be divided into two different groups as the figure below illustrates.

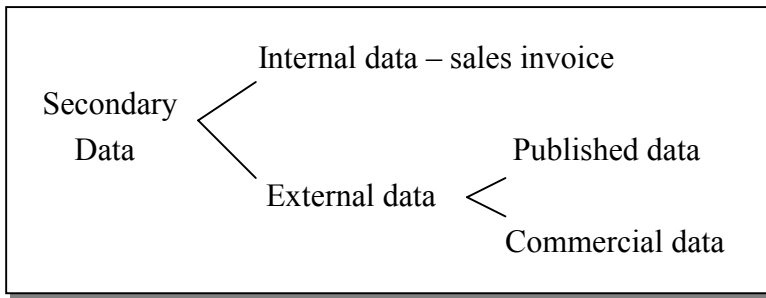


Figure 13: Types of secondary data

Source: Churchill, 1995, p. 279

The secondary data that I needed for performing my theses was of both internal and external nature. I have already mentioned internal data. The external data I used consists of published data in the form of related logistic literature and commercial data such as annual reports, company brochures from Tamro and internal education material from Apoteket AB.

4.5.1 Interviews

One of the most important skills that are required from a person working with a case study is to be able to ask good questions and to interpret the answers. Secondly he/she should be a good listener. One insight is that research is about questions and not necessarily about answers. (Yin, 1994, p. 56f) This follows that interviews are one of the most important sources of information. Interviews can take several different forms like open and focused, illustrated in the figure below. (Yin, 1994, p. 84f)

Interviews can be done in different ways with different purposes. The following figure illustrates this.

QUESTIONS	Structured	Unstructured
ANSWERS Standardised	Inquiry with prepared answered	Inquiry or Interview with open questions
Unstandardised	Focused Interviews	Journalistic interviews

Table 5: Variances of Interviews

Source: Patel, Tebelius, 1987, p. 103

In the so-called journalistic interviews, the respondents are free to respond in their own words and the questions are formulated in a loose predetermined way. I have chosen to use the unstructured-unstandardised form of interviews to learn how Apoteket's logistic function works and also to learn more about the pharmacies.

Three major types of questions should be avoided in an interview. First multiple questions should be avoided that do not allow the respondent to answer the questions one by one, Secondly avoid leading questions that might get the respondent to accept the researcher's point of view. Thirdly yes-or-no questions should be avoided since these questions gives almost no information. (Merriam, 1998, p. 79) It is difficult to avoid these questions totally, but I have tried to minimise their frequency in my interviews as much as possible. Leading questions could for example be formulated as hypothetical questions instead and in this way I will get a neutral answer.

There are other ways of getting information to a case study. One type relevant for the type of case study I try to encircle is observations.

4.5.2 Observations

Observations can range from formal to causal data collection. Direct observations can include observations of daily activities. In a participant observation the observer may participate in the event being studied, the big opportunity is the ability to gain access to events or groups. (Yin, 1994, p. 86ff)

My purpose has not been to use observations, but since it has turned out that my interviews to some extent can be combined with observations, I will take the opportunity and learn as much as possible from these occasions. It could for example be through a "guided tour" in a pharmacy or insight to the pharmacies present inventory control system.

I also got a guided tour in Tamro's distribution centre and central warehouse where I got the opportunity to see the entire process, from order to delivery.

4.5.3 Practical Data Collection

After learning more about pharmacies purchasing system through Tamro's statistics I had a meeting with two people at the logistic department at Apoteket AB in Stockholm. Later on I met the logistic manager for Apoteket AB to confirm that my ideas were interesting for Apoteket AB. To better understand the reality I had three interviews with pharmacies and I did also meet three of the new "Apotekslogistiker" that are going to work with logistical related questions at the pharmacies and especially with the new inventory control system. Finally I found out that Tamro's daughter company in Denmark, Nomeco is presently running a VMI project so therefore I had an "e-mail interview" with their project leader.

4.6 Sample design

Since I had problems with getting the right information to be able to compare the present inventory situation with a future VMI system I will carefully describe the statistical calculation methods in a later chapter called Proposed research design for calculating the benefits of VMI. As an introduction to that chapter I will here briefly discuss methods behind sample design. The sample design can, according to Churchill (1995, p. 579) include either probability or non-probability samples as the figure below illustrates.

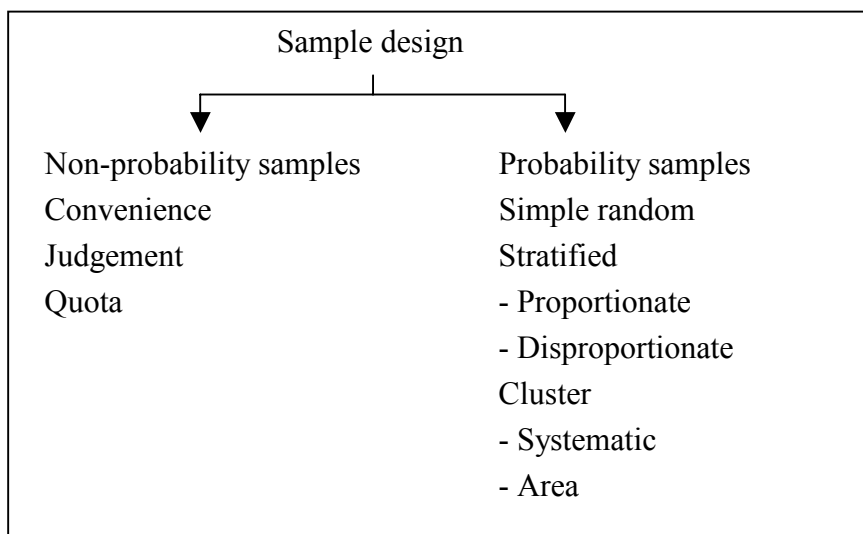


Figure 14: Sample design

Source: Churchill, 1995, p 579

4.6.1 Non-probability sample

The convenience sample could be used for exploratory research with the purpose of getting ideas and insights into a problem. The risk with this sampling method is that there are no guarantees that the sample is representative. A judgement sample could also be called purpose sample, since it is a handpicked sample expected to serve a research purpose. Finally the quota sample is a representative sample selected in such way that the proportion of the sample elements possess a certain characteristic in approximately the same way as in the reality. The uncertainty is that the selection of the sample relies on the researcher's subjective judgement. (Churchill, 1995, p. 581ff)

4.6.2 Probability sample

In a random sample all items have equal chance of being selected. One way of doing this is to estimate a confidence interval where a specific percentage is within a certain number of standard deviation of the mean. A stratified sample is got when one divides the parent population into exclusive and exhaustive subsets and then chooses a simple random sample from each group of subsets. This method is comparable to the cluster sample where the parent population is divided into mutually exclusive and exhaustive subsets from which a random sample of the subset is selected. (Churchill, 1995, p. 594ff)

4.7 Data Analysis

Analyses of the collected data are the part of a research report that should create meaning. It is to big extent dependent of the researcher's ability to combine his/her creativity and knowledge. During data analysis the collected information is consolidated, systematised and expressed, with the goal of reaching reliable conclusions. (Merriam, 1994, p. 178f)

There is no fix schedule how to analyse data from a case study like it, for example, could be in a statistical analysis. The table below gives an idea of how an analysis can be built up.

TYPE OF STRUCTURE	PURPOSE OF CASE STUDY		
	Explanatory	Descriptive	Exploratory
Linear Analysis	X	X	X
Comparative	X	X	X
Chronological	X	X	X
Theory Building	X		X
Suspense	X		
Unsequenced		X	

Table 6: Analysis of a case study

Source: Yin, 1994, p 138

I will use an analytical method that is most comparable to linear analysis. The entire project could, according to Merriam (1998, p. 161ff) be undermined if the analysis of data is saved until after all data is collected. Data analysis is according to Merriam the process of making meaning, therefore one should develop analysis questions and organise data during the entire process.

The analysis should start with examining the problem-formulation that initiated the work. In a case study consisting of more than one case, it could be an idea to first present the results separately and then generalise through a cross-analysis. (Merriam, 1994, p. 197)

4.8 Ethics

Ethics is according to Velasquez (1998, p. 7ff) the study of morality and is the activity of examining one's moral standards. Ethical issues can arise from the relationship between the researcher and his/her host organisation but also between the researcher and the subjects of his/her studies. (Gill, Johnsson, 1997, p. 126) Another important aspect related to ethical issues concerns the reliability, therefore I will describe how I have worked with this aspect in a later chapter called Reliability.

4.9 Practical way of working

I started my work at Tamro with going through all Swedish pharmacies orders of Treo, a cheap product with high volume and Losec-Mups that is an expensive

high volume product both over three and a half months to get a first idea of the pharmacies purchasing behaviour. I did also get an idea of the other side of Tamro's business, which means their purchasing system for all approximately 8500 products. Including their reorder point, reorder quantity, safety stock, packaging size and so on.

This overview of the whole system created a good base for the next step where I selected three interesting pharmacies based on their ordering behaviour regarding Treo and Losec Mups. Another selection criteria was that I wanted to study "different" kind of pharmacies. The pharmacies I selected created a good understanding of the structure between different products and the way these are ordered by the pharmacies.

After having done a detailed investigation for the existing order behaviour, I was able to see where there were improvement possibilities.

5 DATA COLLECTION

The following chapter consists of my actual investigation done at Tamro. The chapter consists of a system analysis, a purchasing description of Apoteket's new inventory control system, information from interviews and finally information about alternative inventory systems.

5.1 Current structure – System analysis

The information in this sub-chapter is built upon unidentified sources at Tamro.

Figure fifteen is a general illustration of Tamro's supply chain. This structure should be compared with the figure that I started my introduction chapter with.

