Master Thesis

Identification of Improvement Potentials obtained by Auto-ID

–A case study of a SCA supply chain

Lindholm Marcus, Svensson Johan

Packaging Logistics
Department of Design Sciences • LTH • 2008

ISRN LUTMDN/TMFL— 08/5059

Restricted version

Preface

This essay has been created in the purpose of being a Master thesis for a Mechanical Engineering education at Lund Institute of Technology. To write a Master Thesis is the final examination in the engineering education. The purpose of making a thesis like this mandatory is to give the students an opportunity to learn about the corporate world and also to provide the company with the latest theories in the chosen subjects and tasks.

The thesis has been made at SCA R&D Centre during the spring of 2008.

Several people have made this thesis possible, due to their willingness to give up their valuable time and support us. Therefore we would like to give expression of our gratitude to these people. First and foremost we would like to thank our supervisors at SCA, Michael Franvin, Folke Johansson, Alexander Lundin, Olle Söderström and our supervisor at the department of Packaging Logistics, Henrik Pålsson for their commitment, support and for sharing their knowledge with us. Further, we would also like to thank the following people for their help to create this thesis;

SCA Packaging AB
Per-Johan Ahlzén, Hans Carlsson, Eva Hansson, Niklas Strand, Conny Svensson, and all forklift drivers at the FGW

SCA Personal Care AB
Eva Bergenheim, Christian Bona, Pär Engström, Bengt Johansson, Susanna Karhunen, and Oscar Österberg

RFID Constructors AB
Olle Hydblom

Lund Institute of Technology
Mats Johnsson and Johan Marklund,

ICA AB
Peter Landenberg, Johan Rösler, and Fredrik Sjulander

ICA MAXI Västra Hamnen AB
Calle Stockenberg

Sigurd Anderssons Hauler AB
Hans Andréasson and Bo Holm

Abstract

The studied supply chain consists of; SCA Packagings' factory in Värnamo, Sigurd Anderssons Hauler in Falkenberg, SCA Personal Cares factory in Falkenberg, ICA's Distribution Center in Helsingborg, and ICA MAXI Västra Hamnen in Malmö. SCA Packaging is a part of the SCA group and they produce packages of corrugated cardboard for different applications. The factory is one of the most advanced corrugated cardboard plants in Europe. Sigurd Anderssons hauler is a company that among other tasks keeps cartons in stock for SCA Packaging that have been ordered by SCA Personal Care in Falkenberg. SCA Personal Care is also a part of the SCA group. They manufacture and distribute diapers for babies, incontinence care and sanitary protection. ICA's distribution center in Helsingborg Sweden is one of the most advanced and automated in Europe for the general retail industry. ICA Maxi in Västra Hamnen is a typical, large supermarket.

The purpose of this thesis is to investigate and determine which advantages and limitations some Auto-ID technologies have compared to each other. It is also to investigate if the theoretical opportunities and benefits with Auto-ID technology can be gained in reality. If there are gains to be made, they will be described in quantitative and qualitative terms.

To fulfill the purpose was theories in different areas, and information about the characteristics of the supply chain, gathered. The results in the thesis were reached by comparing theory about Auto-ID with information about the processes and activities in the supply chain and then finally extract a result through theory about logistics and supply chain management.

A result that this thesis presents is that barcodes still holds great potential for managing goods and demand. RFID which is a newer form of Auto-ID has in reality not so many clear advantages compared to barcodes that the theory often states. The only advantage that can be quantified is automated registration and the qualitative advantages are mainly increased durability and theft protection. The conclusion from this thesis is that barcodes still is the best Auto-ID alternative for this supply chain, due to that RFID still cost much more and the fact that the barcode technology is widely used which is not the case with RFID.

Despite this is it concluded that the full potential of barcode technology is not yet reached. Great potential lies in areas of searching for pallets, warehouse space utilization, administrative work, shipping accuracy, and demand management. Also, other improvement potentials have been found that could not be quantified. These are mainly benefits from improved demand

management, good-will for shipping accuracy, less traffic in the warehouses and stock keeping in real time.

Table of contents

List of Abbreviations

- D.C. – ICA Distribution Center in Helsingborg
- FGW – Finished Goods Warehouse
- FTL – Full Truck Load economics
- Maxi – ICA MAXI Västra Hamnen in Malmö
- P.C. – SCA Personal Care in Falkenberg
- RFID – Radio Frequency IDentification
- RMW - Raw Material Warehouse
- S.A. – Sigurd Anderssons Hauler in Falkenberg
- SCA-P – SCA Packaging in Värnamo
- SI – Safety Inventory
- UPC – Universal Price Code

1. Introduction

This chapter describes the general conditions under which this thesis has been created. It contains background, problem definition, purpose, focus and delimitation and ends with a description about to which groups this thesis is targeted.

1.1 Background

Over the last quarter of the twentieth century globalization has accelerated significantly[1]. This increased level of globalization has had a big effect on the entrepreneurial climate. Companies have gained several advantages due to this, but they have also experienced complications such as more complicated sourcing and distribution processes. Another factor that increases these problems is the expansive proliferation of products. This combined with that products have shorter life cycles, has made variability management more complex and important.[2]

One subject that has proved to be powerful for overcoming these obstacles is Supply Chain Management (SCM). It states that to obtain the highest performance possible, it is not the single company, but the entire network of companies that are involved in the products travel from raw material towards the final customer that has to be improved.[3]

A problem with this perspective is that if companies in a supply chain are going to work together as a whole, a high level of integration is needed. To achieve this, a lot of information has to be shared between the different actors and for this task information technology is necessary. This technology is crucial for the performance of the supply chain since information is the basis on which managers and operators make decisions. The foundation of making decisions is information about, for example; characteristics of the demand, inventory levels, and suppliers lead times.[4]

A crucial postulation is that the systems used to share the information have access to data that is up to date and accurate. To get hold of information about supply chain characteristics with the performance mentioned above every item

[1] Nayyar (2006)
[2] The Impact Of Automatic Identification On Supply Chain Operations (2003)
[3] OSD Comptroller iCenter (2007)
[4] Chopra et al. (2007)

and its location must be accounted for. This is preferably done with Auto-ID technology. Examples of such technologies are barcode or RFID technology. [5] Advocates of AUTO-ID are claiming that if it is used properly, a gain in supply chain performance will be reached. This is achieved because they provide companies with the opportunity to track product information faster and allows greater flexibility in managing goods[6]. This makes collaboration on planning, forecasting and replenishment more efficient[7]. It has also been concluded that retailers can expect benefits from reduced inventory, reductions in store and warehouse labor costs and in out-of-stock[8].

1.2 Problem definition

The challenge for managers is to control the costs and at the same time realize the perceived benefits that were described above when implementing or improving the use of their current Auto-ID technology.[9] Since Auto-ID technology is widely spread and reliable, information given by this technology is a natural founding to base calculations, systems, and decisions upon to improve efficiency in different operations in the supply chain. The key question is if the theoretical benefits really exist and if they do, how great they are and how they can be gained. It is in this context that these following questions have emerged:

- How can Auto-ID and information from this technology be used to improve supply chain operations?
    - Which operations have most potential for improvement?
        - How much better will these operations perform?
        - What cost-savings lies in these improvements?

1.3 Purpose

The purpose of this thesis is to investigate and determine which advantages and limitations some Auto-ID technologies have compared to each other. It is also to investigate if the theoretical opportunities and benefits with Auto-ID technology can be gained in reality. If there are gains to be made, they will be described in quantitative and qualitative terms.

---

[5] The Impact Of Automatic Identification On Supply Chain Operations (2003)
[6] Jabjiniak et al. (2004)
[7] BMWI (2008)
[8] Techtarget (2008)
[9] Vijayaraman et al (2006)

1.4 Focus and delimitation

The main focus of the thesis is how and where the use of Auto-ID can improve the entire supply chain and its components. When this is defined, the improvements are then to be quantified in terms of cost savings. However, for some areas it is not possible realize this quantification, so for these a qualitative discussion will be made instead. To be able to reach satisfactory results for this task, investigations about the costs for creating these improvements have to be delimitated. Another reason for this delimitation is that this work is best managed between the potential customer and sales companies.

For certain areas will it be acknowledged that the potential for improvement is rather small. These areas will not be investigated to a greater depth due to the more beneficial purpose of focusing on the areas with larger potential. The areas with less potential will still be presented shortly since this also is valuable knowledge.

To obtain focus and reach deeper conclusions, it was crucial to make delimitations in terms of selecting how many supply chains that should be investigated and analyzed. In this thesis a choice of a smaller investigation area has been made, with the result that one supply chain has been investigated. The companies in the supply chain that will be investigated are SCA Packaging, Sigurd Anderssons Hauler, SCA Personal Care, ICA, and an ICA supermarket.

Another delimitation that was made were that only two forms of Auto-ID technologies where investigated and these were RFID and barcodes.

The levels that are focused upon will be secondary packages and pallets since these are the two levels that almost all of the handling is made through the supply chain. The products that are investigated are the packages that SCA Packaging produces and also the diapers and the sanitary protection products that comes in to the supply chain at SCA Personal Care.

1.5 Target groups

This thesis is mainly targeted towards staff and decision makers at SCA Packaging, SCA Personal Care, and ICA. Hopefully it can be useful to other divisions at SCA as well. The conclusions of this thesis will mainly be of interest to supply chain managers, planers of material and transportations, purchasing and sales managers at these companies.

Another target group is engineer students that write reports in courses that involve some of the subjects in this thesis and those that are writing their own master thesis. Hopefully, they can use this thesis as an inspiration and also find use of the results.

Finally, the thesis is targeted towards the staff at the Department of Design Sciences at Lund Institute of Technology and other people that are interested in supply chain management and Auto-ID.

2. Methodology

The methodology chapter describes how this thesis was created and presents the different methodologies in science and research methods used to write it. This chapter contains a presentation of the scientific approaches that were used in this thesis, followed by the more applicable research methods. Finally, a description of the data gathering is presented.

2.1 Scientific approaches

The theories that are presented in this chapter were crucial for the thesis in that sense that they made the handling of information and data in an objective manner possible. Method theories originate from the scientific approaches which conceive the necessary assumptions in order to investigate, explain, and understand the truth[10]. Because of this relationship, the scientific approaches is the overseeing theory in the methodology chapter and in a sense therefore also for the entire thesis.

2.1.1 Case study

The definition of a case study is: "an investigation of a specific phenomenon, for example an event, in a defined and limited system" [11]. This definition fits the problem definition and the focus and delimitations of this thesis perfectly. The event is the impact the higher utilization of the information from Auto-ID may have and the limited system is the investigated supply chain.[12]

In this thesis both qualitative and quantitative research have been made, the handling of these different researches has been separated in a way that can be showed in table 2.1:

[10] Wallén (1996)
[11] Merriam (1994)
[12] Ibid

	Qualitative	Quantitative
Focus	The nature of the object	How many, how much
Background theory	Hermeneutics	Positivism
Data collection	Interviews, observations	Time measurements, data handling
Analysis	Inductive	Deductive, by mathematical methods

Table 2.1: The structure of chosen tools for the handling of qualitative and quantitative data. Source: Merriam (1994)

The case study in this thesis can be described as a frame that contains all the methodologies that have been selected. These are presented in the following chapters.

After the qualitative and quantitative data was collected, it had to be analyzed. There are several ways to do this in a case study. The tools that were used for this thesis are described below: [13]

- **Performing calculations** –This was done to secure that the result would be objective and correct.
- **Finding patterns**– Patterns were found by asking different people the same questions. In this process it was important to secure that there were support for the patterns and themes that evolved by comparing the answers with quantitative data, when it was possible.
- **Clustering** – This means that results that resembles each other was grouped into categories. By structuring it became easier to perform the analysis.
- **Dissecting the variables** – General variables were dissected into smaller variables and factors. In doing so a greater depth in the analysis was achieved.
- **Building a logic chain of evidence** – Here were theories, data and themes integrated into a connected entirety, which basically created the analysis in this thesis.