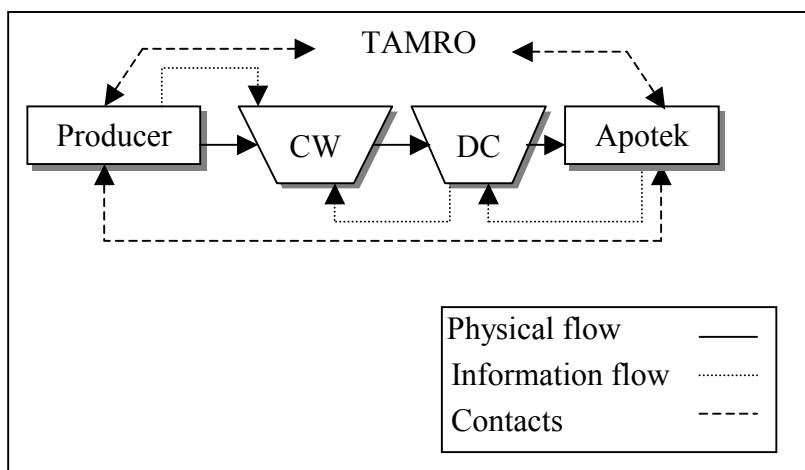


Figure 15: Tamro's supply chain

Source: Own construction

The different pharmaceutical manufacturers plan their inventory level in the central warehouse (CW) that Tamro operates as a consignee, after their production cycle. The lead-time can therefore be between some weeks up to a couple of months since this upper part of the supply chain is operated like the push system, described in the literature chapter.

The replenishment lead-time for cross deliverance between the three central warehouses -located in Gothenburg, Malmö and Stockholm - to Tamro's four distribution centres (DC), located in Gothenburg, Malmö, Stockholm and Umeå - vary for the different pair of locations. From the central warehouses in Stockholm

and Malmö the products will be delivered to the distribution centre in the same city during the same day as the order was placed. The central warehouse in Gothenburg has a lead-time of 48 hours to all distribution centres, except Umeå where it can be up to 72 hours.

The physical flow of products from central warehouses to distribution centres and also from distribution centres to pharmacies is performed by different forwarding companies that are hired on a contract base. The transportation between the central warehouse and the distribution centres is a full truckload (TL) service operated by both ASG and Schenker-BTL. The transportation between distribution centres and the different pharmacies is done on specific routes on a less than truckload (LTL) basis. The transportation from the distribution centre in Gothenburg to pharmacies is presently and has for at least ten years been performed by the same company, Beves.

All orders, illustrated as information flow in the figure above, are to more than 99 % handled through EDI (Electronic Data Interchange).

The content of this is that the general service level and the time taken to perform the pharmaceutical distribution is very effective compared to other industries.

5.1.1 Ordering routines

The pharmacies do not currently have a complete computer based inventory control system. With complete I mean that the product information and the inventory status presently are kept on paper. The pharmacies place their orders through EDI with a possibility of manual changes.

According to Maria Astegren (000922) the present inventory system called ATS (Apoteket's Terminal System) is updated by Apoteket once a month regarding for example packaging sizes. The system indicates if a product should be kept as inventory or not and this is decided locally at each pharmacy. Most pharmacies use an order point system today where a preliminary order is created when the decided order point is reached but a periodic-review system can also be used where a fixed quantity is ordered once a week. As a second step the planned order can, if necessary, be changed manually and finally the orders are sent to Tamro at a specific time every day.

If Tamro change an order in some way, they will send back a message to the pharmacy within one hour. When a product is back ordered at Tamro, the order will be kept by Tamro and immediately treated when this product reaches its distribution centre. It should be noted that the pharmacies do not have any insight into Tamro's inventory status and vice versa.

Another remark is that the pharmacies far from always have the knowledge of the right size of the secondary packages or pharmacy packages as they normally are called. This information would considerable reduce the work done both by both Tamro and the pharmacies.

5.1.2 Information in the Supply Chain

The information flow in the supply chain is mainly reactive with a lot of organisations involved, as figure sixteen gives an indication of.

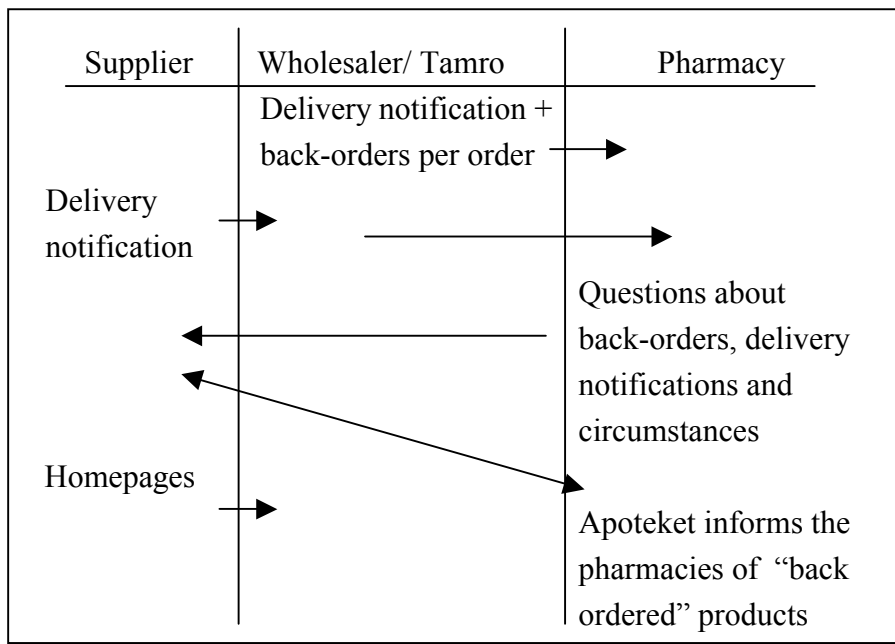


Figure 16: Information through the supply chain

Source: Hjalmarsson A, 2000, Consultant report

Tamro send back information to a pharmacy after they have received an order. Tamro in their turn get information both direct from the pharmaceutical manufacturers but also from their Internet sites.

5.1.3 Cost structure

The table below illustrates the cost structure in the supply chain. Some of these numbers are given further explanation. Since Tamro does not want to go public with some key-figures, I have chosen to keep table seven confidential.

Cost components	CW	DC	Apoteket
Ordering cost (SEK/order line)	-	A	B
Inventory Availability (%)	-	C	D
Cost for out of stock situations (MSEK/Year)	-	?	E
Inventory cost (%/year)	-	F	G

Table 7: Cost Structure in the Supply Chain

Source: Based on Information from Thomas Norstedt and Jonas Friberg

5.1.3.1 Ordering Cost

Apoteket has through Activity Base Costing (ABC) calculated their ordering cost to be between A1 SEK and Tamro have a cost of between A2 SEK for receiving an order from the pharmacies. Both of these costs are calculated in the same way and based upon variable costs. Since I think that all the “system related” costs have to be included when one order between two places is considered, I added the cost for sending and receiving an order.

The central warehouses do not have any ordering costs since, as I mentioned previously, the producers themselves have the replenishment responsibility for the inventories placed in these warehouses.

5.1.3.2 Inventory Availability

Tamro have decided to have a service level of C1% from their distribution centre to pharmacies. Of these maximum Cx% should relate to Tamro's own business. The actual service level from the distribution centre is therefore between C1 and C2%.

The inventory availability is not measured for the pharmaceutical suppliers. The goal for Tamro is to fulfil the service goal set by Apoteket. Presently Apoteket has concluded that a service level of D% will keep the customer satisfied.

5.1.3.3 Cost of being out of stock

The cost for the pharmacies associated with being out of stock have been calculated “non scientifically” by the consultant Alf Hjalmarsson to be between E1 and E2 MSEK/year. This calculation have been based upon the appreciated time it takes to handle a back-order, which is between 2-4 minutes, the total number of order lines that are expedited in one year, the service level and the cost for the pharmacy's personnel.

Tamro have not made any estimation of the cost for their distribution centre to be out of stock, but it should be a much lower figure since Tamro have almost completely computerised systems.

5.1.3.4 Interest Rate

The cost for keeping inventory or the interest rate, for Tamro's distribution centre is set at F% per year.

When I asked Edit Szerző about Apotekets general inventory cost, during my interview with her and Carina Sintring she answered that Apoteket have not calculated any number but if she should guess, she believed that the interest rate should be around G1% per year. When I met Apoteket's logistic manager, Jonas Friberg he estimated that the interest rate should be G2-G3% per year and it ended up as G% per year.

5.1.4 Discussion

The current cost structure between the pharmacies and Tamro is considering the ordering cost quite low. The reason for this is the good technical computer based information system. The problem is as I see it that the technical equipment that exists today is not, as I see it, used in an optimal way. Secondly Apoteket does not have any inventory control system, which might be one of the reasons that they do not have full control over their inventory system. This is illustrated in the previous part describing the interest. Since Apoteket presently is planning to

purchase an inventory control system that system will have the possibility to improve the pharmacies inventory system and its related costs.

5.2 Apoteket AB

The information used in this subchapter is mainly built on an interview with Edit Szerző, responsible for the purchasing of the new inventory control system, and Carina Sintring at Apoteket AB.

5.2.1 Organisation

Apoteket AB is the central authority for the about 900 different pharmacies located all over Sweden and it is an organisation with about 10 000 employees. A bit simplified, Apotekets organisation looks as figure seventeen illustrates.

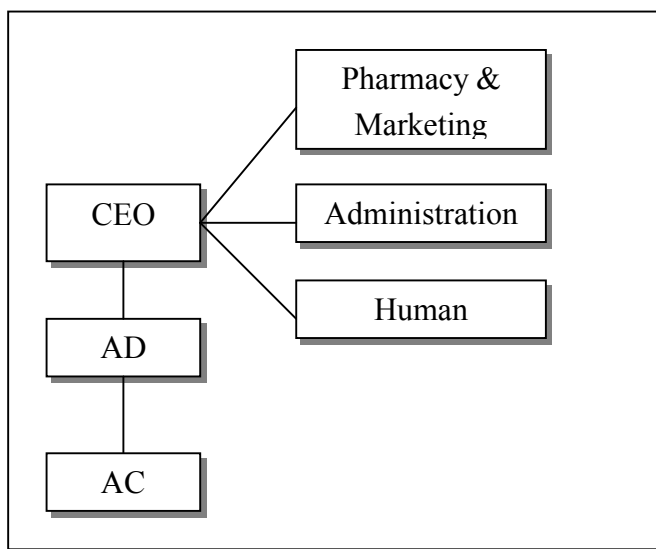


Figure 17: Apotekets Organisation

Source: Interview with Edit Szerző and Carina Sintring, 000809

The headquarters, which consists of about 300 employees, is divided into three different areas Pharmacy and Marketing, Administration and a Human resource department.

Directly under the C.E.O Stefan Carlsson there are 23 managers (AD) each one responsible for one group of pharmacies. These different groups are based on the Swedish system of county councils. Under the manager for the pharmacy group there is one pharmacy manager (AC) for each of the pharmacies in the group.

The Logistic department's is organised under the group called Pharmacy and Marketing and it consists of five employees and a Logistic Manager.

In year 2001 Apoteket are going be reorganised into four business units Health, Care, Hospitals and Apoteket.se and three profit centres. One major change for the logistic function is that it is going to be an own profit centre in the new organisation.

The logistic departments main responsibilities can be summarised into the following points:

- ◆ Inventory control
- ◆ Inventory consult and support
- ◆ Co-ordination with ERFA (Experience exchange with the wholesalers)
- ◆ Inventory handling and Education

5.2.2 Future Improvements

It would, according to Edit Szerző, be a really good improvement for the pharmacies if these could get deliveries ready to put directly on the shelf. This would include an increased zone assortment system.

5.2.2.1 Zone-assortment

There is presently an agreement between Tamro and Apoteket that the pharmacies, a bit simplified, can choose between two different zone assortment systems based on the specific pharmacy's size.

The Zone-assortment system means that Tamro sorts and packages the articles according to how the pharmacy is designed. This service saves time and resources for the pharmacy and it will take less time to place the products on their shelves. (Material from Tamro, Från den ena till den andra, 1998)

5.2.2.2 Recommendations to pharmacies

Apoteket have informed all the pharmacies that they should buy a quantity that will last for at least one week. The pharmacies have further also been told to buy secondary packages to the biggest possible extent and they should also be less

careful when they purchase cheap products, meaning cheaper than 1000 SEK AIP (pharmacy purchasing price).

5.2.2.3 Co-operation

The co-operation between Tamro and Apoteket could according to Edit Szerző be improved through a better information flow between the two organisations. The new inventory control system that Apoteket are buying, will most likely be a very important improvement in this aspect as well as education of employees. These areas are not only related to the co-operation between the two companies but they can also simplify and improve the daily work at the pharmacies.

Apoteket is a governmentally controlled company subsidised by the Swedish government, with a public responsibility. So it is, according to Edit Szerző, in Apoteket's interest to find a rational and effective way of working and therefore a more developed co-operation in the supply chain is necessary for the future

5.2.2.4 Optimal delivery

An optimal delivery to a pharmacy should, according to Edit Szerző, be easy to control, it should be right in all aspects, it should go fast to check the delivery and it should also be easy to place the products in their right places.

5.2.2.5 Simplified order behaviour

A simplified and improved ordering behaviour, that is supposed to come together with the planned inventory control system, can according to Edit Szerző immediately reduce the pharmacies costs by 10%. The inventory control system has also the possibility to improve the effectiveness at the pharmacies.

5.2.2.6 Internal improvements

A general improvement for the pharmaceutical business would according to Edit Szerző be to increase the status of the work related to inventory control issues. It is very important that employees in the organisation see the connection between the end customer service, for example the well-known queues at the pharmacies, and an efficient inventory system.

5.2.2.7 Weekly imbalances

An improvement of the current imbalances of the size of the orders from the pharmacies during the week is also an area that Apoteket think could improve the working conditions out at the pharmacies.

5.2.2.8 Product strategies

Apoteket could, according to Edit Szerző, save money through a more efficient use of tied-up-capital. Different strategies for different product groups, clear goals for the service level and measuring the service level in different and more advanced ways than is done today is one possible method to decrease the amount of tied-up-capital. Another way is through a more effective and efficient Inventory handling, as I have mentioned previously.

5.2.3 Purchasing

Apoteket do not have a central purchasing department so there are about 900 different locations and ordering positions today. A comparable situation regarding its complexity will, according to Edit Szerző, be very hard to find. Each and every pharmacy owns and is responsible for its own inventory. A purchasing order is made and sent through EDI, as I have explained previously, to Tamro at least five times a week. The thing that is missing today is according to Edit Szerző more or less an intelligent calculation system within the inventory control system that continuously calculates the right ordering quantity.

Apoteket will in their new inventory control system control their products in a system based on different categories. The assortment will be divided into categories based on for example the volume value, but exactly how this will be managed is not decided yet.

5.2.4 Product categories

The products that are sold at the pharmacies are divided into two main categories, pharmaceutical products and merchandise. The merchandise is controlled by economic parameters and the pharmaceutical products are controlled on base of their interest for the society.

5.2.5 Ordering behaviour

5.2.5.1 Subscription of products

I asked Edit Szerző during my interview with her and Carina Sintring about her opinion of a system where the pharmacies would subscribe certain pharmaceutical product. Her opinion was that it is a changing environment for most of today's pharmaceutical products and it could be an interesting alternative. The vision from Tamro to offer a system where pharmacies could subscribe products got, on a later occasion, positive response from Apoteket's logistic manager Jonas Friberg. Edit Szerző saw a future where Apoteket's inventory control system will generate good forecasts that Tamro could get.

5.2.5.2 VMI

I asked Edit Szerző of her opinion of a system where Tamro would provide the pharmacies with pharmaceutical products (VMI) as an alternative to the present situation where a pharmacy places orders by itself. Her answer was that the cost for such a system would be a very important factor.

5.2.5.3 Classification of pharmacies

Apoteket would like to classify or group the pharmacies in an efficient way to get as much as possible out of the new inventory control system. They would like to base this upon the groups that are used today: hospital pharmacies and "open-care" pharmacies divided into big, medium sized and small pharmacies based on their annual turnover or the value of their inventories.

All pharmacies within one group are two times a year compared to similar pharmacies in their group. The measurement is done through comparing the annual turnover, the value of the actual inventories and what the theoretical value of the inventories should have been.

5.2.6 Packaging

There is an agreement between Tamro and Apoteket saying that at least 70% of the pharmacies should buy secondary packages/pharmacy packages. If the agreement were completely fulfilled (which there are doubts about today) the

daily work both at the pharmacies and at Tamro would probably be more efficient.

Apoteket have a system where they send signals to the pharmaceutical industry regarding packaging sizes etc. But according to both Jonas Friberg and Thomas Norstedt this is an area that can be further improved.

5.2.7 Apotekslogistiker

Apoteket had as the time this text was written started to hire “Apotekslogistiker” that are going to support the pharmacy manager and the personnel in one group of pharmacies in questions related to the pharmacies assortment, its inventories level and its control parameters. This means that the pharmacies should use this person for repeating problems but not in their daily problems with keeping an optimal inventory level. The 23 “Apotekslogistiker” that will be hired will be taking care of possible problems during the initial state of the new inventory control system. He or she should have a consultative role since the person is going to come up with new suggestions and decision criteria, but the responsibility to make the actual decision and its consequences will be with the local pharmacy and its manager. (Apotekslogistiker, 1999, p 2ff)

Apoteket have suggested the following job- description for the new “Apotekslogistiker”. He or she should: (Apotekslogistiker, 1999, p 5)

- ◆ Help the pharmacies with up new decision criteria.
- ◆ Help the pharmacies with the interpretation of the reports from the inventory control system and make economic judgements.
- ◆ Perform some of the physical work on the pharmacies in his/her group.
- ◆ Show how, for example shelf planning, preparations for activities and following-up of campaigns should be done in the most efficient way.
- ◆ In co-operation with a dispenser make the necessary changes in the assortment for a particular pharmacy in his/her group.

- ◆ In co-operation with a dispenser decide the right inventory level (and assortment) to reach the service goal at a reasonable cost.

5.2.8 Discussion

Edit Szerző stressed during my interview with her that it would be a really good improvement for Apoteket if there could be increased co-operation between Apoteket and Tamro. I completely agree and think that the pharmacies have a lot to gain through a close co-operation with Tamro that have a lot of logistic competence in their organisation. A base for future co-operation with pharmacies might be the new “Apotekslogistiker”.

According to Edit Szerző, an optimal delivery should be easy to control and it should be easy to place the products in their right places. With this background one possible idea is to combine the vision of a future subscription system with an increased zone- assortment system.

5.3 Inventory control system

The first part of this subchapter is built upon my interview with Edit Szerző and Carina Sintring but also upon internal material from Apoteket.

The second part of the chapter is completely built upon Apoteket's “purchasing description” of their new inventory control system that has been sent to possible system suppliers.

5.3.1 Five criteria

Apoteket have set the following five criteria that should be fulfilled by the new inventory control system.

1. General requirements:

It should be an order point system for the daily product flow and at the same time a periodic ordering system for some products like for example bulky products and special products for the hospital pharmacies.

2. Forecasting requirements:

The system should include different forecasting methods. There should be hierarchical freedom in the system, which means that it should be possible to use different levels. One pharmacy could be studied or one groups of pharmacies but also all pharmacies within Apoteket AB.

3. Inventory control calculations:

The assortment should be possible to control through different strategies. The idea is that this should be done for different product groups and product classes.

The *first group* consists of pharmaceutical products that save life and those products have to have an inventory availability of 99.9% independent of the costs for the service. Examples of products in this class are anti-venom and asthma medicine.

The *second group* of products can be further divided into classes. *Class A* includes products like Losec that are expensive highly frequent pharmaceutical products. *Class B* consists of cheap high frequent pharmaceutical products. *Class C* can be new products that are worth extra attention and finally *class D* including products that are going to be taken out of the system.

4. Control parameters

Apoteket have defined the following six control parameters: service level, interest rate, ordering cost, lead-time, expected sale and the lowest and highest volume of a product that should be ordered.

The control parameters should be specified in the system and registered at each pharmacy.

5. Following-up possibilities

This is the area with most expectation of the inventory control system since it gives new possibilities to improve the economic situation and gets the possibility to send out signals to specific pharmacies.