2.1.2 Positivism

According to this branch of science, the truth will be found by following a method that is basically independent of the investigations content and context. Also, every influence from the scientists' opinions should be eliminated. The positivistic approach advocates the experimental quantitative methods, with

[13] Merriam (1994)

the goal that scientific statements should be built upon observable data that is objective, unambiguous and quantifiable. The purpose of this is that scientific statements and facts will be separated from values and policies.[14] This approach is because of this natural to use for the quantitative research but it has in this thesis also been used to look upon the qualitative data with skepticism. In doing so, many "half-truths" could be clarified.

2.1.3 The Hermeneutic cycle

Hermeneutics is about interpretations of texts and its purpose is to gain a valid understanding of the text. This theory has been applied in the research through interviews since it enlightens the dialog that creates the interview texts. Further, it is also relevant for clarifying the process of interpreting the text from the interviews.[15]

The interpretation of a sentence is characterized by a so called hermeneutic circle. The circle has its origin in the understanding of a text. By the use of this circle or spiral was a deeper understanding of the context given. First, a reading of the entire interview to obtain a broad outline was done. Then, a second read-through of certain themes and expressions was made to search for a deeper meaning in the interview. After this the spiral continued by returning to the big picture and so on. Such a hermeneutic interpretation is in theory an infinite process but in reality it ceases when a reasonable sentence, free from inner contradictions, has been developed.[16]

Another principal for hermeneutic interpretations of a text says that the persons asking questions must have an extensive knowledge about the theme of the text. This knowledge gathering was made in the beginning of the project. A great gain with this approach was that when a qualitative research interview was made, nuances in the different sentences and contexts were identified.[17]

---

[14] Kvale (1997)
[15] Ibid
[16] Ibid
[17] Ibid

2.1.5 Multi Science

This thesis can be defined as a multi-scientific examination, which is basically an interdisciplinary examination. This approach has been used to gather information and theories from a number of areas to create an overseeing hypothesis, which is presented in the frame of reference. A multi-science approach gives the effect that the work has been done with a structured division of duties between the subjects and their theories, even though the final product is integrated. The areas that were integrated to create the frame of reference in this thesis are theories about supply chain management, logistics, and Auto-ID. Figure 2.1 shows the integration intentions between the chosen areas of this thesis and how the proportions of the chapter are distributed between these areas.[18]

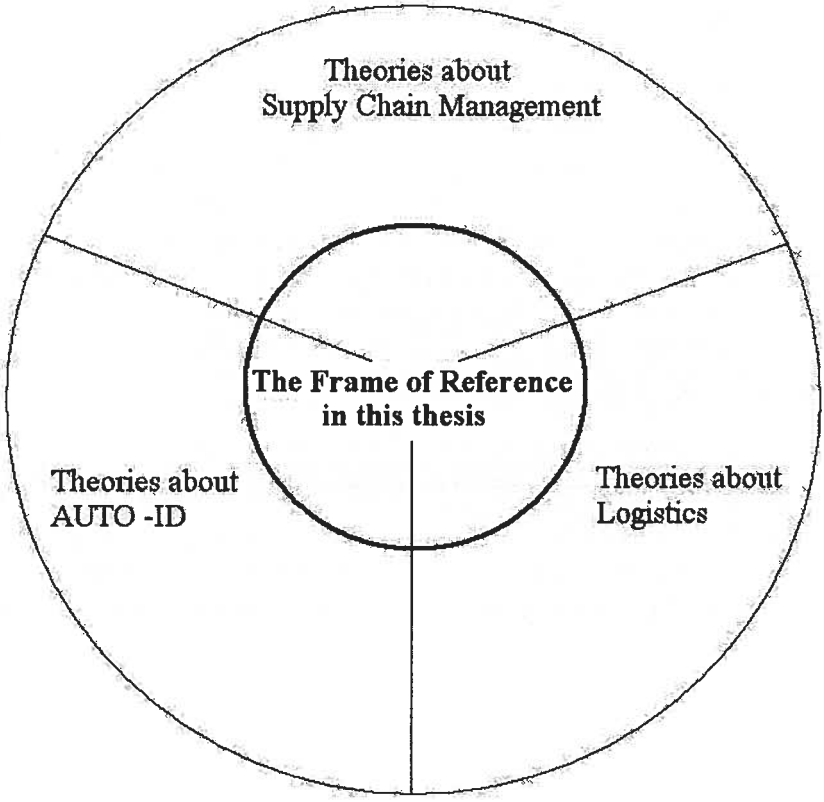

Figure 2.1: The areas and their respective influence on the frame of reference in this thesis.

[18] Wallén (1996)

2.2. Research methods

This chapter is about the different types of research methods that were chosen to be used. The following methods have originated from the science methods and are more descriptive for the creation of the thesis.

2.2.1. Qualitative and quantitative approaches

The results in this thesis have been desired to be presented in quantitative terms. The qualitative examination has been executed for two reasons, first to be able to measure characteristics that can not be measured using quantitative methods. Secondly, to establish which factors that influence the areas with potential for improvement and therefore later will be measured by quantitative means. The qualitative data has been primary and secondary and has been complemented with some primary and secondary quantitative data to give a more robust structure to the thesis. For example, when primary qualitative data from, say an interview, has indicated potential for improvement in a certain area, this has been confirmed by gathering and processing quantitative data. [19]

2.2.2 Research Procedure

The creation of this thesis started with a consideration about what in this subject was interesting and why. When this became defined, the problems in this area could be visualized. This context is the foundation of the introduction chapter and gave the fundamentals of the methodology. In this chapter it is established how information was gathered to answer the problem definition in an accurate way. It was obvious that an initial study-visit at all of the companies in the case study were crucial to begin with, so that potential areas could be identified. These initial investigations had a broad outline to reduce the risk of missing an area. The investigation continued by continuously narrowing the investigation areas until a level that would generate maximum results was reached. In this process the interview questions were narrowed from general to specific and direct. In the beginning of the empirical investigation theories on how to analyze the results were examined, and chosen, so that the problem definition could be answered. Finally, was the results from the analysis discussed and generalized and then conclusions were drawn so that the purpose of the thesis was reached. An illustration of the research procedure is shown below:

Chapter 1 Introduction

19 Wallén (1996)

What about this subject is interesting and why?
Wherein are the problems?
What is the purpose of this thesis?

Chapter 2 Methodology
How will the questions in **chapter 1** be solved in an objective manner?
How will the validity and reliability of the results be assured?
Which objectives and methods are required for this?

Chapter 3 Frame of reference
What knowledge is required to solve the questions in **Chapter 1** and to describe the conditions of the supply chain in **Chapter 4**? Also, this chapter needs to contain information to create correct results in **Chapter 5**. The information in this chapter must be supported or objectified by **Chapter 2**.

Chapter 4 Empirical data
By using the objectives in **Chapter 2** and the problem definition in **Chapter 1**, what are the characteristics of the supply chain and where is there potential for improvement? When the latter is defined, the performance and problems of these areas were investigated and defined.

Chapter 5 Analysis
How can the problems **from Chapter 1** be solved by using the theories from **Chapter 3** in the reality that is described in **Chapter 4**? How will these results be supported in **Chapter 2**?

Chapter 6 Discussion
How can the results in **Chapter 5** be generalized?
What should be the next step for the studeid supply chain?

Chapter 7 Conclusions
Has the purpose in **Chapter 1** been fulfilled and what was the result?

2.3 Data collection

This chapter is about the different ways to gather, handle and analyze the data needed to create the empirical chapter. Also, the terms validity and reliability will be defined.

2.3.1 Qualitative data gathering

Since much of the data gathering for this thesis was done by qualitative interviews it was highly important that these were well founded in the method

chapter. By doing this the objectivity of this central information gathering has been secured and the exchange of information in the interviews has been optimized.

The interviews were conducted by a semi-structured interviewing method. The reason that this method was chosen is that it creates casual dialogs in which information can be easily exchanged without demanding that the interviewers have deep knowledge about the operations existing in the organization. These data collections were executed with an interview guide so that the interview could have continuous focus on the problem definition, so that this could be possible to answer in the future. The more spontaneous the interview is the more likely it is that the answers will be exhaustive and unexpected. Likewise, the more structured interview, the easier it will be to analyze.[20]

When an interview guide was created an important aspect was to make sure that the questions were easy to understand. They had to be short and contribute to an easy flowing conversation. This was done so that the interviewee would be comfortable and open minded.

The data gathering from the interviews is based upon these four stages[21]:

1. **Developing a theme** – The purpose and the subject for the investigation were clarified before the interview began. Also, the questions *what* and *why* has been answered before the question of *how* were asked.
   - What – Knowledge about the subject was gathered in the purpose of understanding the basic relations of the area to which the interview concerned, so that a relevant theme could emerge.
   - Why – The purposes of each interview were identified so that the goal of the interview could be identified.
   - How – Each interview was different from the other. Here were the interview guides of great importance to obtain focus. Since the interviews were semi-structured the questions in the interview guide could be modified to fit the interviewee during the interview. This was helpful for obtaining focus and to reach the goal of the interview.
2. **Interview** –All interviews have been recorded in the purpose to maximize the result from them. Another advantage with this method is that the interviewers can focus on the questioning and discussion instead of taking notes.

[20] Kvale (1997)
[21] Ibid

3. **Verifying** – The results from the interview were determined in terms of reliability and validity. The reliability was improved by comparing the data from the interview with data from other sources and thereafter finding explanations for the differences. The validity was determined by comparing the qualitative data with data from other sources and sometimes quantitative data. To improve the validity of the data that seemed strange in comparison to other data, the sources were confronted with their previous answers and asked to search for more accurate data.

Further, a separation between science issues and interview questions were made to secure the purpose and the expected results of the interviews. Science issues are abstract questions that the researcher hopes to solve and interview questions are the questions that need to be asked in able to solve the science issues. [22]

There are many different types of questions that can be used in different purposes in a semi structured interview. Those that were used in this thesis are shown below[23]:

- **Initial** – These questions gave spontaneous and rich descriptions. An example is "Can you tell me about…".
- **Follow-up** – By asking a direct question about what was just said, an answer with more content and a deeper meaning was reached. These were often asked spontaneously if the previous question did not give the answer it was supposed to.
- **Probing** – Here were answers sought without stating any boarders. An example is "Can you give some more examples of this?".
- **Specific** – In an interview with many general statements more precise answers were obtained by asking for example "How do you do this?".
- **Direct** – Here were the interviewer looking for straight answers about strictly limited questions. An example of such questions is "Do you think that this action can result in a improvement and why or why not?".

2.3.2 Quantitative data gathering

The quantitative information has been collected from two different kinds of sources; data from the investigated companies and also from, books and scientific articles. When the gathering of data from the companies were made it was important to make sure that the data were relevant and correct. If the

[22] Kvale (1997)
[23] Ibid

qualitative data differed much from the qualitative descriptions given in the interviews, then were both data types questioned. Further, the type of calculations that were intended to be used was developed before the data sources were approached. In this way, it became easier to explain which data was searched when the sources were approached.