5.3.2 Authority levels

There will be different authority levels in the planned inventory control system. The first level will be located at Apotekets headquarters, and the responsible persons will have access to all parameters and reports. In each of the 23 pharmacy groups the pharmacy manager (AD) and the "Apotekslogistiker" will have access to parameters and reports within their own group of pharmacies. Finally all the local pharmacy managers will have access to reports for the own pharmacy and the person responsible for the inventory will have access to certain parameters and reports on his/her own pharmacy. (Behörighetsnivåer, 2000)

5.3.3 Purchasing description

The inventory control system is expected to contribute to a improved availability of the right product in right quantity and at the right time at each pharmacy, at the same time the inventory costs are expected to be reduced.

To fulfil these expectations Apoteket are looking for a supplier/partner that can offer both a technical solution and take responsibility for the implementation of the system. The company should also educate employees on pharmacies and have an overall responsibility for the system.

The inventory control system should help the pharmacies to make the right decision regarding inventory economy and assortment. It should then reduce the costs and the time spent on inventory handling. Finally the system should contribute to improved following-up and report possibilities. When these goal are reached the effects will be improved customer service and also more effective and efficient work at the pharmacies.

There should be a possibility to differentiate the inventory control between products but also between different types of pharmacies.

The calculation of EOQ should be based on previous sales. The forecast system should consider both expected and actual sales. Expected sales should be possible to adjust at a central position (meaning headquarters) for specific products and pharmacies. From this follows that changes in the forecast should not done

locally at each pharmacy but at the same time the local pharmacy should have the possibility to make changes in their own forecast model.

It is desired that it should be possible to predict what kind of products that are going to be sold on specific days during the week, within the forecast system. This will simplify the calculation of order recommendations specifically for pharmacies located in a hospital that have orders from hospital departments.

The calculations of the Economic Order Quantity (EOQ) should further include all unique characteristics of each and all products at every pharmacy.

Apoteket's inventory policy is that one product should be handled maximum once a week, meaning that one product should be purchased to last for at least one week. One of the requirements on the planned inventory system is that it should be possible to exchange information about the inventory situation for a specific product with other pharmacies in a comparable size, geographic area or with similar customers to make it easier to order new products.

It is stated in the "purchase description" that there is a connection between the service level offered and the safety stock, saying the higher service level the more safety stock. It should be possible to choose the desired service level for a group of articles or a specific pharmacy or group of pharmacies.

It is desired that the system should calculate the interest rate automatically, as an alternative to this it is appreciated if the system supplier could be active in the calculations for different products and different types of pharmacies. This means that packaging size should be handled systematically since big packages will occupy more of the expensive space and therefore affect the interest rate. The system should further be able to round the ordered quantity to the closest secondary/pharmacy package according to Apoteket's rounding principles.

It is strongly desired that the ordering costs that presently are fixed should be differentiated between for example geographical areas within the coming inventory control system.

The inventory control parameters should as I have mentioned previously be set and controlled centrally but two parameters, the lead-time and the lowest and

highest volume of one article that should be ordered, should be possible to choose and be changed by the person responsible for inventories at each pharmacy

The pharmacies should become more similar from a profiling view and there will be a better exposure of the products. Therefore it is planned that the current Space Management System should be integrated with the inventory control system.

5.3.4 Discussion

Apoteket have very high expectations for their planned inventory control system. I believe that it most likely will take quite a long time before all of these expectations are going to work in reality, for all pharmacies.

All of the criteria expected for the planned inventory control system are definitively needed. Therefore I think it would be a great idea if Tamro and Apoteket (and the pharmacies) could build up a closer co-operation. In that way it would probably be possible to reach the goals set for the inventory control system in a much smoother way.

5.4 Present purchasing behaviour

To get a good overview of the general order behaviour at the pharmacies I picked out four pharmacies, as I described in my methodology chapter, and studied their ordering behaviour. Another aspect of this study is to see the effects of a changed ordering behaviour from the pharmacies. The results of this study are explained in this sub-chapter.

5.4.1 Complexity of the pharmaceutical system

The table below gives an idea of the complexity and the wide range of products sold by pharmacies. The table illustrates the number of order lines divided among the official product categories used by the pharmacies. Four types of pharmacies with interesting purchasing behaviour during the period April to June 2000 are included in the table. The four pharmacies are: one of the biggest pharmacies Scheele in Stockholm, a medium sized Herrestad in Uddevalla, a small pharmacy, Räcksta in Vällingby and the hospital pharmacy in Örebro.

The main groups in the table below are Pharmaceutical RX, meaning pharmaceutical products that need a prescription, Merchandise that are products that consist of everyday products like for example plasters and vitamins. Finally Pharmaceutical OTC are pharmaceutical products that do not need prescription, one example is aspirin.

Order lines/Group	
Group	Total
Blank /delete	1
CE product, medical technical	138
Herbal Pharm. Rx	12
Herbal Pharmaceutical OTC	4
Instead of code 031 for SCX	39
Merchandise	2259
Pharmaceutics. OTC	1288
Pharmaceutical non-reg.	29
Pharmaceutical Rx	4233
Pharmacy product	69
Raw material: non- pharmaceutical.	296
Raw material: pharmaceutical RX	120
Stomi Diabetes	436
Veterinary product OTC	22
Veterinary product Rx	113
Veterinary product Non reg.	1
(blank)	1
Grand Total	9061

Table 8: Number of order lines bought by 4 pharmacies during 3 months

Source: Statistical information from Tamro

In the table below each pharmacy's purchasing behaviour is illustrated individually. In this way the size of different types of pharmacies and the purchasing differences are described. The four pharmacies are Scheele that is one of the two biggest pharmacies in Sweden located in the city centre of Stockholm, Herrestad is located in Uddevalla, the third pharmacy is the hospital pharmacy in Örebro and finally Räcksta is a small pharmacy located in Vällingby.

PRODUCT CLASS	Scheele	Herrestac	Örebro	Råcksta	Total
Blank/deleted	3				3
Medical tech	1243	30	6137	250	7660
Herbal pharm Rx	22	4		4	30
Herbal pharm. OTC	408	6	99		513
Instead of...	103		1467	8	1578
Merchandise	140702	2595	53820	559	197676
Pharm. OTC	129900	3438	50979	902	185219
Pharm. non reg.	276		211		487
Pharm.I Rx	74115	4279	75547	2032	155973
Pharmacy product	560	67	3603	12	4242
Raw mat Non pha.	2521	126	2275	83	5005
Raw matl pha. RX	1207	19	1635	3	2864
Stomi Diabetes	5362	356	5806	229	11753
Vet. Prod OTC	89	48	248		385
Vet. Prod. Rx	891	28	500		1419
Vet. Prod. non reg.	4				4
Grand Total	357406	10996	202327	4082	574811

Table 9: Individual buying behaviour

Source: Statistical information from Tamro

5.4.2 Classification of products

One idea to structure the products is by their volume value (Vv). To see how this classification would affect the system consisting of Tamro and Apoteket I used the system that I described in the theoretical chapter where about 60% of the volume value are classified as A-products. This group will then consist of 10% of the articles. The B- group consists of 30% of the volume value and also 30% of all products. Finally the last group-C includes 10% of the volume value and 60% of all products. This is illustrated in the table below.

I used the group of pharmacies that described in connection to table five.

The result of my classification is, that if it is managed in the right way the order lines for the products in class- A could decrease from the about 2340 that it is today to 1243 order lines. This means an improvement of 53%. The order lines in class- B could, with this classification system be improved with almost 54% and the products in the C-category would be ordered with 41% less order lines.

I mentioned that the condition for this improvement is a correctly managed system. This means that the products, mainly within the first product group A,

that today are not ordered in the way that Apoteket recommend have to be improved.

This example is based upon the Economic Order Quantity (the Wilson formula) and the relation that the order line is equal to the total demand divided with the order quantity. The total demand for a given period is found in Tamro's statistical data and the order quantity is calculated through the normal Wilson formula described in the literature chapter. These two parameters are divided and the result is the optimal number of order lines based upon the Economic Order Quantity. When the Economic Order Quantity is calculated the data described in the subchapter called cost structure are used.

Groups	Description of the groups	
A	Count of article numbers	202
	Sum of total packages	127,271
	Average of price/item	1,209.38
	Sum of volume value (Vv)	43,370,350
B	Count of article numbers	1,294
	Sum of total packages	274,365
	Average of price/item	347.61
	Sum of Volume Value	20,939,861
C	Count of article numbers	3,079
	Sum of total packages	154,077
	Average of price/item	122.84
	Sum of volume value (Vv)	5,070,080
(blank)	Count of article numbers	138
	Sum of total packages	1,795
	Average of Price/item	86.79
	Sum of volume value (Vv)	-24,809
Count of article numbers		4,713
Sum of total packages		557,508
Average of price/item		230.06
Sum of volume value (Vv)		69,355,481

Table 10: Classification of products

Source: Own construction

There is one group in table ten that is named "blank" and since this includes samples of new products and so on, this group is excused from this calculation.

5.5 Interviews

I have made six interviews. Three with pharmacies in Gothenburg, a small pharmacy Kärra, Kronan a medium sized pharmacy and one of the two biggest pharmacies in Sweden Vasen. I have also interviewed three of the new "Apotekslogistiker" in Gothenburg- and Bohuslän, in Skaraborg and in Älvsborg.

The reason for doing those interviews was to get information from the pharmacies about their current situation and what kind of ideas they have about their future. This is important since such contacts do not exist between the pharmacies and Tamro today.

5.5.1 Optimal delivery

I got very differentiated answers when I asked how an optimal delivery should be and the answers from the respondents are illustrated with crosses in the table below. I chose this method since the ideas of how an optimal delivery should look was quite similar, as the table eleven illustrates.

OPTIMAL DELIVERY	KÄRRA	VASEN	KRONAN	GBG & BOHUSLÄN	SKARABORG	ÄLVSBORG
Back ordered items	X			X	X	
Right time		X		X		X
Right items		X				X
Right quantity		X				X
Alphabetical RX sorting			X	X	X	X
"Egenvård" in groups			X			
Easy to handle					X	X
Box assortment					X	
Easier administration					X	X

Table 11: Optimal delivery

Source: Interviews

5.5.1.1 Backordered items

Backordered items include a quite broad spectrum of ideas. Basically the pharmacies want to know in advance if a specific item is back ordered at Tamro's warehouse. One opinion is that it would be really good if Tamro could send out a question when they get an order of a back ordered item if the pharmacy want to keep their order or not. Another opinion is that in an optimal delivery the former back ordered items should be packed in separated boxes. For some types of products, some pharmacies would appreciate if Tamro could exchange a back ordered item to a comparable product.

5.5.1.2 Right time

Right time was specified by two respondents. Previously it had not been unusual that the delivery from Tamro was a couple of hours late. It was also stressed that pharmacies want an optimal delivery to arrive before the pharmacy is opened.

5.5.1.3 Right items in right quantity

Right items and also right quantity means that it is appreciated if there can be as few picking mistakes from Tamro as possible.

5.5.1.4 Alphabetic RX sorting

Two thirds stressed that they would like to have RX (products that need a prescription) delivered in alphabetic order and one even said that this system must come as soon as possible. A reason is that, especially at the big pharmacies there is a physical distance between A and Ö.

5.5.1.5 Egenvård in groups

Egenvård in groups basically mean that the pharmacies would like to have their delivery according to their physical organisation.

5.5.1.6 Easy to handle

The two respondents that answered that an optimal delivery should be easy to handle meant that the boxes in a delivery should not be too heavy to handle for the personal or too full so the products could be damaged.

5.5.1.7 Box assortment

Box assortment means that it would be optimal if the boxes were sorted so the products that need to be placed in a fridge should be placed at the top of all the boxes.

5.5.1.8 Easier administration

Easier administration means that the pharmacies for example would like to use a hand scanner to register delivery in the future. Another opinion is that easier delivery notifications would be very appreciated.

5.5.2 Classification of pharmacies

When I asked for the respondents' opinion of classifying the pharmacies in groups that will have a fixed assortment of products that do not need a prescription, with some divergences, I got very different answers.

One meant that a classification based on the size of the pharmacies would not be possible since they have different types of customers. On the other hand the same respondent meant that if the classification is managed in correct way it could be a good idea and give the pharmacy a clear profile. Another view is that this would be good both for the pharmacies, since it today can be very hard to know what products they should have, and for their customers. The last view is consolidated by the fact, stated by one of the respondents, that the pharmacies are very service minded and therefore its very tempting for them to increase their assortment with extra products. My question was also answered by one of the respondents before I even asked it and she meant for example that a small pharmacy should not need to have several different types of aspirin. She further meant, a bit simplified that it is not a problem for the customers if a pharmacy slightly decreases its assortment but it is for the employees. Finally, if the directives came from Apoteket it would, according to this respondent, not be a problem to introduce such a system.

5.5.3 Unpacking of a delivery

At the small pharmacy I visited it takes approximately two hours to unpack the daily delivery, their cleaner handles the work and they are very satisfied with this.

This can be compared with the three persons that handle the daily product flow on a big pharmacy. One of the persons I interviewed told me that some pharmacies in some way would need help with unpacking deliveries and there have been discussions of building up an internal “organisation” for this. It can for example take two days for a small pharmacy to unpack its products and the big pharmacy Vasen in the city centre of Gothenburg recently got presently a delivery from Tamro on Fridays that could not be unpacked before Monday morning. Vasen is a pharmacy that is open fourteen hours per day seven days a week.

It is most common that pharmacy assistants handle the product flow, but there is a big variance between pharmacies and it can be handled by pharmacy technicians and also, in some rare cases by dispensers.

5.5.4 Suggestion of new inventory systems

During my interviews I asked the respondents for their spontaneous opinions both about a system where the pharmacies can subscribe specific products and also about the VMI system I previously have described.

One of the respondents said that neither of the two systems is preferable since the subscription possibilities according to this respondent will increase the work for the pharmacy. She continued by saying that a VMI including POS-data could be dangerous for the pharmacy.

Another of the respondents had a much more positive attitude to these systems. One of the respondents told me that there had been wishes about prescription possibilities together with the coming inventory control system. This respondent continued saying that she hoped that the new inventory control system would bring the pharmacies closer to the theories behind VMI.

One of the respondents answered that the possibility to subscribe products could be a good idea if the system was good and simple for employees at the pharmacies.

Finally another respondent underlined the importance of a closer co-operation with Tamro and meant that both the possibilities for prescription and VMI are based upon co-operation.

5.5.5 Problems and improvement areas

One of the respondents told me that her pharmacy sometimes has the problem with getting products with short dates and therefore these can not be returned to the distributor. Further there is presently a problem with the packaging sizes given to the pharmacies in the ATS system since these sizes are valid for all products. The sizes given in ATS are currently used to set the order quantities.

In another of my interviews the respondent meant that it would be an improvement for her pharmacy if the secondary/pharmacy packaging sizes could be slightly bigger. She would further like to get better information when and why a product is logged out.

Many pharmacies that are open more than five days a week have an irregular demand, since they get delivery five days a week. When I talked about this “problem” with one of the respondents she told me that there have been thoughts about limiting the number of days when “handelsvaror” should be delivered and this idea was repeated from one of other respondents. I have an idea that the order point should be increased by 15-20% for pharmacies open on Saturdays to avoid the irregular demand at the pharmacies, since these get a delivery from Tamro five days a week. This suggestion was seen as a possible method when I discussed it with the respondents.

One of the pharmacies I visited has presently a problem to know how long the lead-time will be for some special food products. The problem arises when it is very hard to tell a customer when they can come back to pick up their products distributed by Tamro. The reason for this problem is that some of these products are warehoused by Tamro in Stockholm and some in Gothenburg. This has led to different lead times for products that are purchased by one customer. Since these products will fill about 15 boxes per week to one pharmacy we were talking about a possible future were these products can be subscribed on a specific day and the respondent was positive to the idea. Another example is the dentist that

wants to purchase products every two weeks on a specific day in the week but this is not possible in the present inventory control system since products in the periodic review alternative are ordered once a week.

The current ordering system is very inflexible. One example is that periodic orders just can be administered once a week and to mention one example there is a dentist that wanted to get sterile products on a specific day every two weeks, which is impossible to administer in the current ordering system. Another problem with the current periodic ordering system is that a pharmacy will get double quantities one week if this product was not possible to get the week before.

As I have described previously, each and every pharmacy presently decide how large their safety stock should be and the size of the order point they shall use. One of the respondents I meet said that it would be really good if Tamro could help the pharmacies and give them indications of unreasonable orders.

Finally it should be emphasised that most pharmacies have a big lack of time in their everyday work.

5.5.6 Discussion

When I asked the different respondents in my interviews how an optimal delivery should look. I got different answers as table eleven illustrated. Some of the nine areas that were identified could be improved through a closer co-operation between the pharmacies and Tamro, as I have mentioned previously. The three last groups easy to handle, box assortment and easier administration might be areas that Tamro should bear in mind for the future. It is for example important that the products arrive in their right condition to pharmacies, so the boxes should for example not be to full.

Apoteket have in the purchasing description for their new inventory control system written that this system should help them to classify the pharmacies and articles. This is an important area and one of the respondents I met meant that it is very hard for the pharmacies to set their assortment. If these new ideas succeed, I think it would be an important improvement for the future for both Apoteket and

Tamro. For Tamro it can be a good improvement if they in the future should offer some type of automatic replenishment system.

During my interviews one of the respondents told me that some pharmacies have problems with unpacking their delivery and that there have been thoughts about starting a separate organisation within Apoteket for helping these pharmacies. This is an area that Tamro should evaluate and offer a service package to primarily pharmacies located close to its distribution centres. Other services that should be included in this service package variances of subscription system. A perfect example where a subscription system would be an excellent service is for the special food products that today can have differentiated lead-times for products to the same customer.

I asked the respondents of their opinion of both and subscription system and a future VMI system and the answers were all together quite positive, but based on these interviews it would be wise to introduce a “development plan”. Where an automatic replenishment system like VMI would be the one of the last steps.

5.6 Base Stock System

If Tamro could get Point-of-Sale data from the pharmacies they would according to Thomas Norstedt at Tamro, get a possibility to optimise their inventory situation. For both low and high frequent articles the supply chain is almost working as the Base-Stock-System suggests. If it was possible to build up a Base-Stock system with Point-of-sale data for the products with a middle frequent demand Tamro could most likely decrease the safety stock level for these products to one day. The approximately 1000 articles that most pharmacies keep as inventory and have a middle-frequent demand have to be identified, and even if the technical solutions for a Base-Stock/Point-of-Sale system will be a cost for Tamro, it will according to Thomas Norstedt be worth the investment.

5.6.1 Discussion

A base stock system is, as I described in the literature chapter the middle way between an automatic replenishment and a “normal” inventory system. The system is based upon point-of-sale but it is not completely taking advantage of information gained but since it could help a company in a supply chain to

improve its inventory position I think it's a very important step towards an automatic replenishment like VMI.

5.7 Vendor Managed Inventory – VMI

The information used in this subchapter comes from an email interview with Nomeco's project leader Carsten Christensen.

Tamro's Danish Daughter Company Nomeco presently runs a project based upon the ideas of VMI called Logistic Partnership.

It should be stressed that the pharmaceutical market in Denmark is very different compared to the Swedish market. Denmark has a "multiple channel market", meaning that the distribution companies compete forward. One result of this situation is that the distributors have more types of products in their warehouses. Tamro store for example about 8500 different products while Nomeco stores about 14000 articles.

5.7.1 Nomeco's partnership program

The main reason that Nomeco want to work together with pharmacies in a logistic partnership is that they want to own/control the flows of information in their supply chain. Other goals are to increase the service level, help the customer and in these way getting an increased possibility to control the product flow to pharmacies so it will be done in the best possible way for Nomeco. Through the partnership Nomeco want to control VMI customers in the increasing competition at the same time as they know that they through this project will release resources at pharmacies that they can use in there core business, serving customers, information search and course activities.