2.3.3 Validity and reliability

When measurements have been performed both validity and reliability have been considered. Validity is absentness from systematical faults and reliability is absentness from random faults. If a lack of validity exists, then the measurement has not measured what was intended. If a lack of reliability exists, then the instrument of measurement has not been reliable. Reliability in this thesis was checked by a simple comparison between the gathered information. When the reliability proved to be insufficient, a greater reliability was reached by double-checking the sources so that no misunderstandings were made. The confirmation and measurement of validity were more difficult to achieve, but this could be done with confirmation by experienced employees' in the studied companies.[24]

In figure 2.2 validity and reliability is illustrated with the absolute truth in the center.

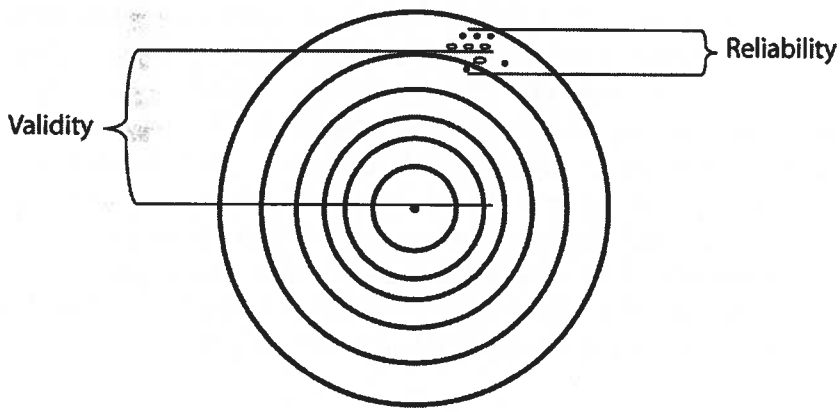

Figure 2.2: Illustration of validity and reliability. Source: Arbnor et al. (1994)

[24] Kvale (1997)

3. FRAME OF REFERENCE

The frame of reference begins with theory and explanations about the technical aspects of the different information technologies used in the thesis. The chapter continues with an introduction of supply chain management. The supply chain has been divided into processes and the theories on how to manage these are presented in the following chapters.

3.1 Auto-ID

Auto-ID is a generic term for data collecting devices, two common technologies that go under the Auto-ID term is barcodes and radio frequency identification (RFID). The technologies under the Auto-ID term is used for automatic identification and tracking of material movement.[25] Auto-ID can be used for many different purposes, for example is one of the most common utilization areas supermarket registers.

3.1.1 The RFID technology

RFID is a generic term for certain technologies that use radio waves to identify and track objects. The objects can be anything from containers, pallets, cases and individual items to keys, etc. An RFID system consists of a tag, which is basically a microchip with a coiled antenna, at least one interrogator and a controller.[26] The Interrogator sends out a radio frequency signal, which the tag then responds to by sending out a response signal, which can contain information such as origin, item number, price, etc. The interrogator receives this response signal and deciphers the information. Once the information has been read by the interrogator it can be shared via information technology such as; Ethernet, LAN, and Internet. An interrogator can communicate with many tags simultaneously. The controller connects the interrogators to create a network and process the information from these centrally.[27] The three parts that an RFID system consists of is illustrated in figure 3.1:

[25] Bridgefieldgroup (2008)
[26] Hunt et.al. (2007)
[27] Jones et al. (2005)

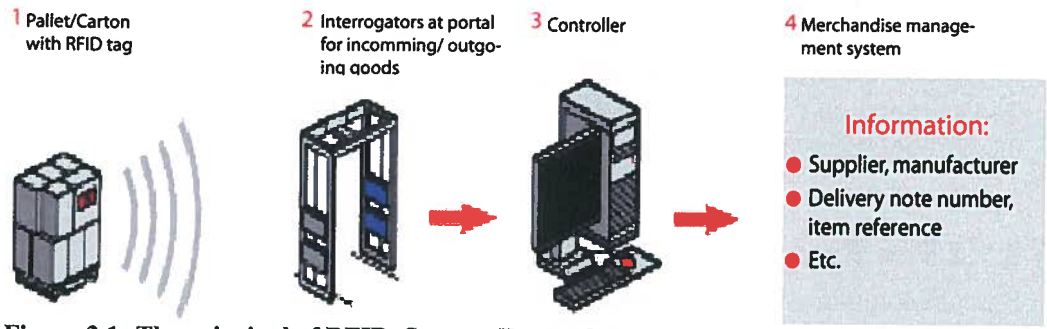

Figure 3.1: The principal of RFID. Source: Future Store (2007)

Interrogators

The interrogator handles all communication between the controller and the tag and it has three functions[28]:

- To read the data contents of an RFID tag
- To write data to the tag
- To relay data to and from the controller

The interrogators can at present use three different frequencies to communicate with the tags, all with different characteristics as shown in table 3.1 below:

	Maximum Read range
Low frequency	up to 0,4m
High frequency	1-3m
Ultra high frequency	3-9m

Table 3.1: Reading range versus frequency. Source: Wyld (2006)

A weakness that has not yet been solved is the lack of a world-wide standard for the communication regarding the "language". EPCglobal is a non-profit organization that is working to establish standards regarding RFID systems and has so far a leading position.[29] However, the EPCglobal standard is only applicable on the UHF band[30].

Identification codes

SSCC (Serial Shipping Container Code) is a code containing a company prefix and a serial number that ends with a control digit. The purpose of this code is

[28] Hunt et.al. (2007)
[29] Ibid
[30] Hydblom (2007)

to provide manufacturers, suppliers, third part logistic companies and vendors with the possibility to identify a container in the same way. The code can be carried by both barcodes and EPC global tags. However, if SSCC is to be implemented on a carrier using a barcode, this must be done by expanding of the number of barcodes by one.[31]

3.1.2 The Barcode technology

Barcodes contains a coded message that is coded by printed bars and spaces between the bars. The width of the bars and spaces forms the coded message that can be read by special readers. When these readers read a barcode the message comes out as a binary code, i.e. in ones and zeros where the bars represent the ones and the spaces the zeroes. This binary code is then sent to a decoder, which translates the code and presents the information it contains.[32] Most of the goods sold in a grocery store, department store and mass merchandiser have a universal price code (UPC) barcode. This code contains information about which manufacturer that has made the product, which article type it is and a control digit that confirms if the code has been read correctly.[33]

3.1.3 Benefits of the RFID technology compared to the Barcode technology

Due to the differences in the technology that RFID and barcodes are based upon there are differences in characteristics between these two. This means that the RFID technology will have certain advantages compared to the barcode technology. Some of the most common strengths that RFID has compared to barcodes are stated below.

Automated registration

One of the most important benefits of RFID compared to barcodes is that the registration process of pallets or items can be automated to a higher degree than if a barcode is used. With RFID, positioning of the product before reading is not necessary, which it is with barcodes. Reading with RFID usually has a higher successful reading percentage than for barcodes.[34]

---

[31] GS1 (2008)
[32] Fileblogs (2008)
[33] Howstuffworks (2008)
[34] Hydblom (2007)

Information capacity

A great benefit is that RFID tags can contain more information than an optic barcode. A generation 2 tag has a capacity of 96 bits which can be compared to a typical barcode that has a capacity of 48 bits or less. This has the effect that an RFID tag can provide unique traceability which a singular barcode can not.[35]

Another advantage with RFID is that data can be put into the tag at any point. This does not work for all tags. However, this can not be done with barcodes. If new information is to be put on the tagged object a new barcode tag must be applied or that a database is used. Both RFID and barcodes that have individual numbers can use a database and store information for that specific individual, at any time, in the database. The big difference between these database technologies is that for RFID is a global database being created that anyone can sign up to, for barcodes is there only "internal" databases.[36]

Reading

Since RFID tags uses radio waves for communication with the interrogator, no physical line of sight is needed. This means that no objects need to be turned towards a reading device. It also minimizes the time consuming manually reading activities, such as that items must be rotated in the search for the barcode. Further, it also means that tagged objects can be stacked on a pallet that just has to be moved past an interrogator.[37] The reading speed for the interrogator can be up to a thousand tags per second with an accuracy that exceeds 98%[38].

Rewritable memory

A great potential that RFID has compared to barcodes is that it can be reused several times. Several producers and vendors claim that a tag can be used up to 100 000 times before it has to be replaced.[39] This means that in a closed loop, for example if the tagged objects are pallets, they can be reused until the pallet is disposed.

---

[35] Hunt et al. (2007)
[36] Hydblom (2007)
[37] Idautomation (2007)
[38] Hunt et al. (2007)
[39] Ala (2007)

Environmental durability

RFID tags are better equipped to endure rough handling than barcodes. Barcodes are more sensitive since if a code is to be read it can not be very dirty or too shredded. An RFID tag is easier to protect and it is not as sensitive to dirt, dust, grease or physical torn etc.[40] However, there are things that the tags are vulnerable to such as; water, static discharge, and high power magnetic surges.[41]

Combination abilities

Another thing RFID can do is to combine a lot of now separate functions into one; anti-theft protection, price, origin, article number etc. all of these can be put into an RFID tag. Now stores do not have to have different systems like barcodes for payment and inventory, and another for anti-theft. Also the process of stock taking will become much easier because with RFID it can be done in a minute compared of doing it manually. This stock taking will also be more reliable than a manual.[42]

3.1.4 Disadvantages of RFID technology compared to Barcode technology

RFID does not only have benefits compared to barcodes, it also has a number of weaknesses. Some of the most common weaknesses that RFID has compared to barcodes are stated below.

Costs

One of the greatest obstacles with implementing an RFID system is to get an acceptable level of return on investment (ROI) in comparison to a barcode based system.[43] One of the biggest differences between the two technologies is that an RFID tag costs about ten times more than a barcode tag. The price for an RFID tag is however expected to decrease due to economy of scale.[44]

Since RFID is such a relatively new technology the rest of the components in an RFID system are still rather expensive. The biggest cost for an RFID system is not the hardware but the software. These costs exist for barcodes also, but they are not as high. This is due to that barcodes is a common technology and much knowledge in how to implement a barcode system exists

---

[40] Hunt et al. (2007)
[41] Idautomation (2007)
[42] Ibid
[43] Poirier et al. (2006)
[44] Hunt et.al. (2007)

and can therefore be done more cheaply than for an RFID system. This will change in time when more companies have implemented it and more practical knowledge exists.[45]

Interference

Similar to the fact that barcodes can be difficult to read in intense light, RFID systems can be disturbed by interference, especially in environments that contains a lot of different radio frequency transmissions, from for example fork lifters, wireless communication, etc. The readability can also become less accurate if the tagged object contains fluids or metal.[46]

Readability

A big problem with the RFID technology is that sometimes when several tags are read at the same time, all of the tags are not read. This happens for several reasons and there is still much research that has to be made to solve these problems.[47]

[45] Hydblom (2007)
[46] Hunt et al. (2007)
[47] Idautomation (2007)

3.2 Supply Chain Management

A supply chain can be described as a stream of processes that involves the movement of products from the customer order, through the raw materials stage, supply, production, and distribution of products to the customer[48]. This is the most common "line up" for a supply chain but there are companies that do not have all of these parts in their chain, Dell for example does not have a retailer or a distributor in their supply chain. There are also other flows than products that exist in a supply chain, like flows of funds and information throughout the entire supply chain. Figure 3.2 illustrates the different flow paths that occur in a supply chain, it also shows how that the chains in reality act more like a network[49]

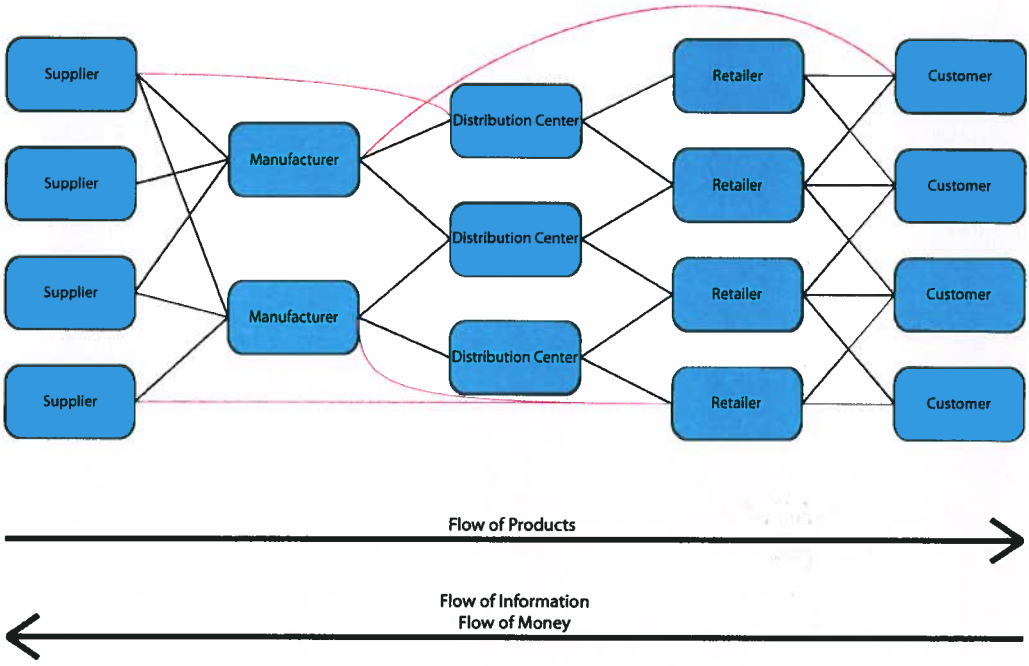

Figure 3.2: The different flows of a supply chain (Modified from source). Source: Chopra et al. (2007)

The supply chain strategy theory was developed with the purpose of shorten the time to market, make quicker fulfillment of orders, and lower costs. It worked fairly well in the early stages, but it was in connection with globalization and the expansion of the information technology that the full potential was shown[50]. Due to the new forms of information technologies, companies can now share information easily between them, which makes a

[48] Rockford consulting (2007)
[49] Chopra et al. (2007)
[50] Major Projects (2007)

supply chain strategy more powerful since it is dependent on information sharing between the affected companies in the supply chain.[51]

The managing of events in a supply chain is called supply chain management (SCM). To accomplish an effective supply chain it is important to be able to coordinate all the different processes as quickly as possible, but without compromising the performance, costs, quality or customer satisfaction. If a supply chain is managed in an effective way, great benefits such as increased visibility, better forecasting and production planning can be achieved.[52] To be able to measure the performance of a supply chain there are several metrics that can be used such as; profit, response time, average product fill rate, and capacity utilization[53]. To be able to reach a higher value of these metrics, it is important to manage the following areas very carefully:[54]

- Demand
- Supply
- Distribution

The purpose of managing demand and supply is to match the demand from the market with the capacity of the company. This task should be fulfilled with the lowest possible inventory levels, fastest possible throughput time, and highest possible capacity utilization. Other goals is to minimize labor hours, maximize the capacity, and not become out-of-stock.[55]

3.2.1 Managing demand

An important process in the supply chain is how companies manage and foresee their future demand. This is especially important if the products that are handled in the supply chain are of the character that reliable forecasts can be made.[56] A more efficient planning and forecasting can help optimizing production, stock management and shipping of products which reduce duties and taxes. It can also enable larger rebates and incentives[57]. Demand management should accomplish an efficient supply chain by reducing the bullwhip effect, make accurate demand forecasts.

---

[51] Schary et.al. (2003)
[52] Rockford consulting(2007); Chopra et al, (2007)
[53] Hunt (2007)
[54] Chopra et al. (2007)
[55] Axsäter (1991)
[56] Chopra et al. (2007)
[57] Techtarget (2007)

Bullwhip effect

The bullwhip effect can be defined as a phenomenon where orders to the supplier tend to have larger variance than sales to the buyer and the distortion propagates upstream in an amplified form.[58] This is illustrated in Figure 3.3 below:

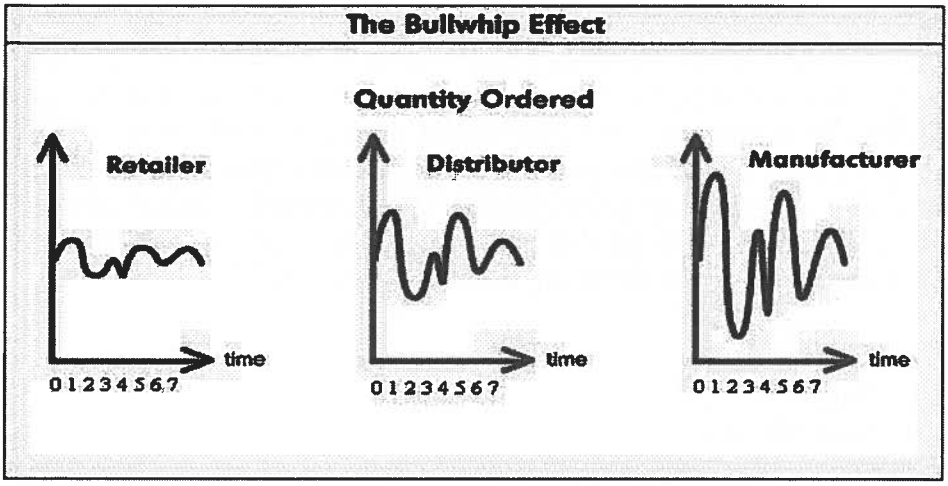

Figure 3.3: The Bullwhip Effect. Source: Trump University (2007)

The bullwhip effect has been observed even in stable markets such as diapers, with orders for raw material highly variable. The complications of a bullwhip effect are; increasing inventory costs, difficulties to organize and plan for future resource requirements, and difficulties to match supply with demand.[59]

There are several origins to the bullwhip effect but the most damaging one is lacking accuracy in demand managing. This weakness is common since the modern supply chain often consists of many different actors. As information moves along the supply chain it is distorted due to the fact that some information is not shared between the different stages in the supply chain i.e. companies or between departments in a company. Also, the information is being delayed as it is processed in all stages.[60] POS-data and information about inventory levels at downstream companies are powerful tools for reducing the bullwhip effect. [61] The sources for bullwhip effect and counter-measures can be shown in Table 3.2 below.

[58] Lee et al. (1997)
[59] Chopra et al. (2007)
[60] Ibid
[61] Lee et al. (1997)

Causes	Contributing factors	Counter-measures
Demand managing	• No visibility of end demand • Multiple forecasts	• Access sell-thru or POS-data • Single control of replenishment
Order batching	• FTL economics • Random or correlated ordering	• Collaboration with other suppliers in the same area • Regular delivery appointment
Shortage game	• Ignorance of supply conditions	• Shared capacity and supply information

Table 3.2: The causes and counter-measures of the bullwhip effect (Modified). Source: Lee et al. (1997)

PUSH – PULL

All processes in a supply chain can be divided into two different categories; push or pull. Pull processes are those that are initiated by a customer order and push processes are driven by demand forecasts. In some companies all processes are pull-oriented and these environments are called make-to-order. In other companies all processes are push oriented and these environments are called make-to-stock. However, most companies and supply chains are divided between these two types of operations. In the boundary of these process categories lies the point of customer order. In these cases it is important to identify and place this point in the supply chain and match demand with supply.[62]

The main advantage with pull processes is that no demand forecasting has to be done in a large scale. In a pull environment, the orders have already been made, i.e. the exact demand is known. A manager in a pull environment knows the exact amount of resources that has to be planned for production, inventory and transportation, since he or she knows the exact demand. Also, inventories can be heavily reduced, decreasing the through put time for the products. On the other hand, the push system has the advantage of a short lead time to customer.[63]

Demand forecasting

The goal of warehouse management is to serve the demand without out-of-stock situations and at the same time keep the costs down. This can sometimes

[62] Chopra et al (2007)
[63] Ibid

be difficult to achieve because of the fact that it is important to keep inventory levels down and at the same time make sure that no out of stock occurs. Another problem is that the lead time is often longer than the time customers are prepared to wait. In these cases the production department must produce against a forecast that estimates the future demand.[64]

Current software applications use mathematical models to predict future demands from historical data. This means that the models and therefore the entire supply system are vulnerable to low quality data and fast shifts in demand. These are the reasons why forecasts always differ from the actual demand[65]. An important thing to keep track of is how they differ, since this determines how large the safety stock has to be[66]. Further, long-term forecasts are usually less accurate than short-term ones[67] Real time Auto-ID information will diminish this problem by a large scale. The quality of the data will increase due to the higher reading accuracy and robustness, and the "freshness" of the data will improve. This means that the models can be optimized so that more accurate forecasts can be made. With this follows a more lean supply chain with smaller inventory levels, which means increased capacity utilization and profit. Also, better forecasting and planning possibilities makes it possible to increase the utilization of existing plants and equipment[68].

A common forecasting method is simple exponential leveling. This method will predict the future demand based on previous forecasts with decreasing weights and historical data of the demand in the previous time period.

$$\hat{a}_t = (1-\alpha)\hat{a}_{t-1} + \alpha x_t$$

Equation 3.1: The simple exponential levelling method. Source: Axsäter (1991)

Where;

$$\hat{x}_{t,t+\tau} = \hat{a}_t \qquad \tau = 1,2,3,\ldots$$

[64] Axsäter (1991)
[65] Chopra et al. (2007)
[66] Axsäter (1991)
[67] Chopra et al. (2007)
[68] Techtarget (2007)

$t =$ the present time period

$\hat{x}_t =$ The forecast for the time period t

$\alpha =$ a constant between 0 and 1. The higher α, the faster will the system respond to changes but it will also be more sensitive to random fluctuations.