5.7.1.1 Nomeco's business

The partnership project is currently in an early phase and it is therefore hard to say what kind of effects it will have to Nomeco's business in the long run. It is already seen that the efficiency and effectiveness per order line has increased so Nomeco will get more picking in such a system in comparison to previous picking expenses. The number of articles that are delivered in one occasion has at this early stage of the project already increased considerably. There has also been

an increased use of secondary/pharmacy packages that create a more rational process for Nomeco since it saves both time and resources. In this partnership system the pharmacies should not be able get deliveries as often as it is done today. Nomeco have also been able to decrease the number of deliveries to its pilot pharmacy, from three per day to two that are done in a more preferable way for both Nomeco and the pharmacy. The pharmacy is getting more products in their morning delivery when they have time to pick up the products instead of getting these in the afternoon, when the pharmacy is full of customers.

5.7.1.2 Practical work

In this partnership project Nomeco plans the pharmacies purchasing. In the introduction phase Nomeco sends purchasing proposals to the pharmacy that they should approve. The reason for this procedure is to build confidence in the system. When the pharmacies have trust in Nomeco's system and the order, the *E3 SLIM* system will run automatically and the pharmacy will not use any resources for ordering products.

5.7.1.3 Development

In the first step of the partnership project Nomeco will offer this service to the pharmacies that only purchase products from them. In the next phase other customers will be offered the same service but these will only get order suggestion of products that they purchase from Nomeco to prevent competitors getting advantage of the system.

5.7.1.4 Reactions

The reactions from the pilot pharmacy have been varied. There are almost always some kind of problems when new systems are introduced but these are continuously improved during the pilot project and the partnership has worked perfectly during its last step, before a second pharmacy is included in the project as a second step.

The problems during the starting up phase have occurred since Nomeco runs several orders per pharmacy during one day and there have therefore been technical problems with the computer system. There have for example been

problems with the system that should update the forecasts and also with the file transmission.

5.7.1.5 The partnership compared to VMI

The theories of VMI, described in the literature chapter, often include a changed financial system within the supply chain. Nomeco do not see any reasons to change the normal financial system where pharmacies pay for their products when they get them.

5.7.1.6 Future

When there are more pharmacies involved in Nomeco's partnership solution, they expect that they will get a possibility to optimise their own business, purchasing and stock-keeping, through the use of point-of-sale data.

Right now it is too early in the partnership project to see the effects that this new inventory system will have on Nomeco's overall stock-keeping but one can see effects of the pilot pharmacy on the part of the warehouse where the products are picked. There are not so many products that should be picked in the middle of the day when most of the current work is done. The pilot pharmacy gets between 70-75% of its products in the morning and these are then picked during the previous evening and night.

The logistic partnership has as such not changed Nomeco's business beside the fact that they now have a VMI organisation that will handle the daily administration and product supply to pharmacies.

Finally it should be emphasised that there is a big focus on the logistic partnership in Nomeco's organisation, since it will strength its position on the market. Nomeco further thinks that it is very important for them to create a tighter relation to its customer. Therefore the goal is to own/control the stock and information flow in the own supply chain, through increased service and focus on the pharmacies' needs which should make the pharmacies choose Nomeco as their premium wholesaler of pharmaceutical products.

5.7.2 Discussion

Nomeco have built up its own variant of an automatic replenishment system. This system is completely based upon the Danish pharmaceutical industry's requirements.

The partnership project has already in the introduction phase been positive for Nomeco's business. Nomeco will through the project be able to adjust possible problems and it is likely that the result will be an improved overall business and more loyal customers.

Although there is a difference between the Danish and the Swedish pharmaceutical markets I think that Tamro should follow the development of this partnership project as its principals are suitable for the pharmaceutical industry on a general base.

6 PROPOSED RESEARCH DESIGN FOR CALCULATING BENEFITS OF VMI

This chapter will highlight the importance of a correct comparison of the present inventory system and a future automatic replenishment system like VMI system between Tamro and Apoteket.

6.1 Important areas

My comparison between the present inventory control system and an automatic replenishment system like VMI will be based upon the following areas:

- ◆ Stock-keeping at pharmacies
- ◆ Handling at pharmacies
- ◆ Delivery to pharmacies
- ◆ Internal work at Tamro

6.1.1 Pharmacies

After my contacts with both Apoteket, headquarters in Stockholm, and different pharmacies I have seen and understood that the pharmacies are very different. I will therefore propose that the effects of an automatic replenishment system, that I am writing about VMI, should be determined for different kind of pharmacies. If it had been possible for me to completely perform this study, I would have picked out a minimum of ten pharmacies spread all over Sweden and of both different sizes and with different clientele. These pharmacies should be selected in co-operation with Apoteket.

6.1.2 Tamro's assortment

There are two possibilities to determine the effect of a changed inventory control system of the about 8500 articles that Tamro distributes to the pharmacies. One alternative is to calculate the effects of a VMI system based upon all articles warehoused by Tamro. This alternative is the best if the required calculation can be performed in a cheap and easy way. If this is not the case then random selected sample has to be used. Random sampling can according to Churchill (1995, page 583) be done through optimising the sample size mathematically. Another way is

to simply take out a sample big enough. The latest alternative can for example be based on products that have been purchased by the selected pharmacies. These products are then divided into groups according to their sale and a proportional sample is taken from every group.

6.1.3 Safety Stock

In both the Order-Point, Ordered-Quantity system (s,Q), described in the literature chapter, that the pharmacies use today and also in other inventory control systems, like for example the (R,s,S) that are used in an automatic replenishment system, the safety stock (SS) is determined through the following relation: (Silver, Peterson, 1985, p. 271f)

$$(1) \quad SS = s - \mu$$

Where μ is the expected demand over a replenishment lead-time in units, and s is the order point in units.

Another relation that is important for calculating the safety stock is the relationship below. Where Z is the safety factor and σ is the standard deviation.

$$(2) \quad SS = \sigma Z$$

In the current inventory control system all pharmacies set their own safety stock level based on their opinion. Therefore it is very important to determine how the pharmacies safety stock levels look today, when the present system should be compared to an automatic replenishment system. The first step is to examine the current system.

6.1.3.1 Current system

When the safety-stock in the current inventory system should be determined, the first step is to divide the products into two main categories. The first category should include products with a demand equal to or lower than one item during the lead-time and the second category should then include products with a demand bigger than one unit during the lead-time. The reason for the classification is that the first group has a Poisson distributed demand and the second has a Normal distributed demand.

The calculations of the two types of distributions are most easily calculated in excel, but to understand the procedure it is important to recognise the following expressions.

Poisson distribution:

$$(3) \quad p(k) = e^{-\mu} \mu^k / k!$$

Where μ is the variance. The standard deviation is $\sigma = \mu^{1/2}$, and k is the number of observations.

Normal distribution:

$$(4) \quad f(x) = (1/(\sigma (2\pi)^{1/2})) e^{-(x - m)^2 / 2\sigma^2}$$

Where m is the mean value and σ is the standard deviation.

The procedure of calculating the safety stock for these two groups will be explained below.

Poisson distributed demand

The Fill-rate is calculated through the following formula:

$$(5) \quad E(k) = Q(1-V) / \sigma$$

From the relationship above the expected number of stock-outs are calculated through the relation:

$$(6) \quad \text{Stock out} = Q(1-V)$$

Where V is the fraction of demand filled from stock and Q is the replenishment quantity.

Handly and Whitin have, in their book *Analysis of inventory systems* (1963, p. 137f), used the following expression for determining the expected number of backorders in a Poisson distribution.

$$(7) \quad I = \sum_{j=s}^{\infty} (j - s)p(j)$$

Formula (6) and (7) is set equally and different values of s will result in a limit or equality value. The value(s) of s that resulted in equality is used for calculating the safety-stock in (1).

Normally distributed demand

For a Normally distributed demand the safety factor (Z) in formula (2) can, a bit simplified, be said to be completely dependent on the service level decided by Management. Where the service level is defined as 1- the probability of being out of stock. To calculate the safety-stock (SS) the standard deviation (σ) is determined in excel. An illustration of the relation between the safety factor and the service level is illustrated in the in the table below.

Service level (%)	Safety factor (Z)
90.00	1.28
95.00	1.65
98.00	2.05
99.00	2.33
99.93	3.20
99.99	4.00

Figure 18: The relation of service level and safety factor

Source: Lumsden, 1998, p. 262

This connection described in the table above is, as I wrote, a bit simplified but it is a good illustration of how the safety stock is influenced by the decided service level. One example is that an improvement of the service level from 95 to 98% will increase the safety stock by 25%. (Lumsden, 1998, p. 262)

The method described above is one of the two separate ways to decide the safety factor where Z (also represented by k) is decided through a policy decision of the fill rate. In the other method the correct safety factor Z , for a normally distributed demand, is determined through the following procedure: (Silver, Peterson, 1985, p. 276f)

$$(8) \quad \text{If } DB/((2\pi)^{1/2}Qv\sigma r) < 1$$

Z should be set to the lowest value specified by management

If it is not, Z is calculated through the following formula.

$$(9) \quad Z = 2 \ln(DB / ((2\pi)^{1/2} Q v \sigma r))$$

Where: D = demand rate in units per year

B = Backorder cost when an unexpected situation of being out of stock occurs

Q = Order quantity

v = unit variable cost

σ = Standard deviation

r = Inventory carrying charge

This is a quite complicated procedure since the order quantity does not always have a fixed value.

Regression analysis

As a third and last alternative the present safety stock can be determined through combining existing statistical information from Tamro and the pharmacies selected. The safety-stock for a limited number of products in the selected pharmacies will be set in relation to their yearly demand. The relation between these two factors will be plotted in a graph and the safety-stock can be determined either graphically or mathematically, through regression analysis, for all kind of products.

6.1.3.2 Automatic replenishment system

As I have mentioned previously the base for an automatic replenishment system is an inventory control system built on the principals of an (R,s,S) system. In these systems the safety-stock is in most cases dramatically reduced and set to an optimum for the supply chain. Therefore I have decided that the safety-stock for this type of inventory system should be calculated to an approximate value through an optimal calculation for the safety-stock.

The method I would have used, and that I will describe here, is valid for normal distributed demand during the lead-time. Therefore the calculation of a future automatic replenishment system might not be completely correct but the intention with the whole comparison is to get an, as correct as possible, approximation of

how an automatic replenishment system like VMI would change both Tamro's and the pharmacies' business.