$\hat{a}_{t-1} =$ The previous forecast

$x_t =$ The demand in time period t

To measure the performance of a forecasting method across different time series, the method of mean absolute percentage error (MAPE) is one of the most commonly used. The MAPE is defined below for forecasts made for periods 1 to *n* of a single series[69]

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

Equation 3.2: The MAPE method (modified). Source: Science direct (2008)

Where;

$A_t =$ The actual demand in period t

$F_t =$ The forecasted demand in period t

3.2.2 Managing Supply

Supply is managed by using capacity, inventory, subcontracting, and backlogs. Capacity can be increased by, for example, increase the workforce, invest in new equipment, update the old equipment, and so on.[70]

Sourcing in retail

Sourcing in retailing differs from sourcing in other companies. The main objective is to obtain the largest possible net margin in products, generally without adding value or modifying the product. In the logistics view, it is most important to keep the stock in motion so that the working capital is not unnecessary tied up, and that the products do not become obsolete. Also, retailers have a broad assortment, and therefore often many more articles to

[69] Science direct (2008)
[70] Van Weele (2005)

keep track of, than a manufacturer. Information such as orders, prices, quantities, origin, etc. must be kept track of. To manage these tasks, purchasing is centralized by long-term contracts, and ordering is decentralized by the use of call-offs.[71]

An important part of the sourcing process is the actual ordering process, and since the main objective in retailing is selling, ordering is kept as simple as possible. Frequent deliveries are common since retailers generally have limited space for keeping stock. Currently most items are scanned in the cash register and then automatically reduced from the store inventory. When the inventory has reached a level that is set by management, an order is automatically sent to the distribution center. It is the distribution centers responsibility to keep the inventory of the retailer at a certain level.[72]

Invoicing and payment processing

Auto-ID systems can be used to improve the speed of the collections, and debiting and billing an account. Also Auto-ID could be used to create more accurate Advance Shipping Notes (ANS) in the purpose of reducing disagreements and invoice deductions. By providing an electronic ASN in the joint ERP, and thereby getting a quick confirmation, manufacturers can improve their shipping accuracy and reduce their invoice deductions.[73]

3.2.3 Distribution

Distribution can be defined as the process of moving and storing a product from the supplier to the customer. This is done between every step in the supply chain. For example, raw material and components are moved from suppliers to manufacturer and finished products are moved from manufacturers to retailers. Generally for a supply chain, distribution has a relatively high cost in comparison to the manufacturing, about 20 percent. The performance of a distribution system can be hard to measure since different customers have different demands. Common abilities that are interesting for a customer are; response time, product variability, delivery speed, delivery accuracy and return ability. [74]

[71] Van Weele (2005)
[72] Ibid
[73] Poirier et al. (2006)
[74] Chopra et al. (2007)

Inventory planning and warehousing

Tactical decisions in this area focus on the inventory and how much products should be held in stock. If the company has too much in stock then the costs grow and the products are at the risk of becoming obsolete. At the same time, if the inventory level is too low an out-of-stock situation can arise which can prove to be expensive. A factor that has to be taken into account is fluctuations in customer demand and whether the product is a season product, etc. [75]

If more accurate forecasts are reached, the amount of inventory needed can be reduced. The financial result of this is that capital is un tied and the capital cost is decreased. Also, increased inventory turns are reached, which in the end lowers the inventory costs. Further, a faster and leaner supply chain returns the capital faster, which gives management an opportunity to be more versatile in their decisions.[76]

In the process of handling stock, reduced time in verifying and allocating the items will be obtained if RFID is implemented, due to no-line-of-sight and faster reading speed. The middleware in an RFID system can also monitor the inventory levels and alert suppliers when new inventory is needed.[77]

A general problem with matching demand with supply is when the lead time is so long that an order has to be based upon predictions of the future demand. To protect the company from faults in the forecasts of the demand, which can lead to out-of-stock situations, the company must have security inventory.[78] A formula for calculation of the safety inventory level if the error in forecasting is statistically independent is shown below.

$$SI = k \times \sigma \times L^{0.5}$$

Equation 3.3 Calculation of safety inventory level. Source: Axsäter (1997)

Where;

k = a factor that corresponds to the level of service to the customer

σ = the standard deviation in the demand

L = the lead time

To be able to reach the full potential in inventory management it is highly important to have access to information such as; inventory levels, backorders, open orders, the value of the goods in stock, the throughput time, which items that are not moving, etc[79]. If this information is inaccurate the decisions that are based upon this information will also become inaccurate. It is in general

[75] Rockford consulting (2007)
[76] Techtarget (2007)
[77] Hunt et al. (2007)
[78] Axsäter (1991)
[79] Fink et al. (2007)

particularly difficult to keep track of the inventory balance, since the factors that are included here are continuously changed.[80]

There are two different solutions for this problem; either the processes for updating the inventory balance is improved or more warehouses have to be built.[81]

Stock handling

There are several different layouts for a warehouse, each with its strengths and weaknesses. Different kinds of layouts often require different kinds of equipment and routines. This makes the choice of layout type very important.

The simplest stock handling system is the free stacking, which means that the goods are placed directly on the floor and often on top of each other. The greatest advantages with this procedure are that it is cheap, compact, and do not require any advanced equipment. This makes it suitable for bulk products. A variant of free stacking is deep stacking, which means that the goods are placed on the floor on top of each other and in front of each other so that the only goods that are accessible is those in front.[82]

A common stock handling system is pallet rack. This system is characterized by that each pallet can be picked independently from the other goods. This makes it suitable for inventories that handle a great number of articles. The downside is that it requires a lot of space. A variant of pallet racks is deep stacking in pallet racks, which is more space efficient. This is suitable when the goods are not strong enough to carry a loaded pallet on top.[83]

---

[80] Axsäter (1991)
[81] Ibid
[82] TFK (2002)
[83] Ibid

Cost structure in warehousing

A common cost structure for warehouses is shown in figure 3.4.

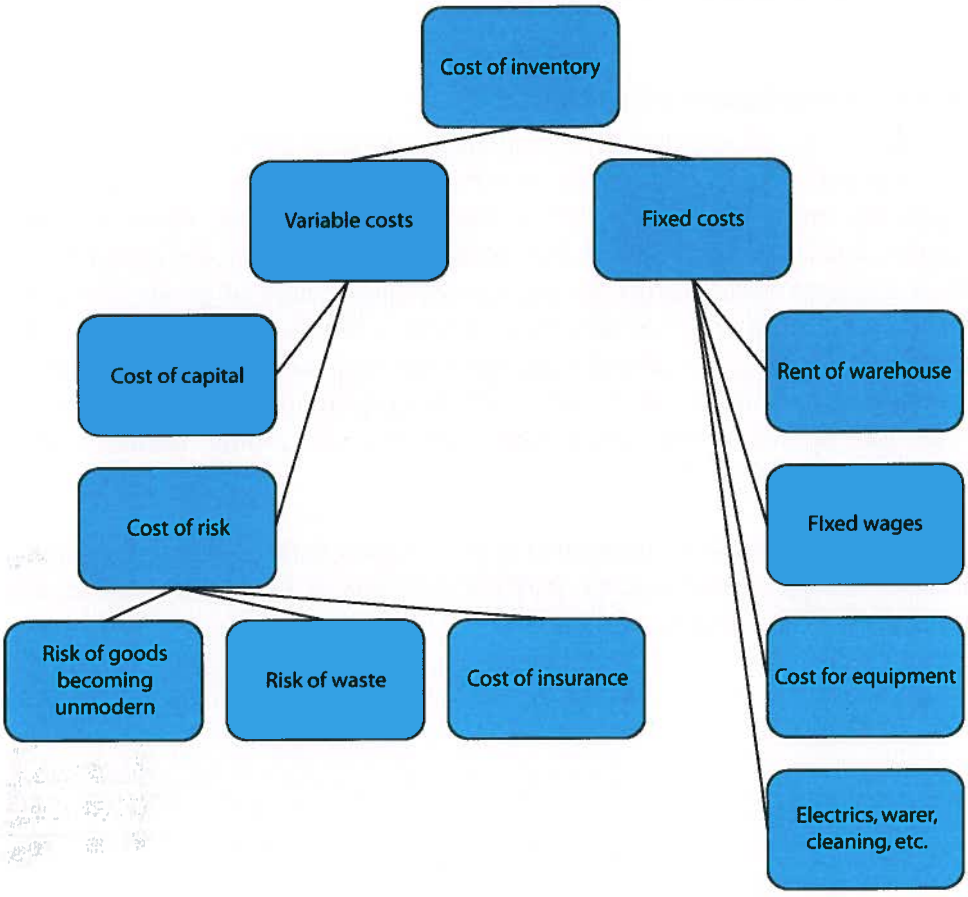

Figure 3.4: The Cost structure in distribution. Source: Aronsson et al (2003)

Other costs in distribution are the costs of[84]:

- Transportation
- Information technology – for example ERP and WMS
- Packing – cartons, wrapping, pallets, etc.
- Administration – receiving, billing, payments, shipping notes, etc.

Systems of handling material

There are two main systems for placement of goods; fixed stock location and random stock location. If fixed stock location is used then every article has a determined space that is reserved in the warehouse. Random stock location

[84] Aronsson et al. (2003)

means that goods can be placed wherever in the entire warehouse. The advantage of random stock location is that it requires less space. The downside is that it must be supported by a system that registers the location, articles and preferably also the number of unit loads.[85]

Warehouse management system

A clear definition of warehouse management systems (WMS) is difficult to state in general terms since these systems tend to expand their areas of responsibility in a rapid pace. This has resulted in that these systems boundaries have become a bit fluent. However, a common definition is; A WMS is a system that controls the movement and storage of goods. Directed replenishment and picking are key functions in a WMS. To manage this, the WMS must have access to information about location, article, quantity, unit of measurements, and order information. All this information can be supported by Auto-ID. A WMS will most likely provide increasing accuracy and reductions in labor costs.[86]

Another process that can be automated is the creation and handling of shipping documents. This provided that the RFID technology is fully integrated in the WMS, ERP and other business systems.[87]

[85] Aronsson et al. (2003)
[86] Inventoryops (2008)
[87] Poirier et al. (2006)

4. EMPIRICAL DATA

The Empirical chapter begins with an introduction of the supply chain as a whole and its components. Then it continues with a more profound description of the different elements in the supply chain.

4.1 Introduction to the studied supply chain

The Supply Chain that will be studied in this thesis consists of five different companies and these are; SCA Packaging, Sigurd Anderssons Hauler AB, SCA Personal Care AB and ICA AB and ICA MAXI Västra Hamnen AB. Some of these companies are spread internationally and have a lot of factories and offices over the world, although not all of them will be studied in this thesis. The studied supply chain will consist of; SCA Packaging's factory in Värnamo (SCA-P), Sigurd Anderssons Haulers warehouse in Falkenberg (S.A.), SCA Personal Cares factory in Falkenberg (P.C.), ICA's Distribution Center in Helsingborg (D.C.), and ICA MAXI Västra Hamnen in Malmö (Maxi). When for example SCA-P is mentioned it refers to SCA Packaging's factory in Värnamo and when SCA Packaging is mentioned it refers to the company as a whole. Figure 4.1 illustrates the supply chain and how a package travels through the supply chain. It also states which scanning procedures occurs in the supply chain. More details about these scanning procedures are presented in the different chapters below.

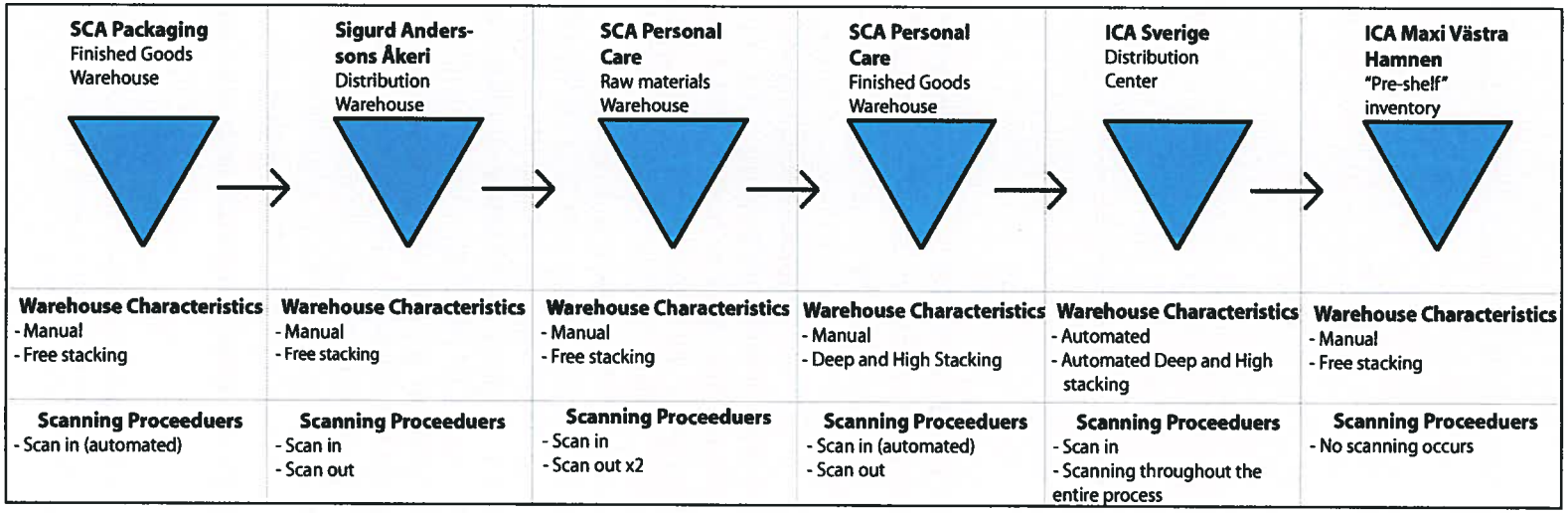

Figure 4.1 The studied supply chain with the scanning activities.

4.1.1 Presentation of SCA

The company as a whole is divided into four different business areas; Personal Care, Tissue, SCA Packaging and Forest Products, which together stood for a total turnover of 11.4 billion Euros in 2007. SCA has about 50 000 employees in some 50 countries all over the world. SCA's main markets are Europe and North America. [88]

4.1.2 Presentation of ICA

The ICA group is one of the leading retailers in northern Europe and includes about 2 300 stores in Sweden, Norway and the Baltic nations. In 2006 the turnover was some 67 billion SEK and the company employed 11 700 people.[89]

All ICA supermarkets and stores are owned and managed by private entrepreneurs. The owners make all of the decisions concerning questions like, product range in the store, pricing, and also from which suppliers they should buy. The store owners must however sell products according to ICAs´ guide lines.[90]

4.2 SCA Packaging

SCA Packaging is a part of the SCA group and they produce packages for; transport, consumer, protective, display and promotional, industrial, temperature controlled and heavy duty uses. The production of the packages is carried out in more than 300 plants in about 30 countries. Sales are conducted in some 50 countries in Europe and Asia. SCA Packaging has 24 100 employees and their net sales for 2006 was 3.664 billion euros. [91]

The studied factory produces packages of corrugated cardboard. The factory was extended in 2005 and is now one of the most advanced corrugated cardboard plants in Europe.[92]

4.2.1 Finished Goods Warehouse

SCA-P's finished goods warehouse (FGW) has a capacity of about 3 000[93] pallets, and about 800[94] pallets are handled every day. It is a free stacking

---

[88] SCA (2008a)
[89] ICA (2006)
[90] Sjulander (2008d)
[91] SCA Packaging (2008)
[92] Johansson (2007)

warehouse which is manually controlled. All of the goods in the warehouse should be delivered as soon as possible, except for one particular customer, where SCA-P keeps goods in stock for them. SCA-P has about [redacted] pallets in stock in the FGW for this company.[95]

SCA-P produces and delivers packages according to the "make-to-order" theory. This has the effect that they do not need a safety stock for their customers. Also, the factory has the strategy of not having inventory of finished goods longer than absolute necessary. This means that their FGW in many senses is functioning more as a distribution buffer than a traditional FGW.[96]

To make sure that the actual inventory levels correspond to the levels that the inventory system states, is a manual stock-taking performed every year. The stock taking is done by four forklift drivers and it takes about three hours.[97] It is important that the inventory levels are correct because one pallet of packages almost correspond to one fully loaded lorry from P.C.[98]

Incoming goods

In the FGW there are problems with the space capacity. The production planning in the factory naturally has a main focus on the production capacity of the corrugated cardboard machines and not on the warehouse capacity. A problem with this can be when the production for the actual week is completed early. Then the production department starts to produce what is planned for the week to come. The problem with this is that the FGW does not have the capacity to store all of this in a way that makes the handling in the warehouse efficient.[99]

A problem with the procedures used in the warehouse and the production strategy, is that to be able to store everything that comes into the warehouse the workers have to put pallets in all of the available gaps when pallets arrive to the FGW. This means that the pallets of a certain batch are not always placed in the same area. Then when a lorry driver comes to collect the pallets for delivery, the warehouse workers does not know where the pallets are. They could be in the middle of a row which makes them hard to find and this also

---

[93] Svensson (2008)
[94] Johansson (2007)
[95] Svensson (2008)
[96] Johansson (2007)
[97] Carlsson (2008a)
[98] Johansson (2007)
[99] Svensson (2008)

means that other pallets have to be relocated when the pallet is to be delivered.[100]

Distribution

SCA-P has outsourced all of their transportation and transportation planning to Green Cargo. About 3 600[101] pallets are shipped out of the FGW in total every week. Green Cargo has access to all of the relevant data systems so they can make the transportation plans as optimal as possible.[102]

When a delivery is due the warehouse workers follow work-cards that contain information about the order that is to be delivered. These work-cards contain information about, which customer that has placed the order, which articles that are to be delivered, the amount of pallets of every article, the measurement of the pallets, the weight of every article type and the number of packages of every article, etc.[103]

The loading of the lorries is done by both the warehouse staff and the lorry drivers. Usually the warehouse workers find the pallets in the warehouse and drive them to the loading area where the lorry driver loads them into the lorry. Lorry drivers that have a lot of deliveries from SCA-P and know the routines can get a forklift themselves and search for the pallets in the warehouse.[104]

Another problem in the FGW is that there are too many people in motion and they all compete for the same space. Lorry drivers that helps out with the loading and finding the pallets take up space, the workers in the warehouse does the same and then there are people there that do not work in the warehouse, but have to check something or talk to someone.[105]

The process of finding the right pallets in the FGW can take a lot of time because of the problems with were the pallets are located in the FGW. If a pallet can not be found and the delivery is not of great emergency it is often replaced with something else that is to be delivered to that customer or they do not replace the pallet at all.[106]

When the pallets of a shipment have been located and the pallets are loaded onto the lorry no scanning is performed. The last thing that is done for a

---

[100] Svensson (2008)
[101] Hansson (2008a)
[102] Johansson (2008a)
[103] Svensson (2008)
[104] Svensson (2008)
[105] Svensson (2008)
[106] Svensson (2008)

shipment is that the warehouse workers make freight bills to the lorry drivers. To create these the workers can either scan in a barcode on the work-cards or manually type in a serial number of that specific work card. The scanning or typing calls the system for information about that specific work card, this information is already in the system from when the work-cards were created and printed. When the information have been gathered from the system and brought up on the computer screen a warehouse worker checks that the information on the screen corresponds to what was actually loaded onto the lorry. If changes have to be made for example, some pallets where not found in the warehouse or that not as many pallets as planned could be loaded onto the lorry for some reason, then the warehouse worker modifies the data in the system. The worker also writes into the system what reference number the, lorry which the goods were loaded into has, and if the delivery was part of an order or if it was the last of that order. When the information has been verified by the worker he or she sends the information back into the system and the inventory levels is decreased and at the same time the freight bills are printed. If the shipment is going to S.A. the worker sends a copy of the freight bill to S.A. so that they know that a lorry is on its way and what it contains.[107]

Shipment error

Faults in the distribution process occur, although they are not common. Most of the time they emerges due to human errors, for example, there can be a miss-count or that one pallet is of the wrong article type, etc. When a mistake has occurred it is usually discovered by the customer, who then makes a complaint to SCA-P. It can also be discovered when SCA-P does its annual stock taking.[108]

4.2.2 Managing Demand

SCA-P receives information about the demand that P.C. has, from a system that is called SMART which stands for "Supply Management Replenishment Tool"[109]. It is a system that is developed to bring benefits between companies that have certain characteristics such as; one of the companies keeps a lot of products in stock for the other part and if there is a high delivery frequency between them. The benefits that can be reached is; decreasing the inventory levels, reducing the lead time between the companies, increasing the security of deliveries, reducing the administrative work and gaining better control of

[107] Svensson (2008)
[108] Johansson (2008a)
[109] Hansson (2008b)

the processes involved as a whole. The system is used by SCA Packaging Europe and SCA Personal Care.[110]

The information flow within the SMART system is as follows; P.C. sends their inventory status and demand for the upcoming ten weeks[111] in a file to SCA-P. This file is sent on a daily basis. When SCA-P receives this file they begin to plan their production towards P.C. for the upcoming three weeks. The rest of the data is only used to see if there are any product changes coming. About 80%[112] of the articles have a modification over a year. When SCA-P does their planning they check what P.C. has in stock and also that S.A. have the packages, which are to be delivered for the upcoming 72[113] hours, in stock. This is the time frame during which SCA-P have to be able to supply P.C. with packages. The purpose of this is that P.C. can have a certain degree of flexibility in their manufacturing. When SCA-P has made their planning, a confirmation file is sent to P.C.[114]

Variation of Demand

The variation of demand concerning packages to P.C. depends on the demand of diapers. This demand is relatively stable on an overall level, though there are certain brands which have a larger amount of variation.[115]

SCA-P states that they do not feel any great changes in the demand from P.C. if, for example, ICA does a campaign that covers all of Sweden. This is due to that they work with the files from SMART, where they can see information about the demand from P.C. over the upcoming weeks.[116]

All pallets that SCA-P manufacturers P.C. have to buy. This however does not ensure that P.C. always has a need for all of these packages. P.C. can for example get sudden changes from their customers and will therefore not produce the entire planned order. In 2007, about [redacted] pallets[117] of packages was terminated due to that P.C. did not need them. SCA-P tries to reduce the number of packages that will not be used in the S.A. warehouse so that inventory space can be used better. If some packages have been in stock at

[110] Johansson (2008a)
[111] Franvin (2008b)
[112] Johansson (2007)
[113] Ibid
[114] Strand (2007)
[115] Johansson (2007)
[116] Ibid
[117] Andréasson (2008)

S.A. for a long period of time, SCA-P sends a notice to P.C. and asks them what their intentions are with the packages.[118]

Traceability

SCA-P places an SSCC barcode on every pallet that they deliver, and with this number Packaging have managed to achieve a great level of traceability for their products. If one of their packages is damaged or if it does not meet the specifications that the customer has ordered, this number can be used to track the exact origin of that product, in order to identify the problem and correct it.[119]

[118] Johansson (2008a)
[119] Franvin (2007)

4.3 Sigurd Anderssons Hauler

Sigurd Anderssons Hauler is a hauler company that also keeps goods in stock for customers, in fact most of the goods that this company have in stock are pallets from SCA-P that is to be delivered to P.C. The warehouse (S.A.) is run by two workers, one warehouse worker and one worker that drive the pallets between S.A. and P.C. This is not the only thing the driver does, he also has other assignments. There is also a third worker that works half time and this worker helps out when somebody is sick or when one of the other two has vacation. This third worker also helps out with other duties in the company.[120]

The S.A. warehouse has recently been implemented with a barcode system that uses hand held scanners.[121] The implementation is because of the SMART system that SCA-P and P.C. uses. Since S.A. handles all of the goods between them, they had to be integrated into the system.[122] The scanning system is used in the receiving and shipping processes, and it is appreciated by the warehouse worker since it informs him if he has taken the wrong article or quantity. However, the warehouse does not have a WMS that identifies the location of the different articles.[123]

The warehouse used for SCA-P's products have a maximum capacity of about 3 900 pallets[124]. The inventory levels in the warehouse usually lies around 2 000 pallets[125], which corresponds to about 14 days of production for P.C. The inventory levels are kept track of by the SMART system, but two times per year a physical stock taking is done. This is to see how the SMART system works and to rectify the inventory levels if diffrences have occurred due to some fault in the system or if a pallet was not scanned when arrived etc. The stock taking is performed by two employees from SCA-P and it takes them between 3 – 4 hours to complete.[126] This combined with the travelling time from Värnamo to Falkenberg the time to take stock in S.A. is equal to one work day.[127]

---

[120] Andréasson (2008)
[121] Ibid
[122] Johansson (2007)
[123] Holm (2008a)
[124] Obeservation from study visit
[125] Holm (2008a)
[126] Andréasson (2008)
[127] Ibid

4.3.1 Receiving

In an average week S.A. receives about 800[128] pallets from SCA-P. Before a new shipment of pallets has arrived, the warehouse worker recives a freight bill through the fax. When the shipment notice is received, storage space is prepared for the arriving pallets. The process begins with that the worker checks which articles are coming and if there are any of these already in stock. Then the worker prepares room for where the coming goods should be placed, all of which is done manually. If an article that is to arrive already exist in the warehause, are the rows with these articles filled up first to save room. [129]

When a lorry arrives from SCA-P the pallets are unloaded and then scanned. When the pallets are scanned they go from "in transportation" into S.A.'s inventory in the SMART system. This is also an confirmation for SCA-P that the packages have been sucessfully transported.[130]

4.3.2 Shipping

When SCA-P has recieved an order from P.C. and processed it, SCA-P calls the warehouse worker at S.A. to inform that the call-off is ready to be printed. These call-off lists contain information about the pallets that are to be delivered the next day. When the warehouse worker has received the file he begins to plan how the pallets should be delivered to P.C. in order to optimize the usage of space in the lorry.