The following formula is used for determining the safety-factor (Z).

$$(10) \quad F(z) = 1 - ICQ/\lambda B$$

Where: I = Interest rate

C = Cost per unit

Q = Order quantity

λ = Demand in units per year

B = Backorder cost per order

$F(z)$ is the standardised normal distribution function and through this value the safety factor Z can be determined from a table. The safety stock will be calculated through the formula, $SS = \sigma Z$.

At the same time as the safety-stock calculation is performed the actual fill-rate (V) should be calculated to compare it to the inventory availability, or customer service goal, set by management. The previously described (7) formula should be used.

Alternative

The (R,s,S) system is basically a periodic review system and therefore the safety-stock can be calculated through determining the expected number of stock-outs. This will be done through the expression, mentioned previously:

$$\text{Stock-outs} = Q(1 - V)$$

Where the average order-quantity (Q) and the inventory availability (V) will be parameters set by management.

The safety-stock will in this alternative be calculated through the expression (1) $SS = s - \mu$. The reorder-point s will be set by management and the expected demand will be determined from the statistics over previous sales.

6.2 Order quantity

The present order quantity is easily determined from Tamro's statistical information and also from the pharmacies chosen for comparison with the present inventory control system to a future automatic replenishment system like VMI.

The order quantities in a VMI system are decided by a management agreement between Tamro and Apoteket. The reason that the order quantity neither could or should be calculated in a optimal level, read economic order quantity, is that in the (R,s,S) system the average interval between replenishment has to be decided for different product categories.

The interval between replenishment can be calculated approximately based upon the yearly demand that is known.

The change of landed cost, which means the Pharmacies purchasing price (AIP) plus the handling cost for placing items in inventory will change as the inventory control system changes. The change of landed cost should be calculated per item to illustrate how both the handling and in one way also the delivery to the pharmacies will be affected through a VMI system.

6.3 Delivery to pharmacies

The total volume distributed from Tamro to the pharmacies will not be changed with a new inventory control system, but the better planning of the deliveries can reduce the amount of work for both Tamro and Apoteket.

It would be preferable for both Tamro and the pharmacies if the general inventory level at the pharmacies could be reduced. Therefore a delivery should be planned in an optimal way for both Tamro and the pharmacies

An important key-figure that should be recognised when the present inventory-control system is compared to an automatic replenishment system is the credit time. In the present inventory control system Apoteket has 45 days credit on the products that the pharmacies purchase from Tamro.

6.4 Discussion

My intention was to perform the calculations needed after describing that evaluation procedure for an automatic replenishment system, but since I understood that it would be really hard to get the data and perform the calculations within this thesis, I will stop with the quite extensive description of the calculation procedure for safety-stock.

My conclusion of this is that the safety-stock and all the calculation needed should be performed in the easiest alternative possible. Since the intention, as I also wrote previously, is to find an approximation of the possible benefits of an automatic replenishment system, an exact value will both be very hard to find and also unnecessary.

7 ANALYSIS

As I have described in my interaction between the chapters, the following chapter will include my analysis of the problem that initiated my thesis

7.1 Problem formulation

My thesis is based upon the following problem-formulation.

How should an inventory control system be designed to reach the biggest possible benefits to the lowest costs for a supply chain?

During the time I have worked with this problem I realised that it would not be possible to present both a quantitative and a qualitative approach to the problem. Therefore I have chosen to analyse my problem from a strategic view, but I do also have some operational views on the problem. I will concentrate the analysis on the main question, how an inventory control system should be designed to create the best opportunities for the supply chain, but the challenge is to create a process to reach this optimal inventory control system. The later question is the most interesting and it will therefore be a very important part of the question.

I started my literature chapter with the following definition of the mission of a logistican.

“...to get the right goods or services to the right place, at the right time, and in the desired condition, while making the greatest contribution to the firm”

This mission does not just describe the mission of a logistican, but it does also exactly describe what the inventory control system should be able to handle.

My initial problem from Tamro was based upon the planned inventory control system that Apoteket are going to purchase and how it will affect Tamro's business.

The effect of a changed purchasing behaviour that is expected to come together with the inventory control system will be analysed from a general perspective.

7.2 Inventory Control System

The basic questions one should ask when an inventory control system is to be designed are how often the inventory status is to be determined, when items should be ordered and how much that should be ordered each time. These questions are one part of a company's/supply-chain's inventory policy, other strategic questions are related to for example placement at distributions centres. In my study of the present inventory situation between Tamro and Apoteket, it is perfectly clear that no type of inventory control co-operation exists, but during my interviews some of the respondents clearly told me that they want to increase their co-operation with Tamro.

Figure three illustrates that products should be purchased often to decrease the value of average stock. This is a general argument and after I had studied the cost parameters in the supply chain this was especially valid for pharmaceutical distribution. The cost parameters that were identified in the literature chapter, for example, purchasing cost, inventory carrying cost and control system cost but to some extent also the cost of changing work force and order sizes should be studied in detail when a supply chain is further developed. Apoteket expect that the cost parameters should become both less varied and more clear in the planned inventory control system.

The order quantity could as I described in figure four, be determined in several ways and a best solution should be chosen with an inventory control system. I described four distinct types of inventory control systems in the literature chapter and the system called (s,Q) , order-point, order-quantity, is the system that the pharmacies are using today. The problem with this system is that the order quantity is decided locally at each of the almost 900 pharmacies and clear decision criteria do not exist. The pharmacies do also have the possibility to use a periodic review system, but the main problem with both of these systems is the lack of flexibility. During one of my interviews I got the example of the dentist that wanted to order products every two weeks on a specific day in the week but this is not at all possible in the present ordering system.

A subscription-system where specific products can get special routines has been a service idea from Tamro and for some pre-identified product categories this would according to my interviews be an excellent service.

Apoteket have planned to introduce a new inventory control system next year that should increase the overall control of the pharmaceutical business. In the specification for this system it has been stated that both products and pharmacies should be classified. Theories in this area suggest that different products and locations should be treated differently. Two ideas of classification are given in figure eight where the volume is compared to the products' profit- contribution and in figure nine where the market growth is compared with the market share. None of these models are possible to completely apply to Apoteket but these models are comparable to Apoteket's ideas of classification.

The effects of an inventory control system will be recognised in the customer service level since the customer service summarised is the same as how well the logistic system is performing in creating in creating time and place utility. Order fill-rate and on time delivery are transaction parameters that most likely would be improved if a new inventory control system was implemented. Another method is to use point-of-sale information in the supply chain and additional service packages like subscriptions systems.

I wrote in the literature chapter that one method for improving the Inventory Management situation is through policy definitions and refinement, information integration and expert system applications. These three points are very important for Tamro and Apoteket when the present inventory systems are going to be improved.

A complete automatic replenishment system can be a too dramatic change therefore a first step might be a Base-stock system. Since there exists an EDI connection between Tamro and the pharmacies it is probably not a big problem to technically get point-of-sale data but it might be a bit more problematic to use the information.

Tamro's Danish daughter company Nomeco has just introduced a new service package called logistic partnership and it is based upon the theories of VMI

(Vendor Managed Inventory). This new inventory control system has already been successful in the introduction phase and among other things Nomeco has in this way been able to develop a more co-ordinated business, meaning better planning and effectiveness. Therefore it is necessary for Tamro to follow the development of this project and also study the software that are used in the partnership when it might be possible to use the system or part of it in a possible Base-Stock-system and of-course also for a VMI solution.

An automatic replenishment system is based on the (R,s,S) –Periodic review, order point, order up to level - control parameters. This control system is a more complicated system than the present (s,Q) system presently used and it needs to be completely computer controlled. Automatic replenishment system is combined with components such as EDI, cross-functional teams and to some extent also category management. These components are needed in a (R,s,S) system where co-operation is preferable if the companies involved are to be satisfied with all the parameters used.

8 CONCLUSIONS

In this chapter I will present the result of my work. This will be done in the form of own constructed models related to important areas for the strategic development of Tamro and Apoteket's supply chain.

8.1 Purpose

The main purpose with this study is to:

Introduce new ordering systems and parameters that will lead to lower cost and, at the same time improve the effectiveness of the part of the supply chain consisting of Tamro AB and Apoteket AB.

8.2 Three Strategies

After performing this study my conclusion is that there are three distinct alternatives for the development of Tamro's and Apoteket's supply chain.

8.2.1 Alternative one

If there is no change in the information available for Tamro, they will have to adjust their business through internal changes. After getting an idea about how Apoteket's new inventory control system will affect Tamro, Tamro will be able to make internal changes towards a more effective business.

This way of going towards a more effective business is the simplest way for the present situation since it does not include any new technical investments or any new inventory system. Following this alternative Tamro have to adjust its business according to Apoteket's new routines. This alternative is not a solution for the future, since Tamro have to develop its business to be able to continue being the market leader.

8.2.2 Alternative two

If Tamro gets information of the different pharmacies' actual needs through Point-of-sale data and the pharmacies still place their own orders, a Base stock system is right model.

This is a middle way for Tamro that will help them adjust their inventory level in their distribution centres (DC) after the pharmacies' actual needs. This alternative of going towards a more competitive business will probably lead to better service for the pharmacies including less problems of being out of stock caused by the wholesaler.

The Base Stock control system would increase the information in the supply chain.

8.2.3 Alternative three

Finally, if the third alternative is applicable, Tamro will get access to the pharmacies demand information and their inventory position and be responsible for supplying all pharmacies with the right inventory at exactly the right time, instead of getting orders. This automatic replenishment system and a VMI are the systems most suitable for Tamro's business.

An automatic replenishment system like VMI would, according to my opinion be the best solution for both Apoteket and Tamro. It should although be recognised that presumptions for this type of concept are trust and willingness to share information.

My suggestion is that this system should be tested in a project on one small pharmacy, since I believe that the small pharmacies will have the biggest need of this kind of system. One task within such a project is to evaluate the cost/savings for introducing a VMI system.

8.3 Development of the supply chain

Based upon my analysis of the problem I have constructed the figure below, for the process to reach an optimal inventory control system.