When the planning is done the worker starts to gather pallets and place them in a certain area in the warehouse. The pallets are placed according to which article they contain and in what delivery they are going to be. There are about 20 shipments to P.C. every week, which is about 800 pallets[131]. When the warehouse worker has completed the gathering of one shipment he scans out the pallets and marks them with information about; that they are scanned, which day they are to be delivered and which shipment they belong to that day.[132] The scanning of these pallets should not be done until late in the afternoon so that P.C. can be flexibe and be able to handle late changes in their production schedule. The worker does not follow this to the degree that the agreement between SCA-P and S.A. states. The pallets are prepared and scanned as soon as the worker has time to do it. This do not cause problems very often, but when it does, extra shipments has to be done and P.C. has to

---

[128] Hansson(2008a)
[129] Holm (2008b)
[130] Johansson (2007)
[131] Andréasson (2008)
[132] Holm (2008a)

recive pallets they do not need at that moment.[133] The reason that P.C. has to recieve the pallets once they are scanned is that when the pallets are scanned a shipment notice is sent to P.C., and a notice is also sent to SCA-P, that then invoices P.C. for the pallets.[134] The information in the shipment notice that goes to P.C. states how many packages of each of the articles that is to be delivered in that specific delivery.[135]

[133] Johansson (2008b)
[134] Ibid
[135] Franvin (2007)

4.4 SCA Personal Care

SCA Personal Care is also part of the SCA group. They manufacture diapers for babies, incontinence care and feminine care[136]. They are world leading in the incontinence fragment but they are also one of the top manufacturers in the world of baby diapers and feminine care.[137]

The factory that is studied in this thesis is located in Falkenberg, Sweden and it produces diapers for babies and incontinence care. There are seven production lines that produce baby diapers and two that produce incontinence diapers. The factory currently produces 140 different articles, but this number varies. Of these articles it is not only SCA's own brands that are produced, but also diapers for "regular" customers such as ICA, which have their own brand of diapers. The factory has a capacity of producing 1.5 billion baby diapers and 300 million incontinence diapers per year.[138]

Last year P.C. began to do upgrades on all of their machines, which resulted in that P.C. has to increase their inventory levels of finished goods. This is done so that they will be able to handle the demand while the machines are being upgraded.[139] The effect of this has been that P.C. now has five external warehouses for finished goods, normally there is only one.[140] The upgrading process will be completed sometime in 2009, if all goes to plan, and then the inventory levels can be decreased again.[141]

4.4.1 Raw Material Warehouse

The raw material warehouse (RMW) is a manually controlled warehouse and the incoming number of lorries is about 120[142] per week. About 20[143] of these are from SCA-P which S.A. delivers. The warehouse is divided into two sections, one for Baby and one for Incontinence. These sections combined can store about 2 300 pallets[144] of material. In the warehouse there are both free stacking areas and pallet rack areas. The packages are placed in the free stacking areas.[145]

---

[136] SCA (2008b)
[137] Franvin (2007)
[138] Ibid
[139] Franvin (2008a)
[140] Lundin (2008c)
[141] Franvin (2008a)
[142] Franvin (2008a)
[143] Ibid
[144] Ibid
[145] Ibid

The free stacking areas in which the pallets stand take up a relatively small part of the inventory. The pallets that are in the RMW are to go into production the day after they have arrived. So the space that is needed for the pallets with packages on is dependent on the production planning. When a lot of different articles are to be produced, more rows are needed than if only one is to be produced.[146]

In- and Out-coming Goods

When SCA-P pallets arrive from S.A. to P.C., a RMW worker takes one of the pallets serial numbers and types it into the computer system for the RMW.[147] All pallets in that shipment are then automatically put into the warehouse, and the different articles are placed in the section where they are to be placed.[148] So in the system the pallets of goods are in their section before the forklift driver has been able to place them there.[149] The forklifts have on-board computers which give the drivers the possibility to see if an article that has arrived is already in stock. If it is, the driver can find the existing ones and place the newly arrived pallets there, so all pallets of one article are in the same area.[150] The system does not however tell the driver where in the Incontinence or Baby section the pallets should stand, just in which of the two.[151]

When the lorry from S.A. has arrived the lorry driver unloads it and sorts out all of the pallets into rows based upon which article the pallets contain. This means that the forklift drivers only have to look on one pallet in each row to know which article it contains. Then the driver can place the pallets in the correct section and row. Sometimes the lorry driver misplaces one pallet in the sorting process, which the forklift drivers do not notice.[152]

If a pallet is misplaced in the RMW it is not a serious problem, because when a forklift driver is to gather the pallet and drive it to the production area, the worker scans the pallet that is taken out of the RMW. If it is the wrong pallet that is scanned, the scanner informs the worker of this. The pallet is then scanned again when it arrive at the machine, where it will be used in the production. In this scanning procedure, the machine is also scanned to confirm that the pallet has arrived at its destination.[153]

---

[146] Franvin (2008a)
[147] Johansson (2008c)
[148] Ibid
[149] Franvin (2008a)
[150] Johansson (2008c)
[151] Franvin (2008a)
[152] Johansson (2008c)
[153] Johansson (2008c)

When a pallet is scanned out of the RMW, is it still in the RMW system-wise. The pallet goes out from the RMW once the pallet and the machine are scanned together, then the pallet goes into a "production stock". At the end of every labor shift the actual produced amount is decreased from the "production stock".[154]

4.4.2 Finished Goods Warehouse

P.C. is not only a manufacturing plant, it also acts as a distribution center for the Nordic region for SCA Personal Care. So in excess of all the products that P.C. produce themselves, they also handle an additional [redacted] pallets.[155] P.C. does not order these pallets, the monitoring of inventory levels and the refilling of the inventory is the job of the factory that produces that specific product. When the factories send their goods to P.C. they also inform P.C. that a delivery is due. When the goods are delivered no scanning occurs. The factory that has manufactured the products has created a file in SCA Personal Cares internal computer system with the delivery. In this file it is written which articles that are delivered, the quantity, etc. Upon arrival, P.C. only have to handle the pallets and mark the delivery as arrived in the system, which then takes care of increasing the inventory levels.[156]

Today P.C. has several storages for finished goods, about fifty percent of the goods are stored in the warehouse that is "in-house", and the rest of the stock is kept in external warehouses.[157] The "in-house" warehouse is a deep and high stacking warehouse. It has room for [redacted][158] pallets and it has 600 rows where [redacted][159] different articles are stored. The warehouse is manually controlled there is only one article in each row. The minimal batch that is manufactured by P.C. is 250 000 diapers, which is about 170 pallets, which is equal to 3.5 rows that can contain 48 pallets each.[160]

The total stock capacity that P.C. has in the beginning of 2008 is [redacted] pallets[161], in the normal situation, with only the one external warehouse, P.C. has a capacity of keeping about [redacted] pallets[162] in stock. These values are theoretical, since there is only one article type in each row so the warehouse is

---

[154] Franvin (2008b)
[155] Franvin (2007)
[156] Lundin (2008c)
[157] Ibid
[158] Ibid
[159] Lundin (2008f)
[160] Franvin (2008a)
[161] Lundin (2008f)
[162] Lundin (2008e)

never full in reality. An estimation of the utilization of the pallets space is [redacted] percent[163].[164]

Distribution

The planning for deliveries out of the FGW is done by a transportation planner, and it begins with that a list of deliveries for the present and upcoming day is printed out. Then the planner calculates how many of each article that is to be delivered in these two days. The planner also checks what measurements in height the pallets that are to be delivered should have. In the FGW there are namely two types of pallets, full height and half height pallets, and the inventory system does not register how many of each kind of pallet that exists in stock. The inventory system only keeps track of the number of packages of every article type that is in the FGW. When the planning is completed, forklift drivers receive a list of which article types that have to be investigated, whether or not there are enough of the different pallet types for the upcoming deliveries. This planning and investigation search is performed twice every day. [165]

When a lorry has arrived for picking up a delivery out of P.C., the lorry driver reports the arrival of the lorry to a receptionist. When the lorry driver has registered him or herself, the order that is to be delivered is printed out. This paper contains information of which articles and quantities that is to be loaded onto the lorry. This paper is then placed in a bin where the forklift drivers can gather it and use it as a picking list. When the forklift driver has picked up the list he or she starts to look for the pallets. The lorry driver does not park at the loading dock until most of the pallets that are to be loaded onto the lorry are found and brought to the loading gate.[166] When the lorry is parked at the loading dock the lorry driver starts to load the lorry with the pallets.[167]

When the pallets are on the lorry the driver needs to get a freight bill from P.C. This is created by one of four different employees that handle the creation of freight bills, decreasing the inventory levels etc. The work of creating freight bills and decreasing and increasing the inventory levels can be estimated to be [redacted] which costs [redacted] SEK per year. The inventory level is always decreased after the pallets have been loaded onto the lorry. [168]

---

[163] Engström (2008)
[164] Lundin (2008c)
[165] Ibid
[166] Lundin (2008e)
[167] Lundin (2008c)
[168] Lundin (2008c)

Error in shipment

If a fault in the shipping process has occurred for example that P.C. has sent the wrong products to ICA, there are different scenarios that can happen. If ICA sells this product they buy it anyway, and P.C. will have to send the correct product with an extra shipment or with the next shipment depending on when it is. If ICA does not sell the product it is sent back to P.C., who pays for the transport and then the correct pallet has to be sent extra or with the next shipment. P.C. also has to change two bills due to every complaint. If ICA gets an out-of-stock situation due to the miss-shipment, they can give P.C. a fine. If something is wrong with the pallets or the products in the pallets, ICA sends it back to P.C., who examines the error and sends a replacement to ICA with the same procedure as described above.[169]

Pick pallets

Most of the deliveries out of P.C. consist of pallets that only contain one article, but P.C. also delivers pallets that contain more than one article. These are called pick pallets and they are custom made.[170] These pallets are created in a special area in the FGW, where pallets of different articles stand opened so that the pick pallets can be easily created. The pallets are created by forklift drivers and there can be up to fifteen[171] different articles on such a pallet. These pallets are only created when a delivery of one is due.[172]

When a forklift driver creates a pick pallet the process begins with locating and gathering all of the different articles that should be on the pallet. If a "stock pallet" is emptied and more is needed or if a pallet with a certain article is not in the pick pallet area, the driver has to go out to the regular FGW and look for a new pallet.[173] The inventory level of the pick pallet area is not separated from the rest of the FGW, so when packages are taken from pallets in the inventory, the levels in the FGW is decreased by that number of packages.[174]