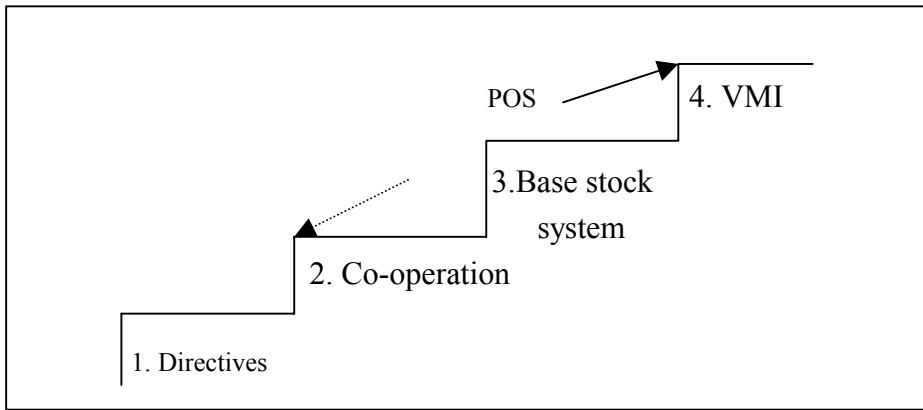


Figure 19: Four steps for better inventory control

Source: Own construction

8.3.1 Directives

The idea behind figure nineteen is that a company has to have overall control over its own business before a strategic improvement can be introduced. As I mentioned in the analysis chapter, Apoteket have to make their own cost structure clear before they can develop their business any further, otherwise it will be impossible to in a correct way calculate the effects of an alternative direction of their business. At the same time as the cost structure is improved, I think Apoteket should create some flexibility for the pharmacies where for example a subscription system would be a perfect alternative. Finally Apoteket have to identify a clear inventory policy and stick to this.

8.3.2 Co-operation

There is a clear and spelled-out wish from the pharmacies to build up a closer co-operation with Tamro. The paradigm shift from Push to Pull should according to my opinion be applied in the supply chain between Apoteket and Tamro. Therefore the co-operation step should be first step into the exchange of Point-of-Sale data and integration of information systems. The co-operation step is an important development since Tamro is the part in the supply chain with a broad logistic knowledge.

To make the use of Point-of-Sale data as effective as possible I think that Apoteket should classify its pharmacies in a clear and effective way, where the following figure could be one alternative solution.

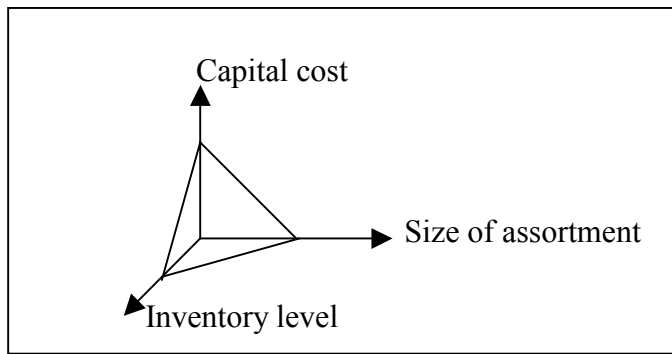


Figure 20: Pharmacy classification

Source: Own construction

This model should be seen as a method to differentiate the capital cost for different pharmacies. This is done through a combination of the number of articles in a pharmacy's assortment and its inventory level.

It is important to bear in mind that the result of a new system should be preferable for the whole supply chain, therefore it is very important to recognise the importance of co-operation, since most companies have realised that one company can not provide the best solutions by itself.

8.3.3 Base-Stock-System

The Point-of-sale data will in this development process, as a first step, be used according to the principals of a Base-stock system. In this way Tamro will get a possibility to improve its own inventory situation.

8.3.4 VMI

Finally I have the opinion that the goal should be to implement an automatic replenishment system like VMI. Therefore it is important for Tamro to follow the Sister Company Nomeco's progress with their partnership project based on the theories of VMI.

9 FUTURE WORK

When I was ending this work I was told that Apoteket is planing to start up its own wholesaling business. This is as I have understood it not completely decided yet but if this will be the alternative for the future my study will not be applicable for the pharmaceutical business.

On the other hand if these ideas are not carried out in reality, I think that Tamro in co-operation with Apoteket should approximate a value of future VMI system and try to get an agreement of a joint- develop plan for the future.

10 RELIABILITY

The reliability of a research report includes judgement criteria of the work. The two scientific criteria that normally are used are validity and reliability and these conceptions will be discussed in this chapter. Finally I will discuss possible shortcomings in my thesis under the sub-chapter, Criticism.

10.1 Introduction

The quality of the research design is judged through its validity and reliability, as the table below illustrates.

TESTS	CASE STUDY TACTIC	PHASE OF RESEARCH IN WHICH TACTICS OCCUR
Construct validity	<ul style="list-style-type: none"> - Multiple source of evidence - Establish chain of evidence - Key informants review 	Data collection Data collection Composition
Internal validity	<ul style="list-style-type: none"> - Pattern matching - Explanation building - Time series analysis 	Data analysis
External validity	<ul style="list-style-type: none"> - Use replication logic in multiple case study 	Research design
Reliability	<ul style="list-style-type: none"> - Use case study protocol - develop case study database 	Data collection

Table 12: Case Study Tactic

Source: Yin, 1994, p. 33

The criteria of validity and reliability could be used to evaluate the strengths and weakness of the research strategies or approaches to the initial problem chosen.

10.2 Validity

To meet the criteria of construct Validity the following two criteria have to be met. (Yin, 1994, p. 34)

1. Select the specific types of changes that have to be studied.
2. Show that the selected measures of these changes reflect the changes that have been selected.

10.2.1 Internal Validity

The internal validity refers according to Gill and Johnson (1997, p. 128) to, whether or not what has been identified as causes or stimuli actually produce what has been interpreted as the effects or responses.

The following six strategies are according to Merriam (1998, p. 204f) important to enhance internal validity in qualitative research.

1. Triangulation: Confirm findings through multiple investigators, multiple sources of data or multiple methods to confirm the emerged findings.
2. Member checks: Taking data and tentative interpretations back to the people from whom they were derived and asking them if the results are plausible.
3. Long-term observations
4. Peer examination: Asking colleagues to comment on the findings as they emerge.
5. Participatory or collaborative modes of research: Involving participants in all phases of research from conceptualising the study to writing up the findings.
6. Researches biases: Clarifying the researcher's assumptions, worldview and theoretical orientation at the outset of the study.

10.2.2 External Validity

When a study has met the criteria for External validity it is stated that the study's findings are generalised beyond the specific case study. (Yin, 1994, p 35)

Gill and Johnson (1997, p. 128f) refer to external validity as the extent to which the research findings can be generalised or extrapolated beyond the immediate research sample or setting in which the research took place. External validity is often subdivided into the following two groups.

- ◆ Population validity: Concerns the extent to which it is possible to generalise from the sample involved to a wider sample.
- ◆ Ecological validity: Concerns the extent to which it is possible to generalise from the situation in which the research has taken place as to other contexts and settings. Another aspect of this type of validity is how artificial or atypical the research setting is relative to natural contexts typical of everyday life.

Action research (and case studies) gain naturalism and therefore its ecological validity is naturally relatively high. When naturalism is gained through these methods, there is an ability to manipulate the incidence of independent variables and control the incidence of extraneous variables. This leads to the fact that the increased ecological validity is reached more or less at the expense of internal validity. (Gill, Johnson, 1997, p. 129f)

Surveys have got much strength in population validity and reliability since they use random selection of samples that enable the results to be generalised for a wider sample with high confidence. Surveys are relatively weak in internal validity, meaning that it is difficult to control hypotheses (Gill, Johnson, 1997, p. 130)

A study must have internal validity before there is a meaning to checking the external validity. The external validity can be strength through: (Merriam, 1998, p. 207)

- ◆ A standard sampling procedure
- ◆ Many cases to study the same phenomena

10.3 Reliability

Reliability refers according to Gill and Johnson (1997, p. 129) to the consistency of results obtained in research. To satisfy the criterion of reliability it should be

possible for another researcher to replicate the original research using the same subjects and the same research design under the same conditions.

Both action research and case studies are performed so the context of the research could be preserved. This will result in a relative decrease in reliability, since the research findings will be difficult to replicate. (Gill, Johnson, 1997, p. 130)

If a later researcher follows exactly the same methodology and he/she gets the same result(s), the case will have a desirable reliability. (Gill, Johnson, 1997, p. 130)

There is according to Merriam (1998, p. 205f) a connection between reliability and internal validity since a study is more valid if repeated observations in the same study have produced the same results of reliability.

There exist several techniques for ensuring reliability. Three of them are according to Merriam (1998, p. 206):

- ◆ Investigators position: Explain the assumptions, theories behind the study and the basis for selecting information.
- ◆ Triangulation: Using multiple methods of data collection and analysis which will strengthen both the reliability and the internal validity
- ◆ Audit trail: Explain in detail how to get the results.

10.4 My position to Validity and Reliability

I have done my best to strengthen the validity of my theses. I have made several interviews based on the same type of questionnaire. If some common procedure was unclear, I got the opportunity for a “third opinion”. I also compared this information with the written information I got in annual reports, brochures, internal educational material and so on. This method is a variance of triangulation to strengthen the internal validity. To some extent I also used a member check/peer examination to get feedback of some specific information.

The pharmaceutical industry is quite special therefore my study will not be possible to completely generalise for other business, but in general terms the

ideas will probably be applicable for most companies. Therefore the external validity of my study may not be perfect but the ecological validity is according to my opinion sufficient for this type of study.

If another person had performed the same study and with the same methodological base I do not think that the result of that study would have been exactly the same as mine. I have although used the three techniques given by Merriam to ensure the reliability of my study. I have for example explained how I reached my results, I have used different methods for my data collection and, according to my own opinion, I have carefully explained the assumption and theories behind my study.

10.5 Criticism

I have no doubts about the reliability of the literature that I have used for this study but it might be possible that I should have used more articles to get “new information” but I thought my literature search was sufficient.

I have had some struggles with the quantitative parts of this study since it was hard to get the information I initially wanted but also since it was quite hard to determine if some results would be applicable in reality or not. This was one of the reasons that I chose to describe calculation procedure between the present inventory system and a future VMI system theoretically in the chapter *proposed research design for calculating the benefits of VMI*. This might not be seen as enough but I did not really see any other possibilities.

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