4.4.3 Managing Demand

When new orders arrive to SCA Personal Care, they are received and handled by their different sale departments. In this process the sales managers look at the inventory levels in the FGW and what lies in production in the close

---

[169] Franvin (2008a)
[170] Lundin (2008a)
[171] Lundin (2008e)
[172] Lundin (2008c)
[173] Lundin (2008c)
[174] Lundin (2008c)

future, to see if in this case P.C. can handle the order. If they can, the goods are marked as booked, but still in stock in P.C.s inventory system. This means that no orders are laid if they cannot be delivered by P.C.[175]

Since the production of P.C. is a push process the demand must be forecasted before the customer can place its orders. This long-term forecasting, on which production is based is made centrally at SCA Personal Care in Gothenburg. SCA Personal Care has a Key Account Manager for every customer.[176] Part of the Key Account Managers job is to create forecasts for future demand together with assistants and Product Managers. To create the forecasts, historic sales data based upon deliveries out from the factories, are used. The forecasting procedure can be divided into two parts; the stable demand and the highly variable demand. The later is due to certain events, for example if the product is new on the market or if it has been promoted in a commercial of some sort. The stable part of the demand forecasting is mainly based upon historical data and the other part of the demand forecasting is made manually. The reason that this must be done manually is that reliable, accurate data for how the specific situation affects the demand, does not exist. The demand can be influenced by factors such as; what the competitors are doing, the current season, the magnitude of the campaign, which it is presented in, etc.[177]

The making of the manual forecasts begins with that the Product Manager sees if there are any campaigns or product introductions. Then the Product Manager studies historical data from similar activities. If this data is, for example, from another season, this is compensated by a factor that is determined based on experience. The same procedure is made by the Key Account Manager. In this process a lot of manual judgments are made and not so many calculations based on data.[178]

All forecasts are delivered to the Customer Service department. The numbers are registered and filed in the SAP system per article and week. The forecasts are made on a 15 month basis but they are changed continually except for the 6 weeks closest to the present. The reason for this is that the production is planned based on these forecasts. When the production planners do their planning for the production they only have to enter the SAP and extract the information.[179]

The forecasts is the foundation of the production planning that P.C. has and thereby it is also the foundation for when it is decided what is to be ordered

[175] Ibid
[176] Karhunen (2008b)
[177] Bona (2008)
[178] Ibid
[179] Karhunen (2008b)

from their suppliers. Due to this the forecasting has an affect on the stock keeping in the RMW and S.A.[180]

If the forecasts are lower than the actual demand, it can result in that P.C. risk to run out of goods in the FGW. If this happens, the production is forced to rearrange the production plan to produce this article earlier than planned. The consequence is inefficient production sequences, longer tripod time, and problems with deliveries from suppliers with long lead time. The long term problems are that inventory levels increase in both the RMW and the FGW at P.C. to avoid these problems.[181]

If the forecasts are higher than the demand a risk for expensive scrapping in both the RMW and in the FGW is prominent. This is due to that the products become obsolete if they are exchanged by a new article. If the FGW still has a high volume of an old article, that is to be replaced by a new article using an introduction campaign, the campaign can be put on hold for a certain period of time until the old article is sold out.[182]

The accuracy of the forecasts is measured by MAPE, and for 61 weeks, from week one in 2007, this index was 24,7[183] percent on all products that P.C. produces for the customers located in Sweden.

[180] Bergenheim (2008)
[181] Ibid
[182] Ibid
[183] Karhunen (2008a)

4.5 ICA Distribution Center

An ICA supermarket procures most of its goods from ICA centrally.[184] This is done so that larger quantities can be bought from a supplier, and therein enabling lower prices, and better terms from the suppliers. To manage this, ICA has placed distribution centers that cover different market regions.[185]

ICA's distribution center in Helsingborg Sweden is one of the most advanced and automated in Europe for the general dealer industry. ICA decided to build the warehouse in 2003 and it was completed in October 2006. The information system used in the D.C. is supported by barcodes. The D.C. handles a total of about 4 700[186] different articles and these are the most common articles that are sold by the ICA supermarkets. The D.C. supplies goods for all supermarkets in Sweden located south of Örebro.[187]

4.5.1 The Colonial Warehouse

ICA has four different product categories; colonial, frozen, fruit and vegetables, and perishables. The D.C. is divided into these four categories and the product studied in this thesis goes under the colonial category and therefore it is this section of the D.C. that will be studied. In the colonial section about 1 800[188] different articles are handled. The rest of the articles that belong to the colonial segment are stored in Västerås in ICA's main warehouse. The colonial warehouse is further divided into two sections, one automated part and one manual part. About 80% of the goods are handled in the automated part. The manual section exists due to that not all products can be handled in the automated part. In the automated part there are restrictions of the boxes and the quality of the packages. These restrictions exist due to the design of the automated equipment.[189]

Receiving goods

ICA has certain demands that their suppliers have to comply with. One of these demands is that the deliveries are to arrive at the D.C. in a pre-determined time frame.[190] Further, the delivery should contain the correct goods and only these goods. It should be the right amount of goods that

---

[184] Stockenberg (2008)
[185] Landenberg (2008a)
[186] Rösler (2008)
[187] Sjulander (2008b)
[188] Rösler (2008)
[189] Sjulander (2008b)
[190] Landenberg (2008a)

arrives, the pallets should be of a certain quality, and the suppliers have to label and mark the pallets in a predetermined way, defined by ICA. If these demands are not met, penalties will be given, an example of such a penalty can be that a fine is given to the supplier.[191]

When a lorry arrives to the D.C., a forklift driver unloads the lorry and places the pallets on a conveyer system. Here the pallets are scanned automatically as they are transported towards the warehouse. On every pallet there are two barcodes that are scanned in the first stage. On these barcodes the inventory system gets information about; which article is on the pallet, which production batch it is from the supplier, the date when it is produced, and if necessary, a best before date, which order it belongs to, and an individual number which helps to keep track of that specific pallet.[192]

[redacted]

The barcodes on the pallets should be placed in a certain way by the supplier so that the scanners will be able to read them no matter how the pallet is placed on the conveyor, this requires that the suppliers put on an extra copy of barcodes on the pallet. [redacted]

[redacted]

[191] Landenberg (2008a)
[192] Sjulander (2008b)
[193] Landenberg (2008a)
[194] Sjulander (2008b)
[195] Landenberg (2008a)

Handling in the automated section

[196] Sjulander (2008b)
[197] Ibid
[198] Ibid

Handling in the non automated section

The non automated part of the colonial warehouse consists of pallet racks. This section contains goods that cannot be handled in the automated section. The section works as any other regular warehouse. It is implemented with a barcode based WMS which tells the workers where the pallet that contains the package type that is to be collected is located. All of the pallets, and their positions, are scanned when they arrive to the section. When a package is collected from a pallet, the position of that pallet and the load-carrier is scanned, and thereby the system knows that one package of that specific type, has been taken from that pallet.[200]

4.5.2 Managing demand

ICA's distribution centers get most of their orders from the supermarkets via an internal computer system called AOB (AutoOrderButik)[201]. When the orders arrive they go into the D.C.s computer system which checks that the goods can be delivered and when the delivery will be. When an order is to be delivered, the order is sent to the warehouse system for assembling. After the order is assembled it is sent for shipping out of the D.C. [202]

When ICA estimates their upcoming demand from a certain supplier, they only make smaller forecasts of what will be needed until they receive goods for the next upcoming order. These forecasts are based upon sales in the stores the past week, how many orders that have arrived from the supermarkets since the last order point, the variations of sales in the past 28 days and their inventory levels, including the safety stock. ICA gets sales information every night at 02:00 for all of the stores that the D.C. supplies. Also other factors are considered when they make these forecasts, such as, if there are any campaigns that the order should cover. If this is the case, then ICA has a department that analyzes how this campaign will affect the order and then change the order amount to what it should be with the campaign. They also have a person that monitors the order amounts of all the outgoing orders so that they are correct. If this person finds a flaw in the order amount or anything else, he or she changes the amount to a more likely amount. This new

[199] Sjulander (2008b)
[200] Ibid
[201] Sjulander (2008c)
[202] Landenberg (2008a)

amount is set by the worker and based upon the experience this worker has of controlling orders.[203]

4.6 ICA Maxi Västra Hamnen

Maxi is a supermarket that has been open for business about 2.5 years, and their sales are still increasing with a regular pace since the opening. The supermarket is a typical, large ICA store.[204]

4.6.1. Pre-shelf Inventory

When Maxi receives goods from D.C., a count of the containers delivered is performed. Spot checks on the contents of the containers are also performed but there is almost never anything wrong with the contents, since the distribution processes at D.C. is so advanced. When the goods have been loaded out of the lorry they are directly put into the pre-shelf inventory. No other manually performed activities occur. The payment process is performed automatically by an internal computer system that ICA has, and this is done when the lorry leaves the D.C.[205]

In the pre-shelf inventory are goods that are to be placed upon shelves in the store within a few days stored. The inventory has very limited amount of space and it consists of a combination of pallet racks and free stacking. Both of these are needed since Maxi receives both pallets and rolling containers from the D.C. The layout in the inventory is that the walls are covered with pallet racks and in front of these racks are the containers placed on the floor.

Inside of the inventory, there is a system where the products should be divided by which kind of article type they belong to, but this is not followed. This segmentation is much more detailed than the one in the D.C. The problem with this system is that it does not, and can not, work as planned, due to that there are too much goods stored and handled in the inventory. Another aspect is that the goods that arrive in roll containers from the D.C. are placed and sorted into the containers with concern to optimize the space usage of the containers, and not by which article category they belong to. The sorting of the products are instead made when the products are put up on the shelves in the store. This filling of the shelves takes place two times per week, in the morning before the customers arrive, and it works perfectly well.[206]

---

[203] Landenberg (2008a)
[204] Stockenberg (2008)
[205] Ibid
[206] Stockenberg (2008)

4.6.2 Managing Demand

Maxi has a computer system that keeps track of which, when and how many articles are sold. When an article is scanned at the register, a signal goes into the system and states that one item of that article type has been sold. The system then decreases the inventory with one of these articles, but then it also sends a signal to a purchasing system. This system takes care of all of Maxis daily ordering from D.C. The only manual ordering that is performed is if another supplier is chosen or if a special event is due. When an article is sold, the purchasing system increases the need for this article by one. When the number of articles sold comes up to the level of one secondary package of this article, the system increases the order that is going to the D.C., by one. The D.C. has a minimum of one secondary package that has to be ordered. The numbers of secondary packages are then increased until the store has a new ordering point from the D.C. This ordering point is determined by ICA and depends on how large the supermarket is and what their sales are.[207]

When a new article is to be introduced, the amount that Maxi should have in the store is uncertain. The purchasing system keeps track of changes in the demand. If the actual demand is larger than the predicted, a larger quantity is bought automatically at the next ordering point, so that the demand can be met. Changes to order quantities, or to the inventory levels, can be done manually and this is done for example if Maxi purchases products outside of the system. Maxi can also purchase goods from others than the D.C., and the regular order have to be regulated due to that the campaign will reduce sales from other similar products etc. The inventory levels in the computer system usually differ from the actual levels. This has many reasons such as theft, waste, or that Maxi has not received the correct product or amount in a delivery.[208]

4.7 Summary of the empirical chapter

All of the companies in the studied supply chain have their own characteristics. In figure 4.2 are the key characteristics presented for the investigated companies, as a short summary of the empirical chapter. This figure will also help with the reading and understanding of the analysis chapter.

---

[207] Ibid
[208] Ibid

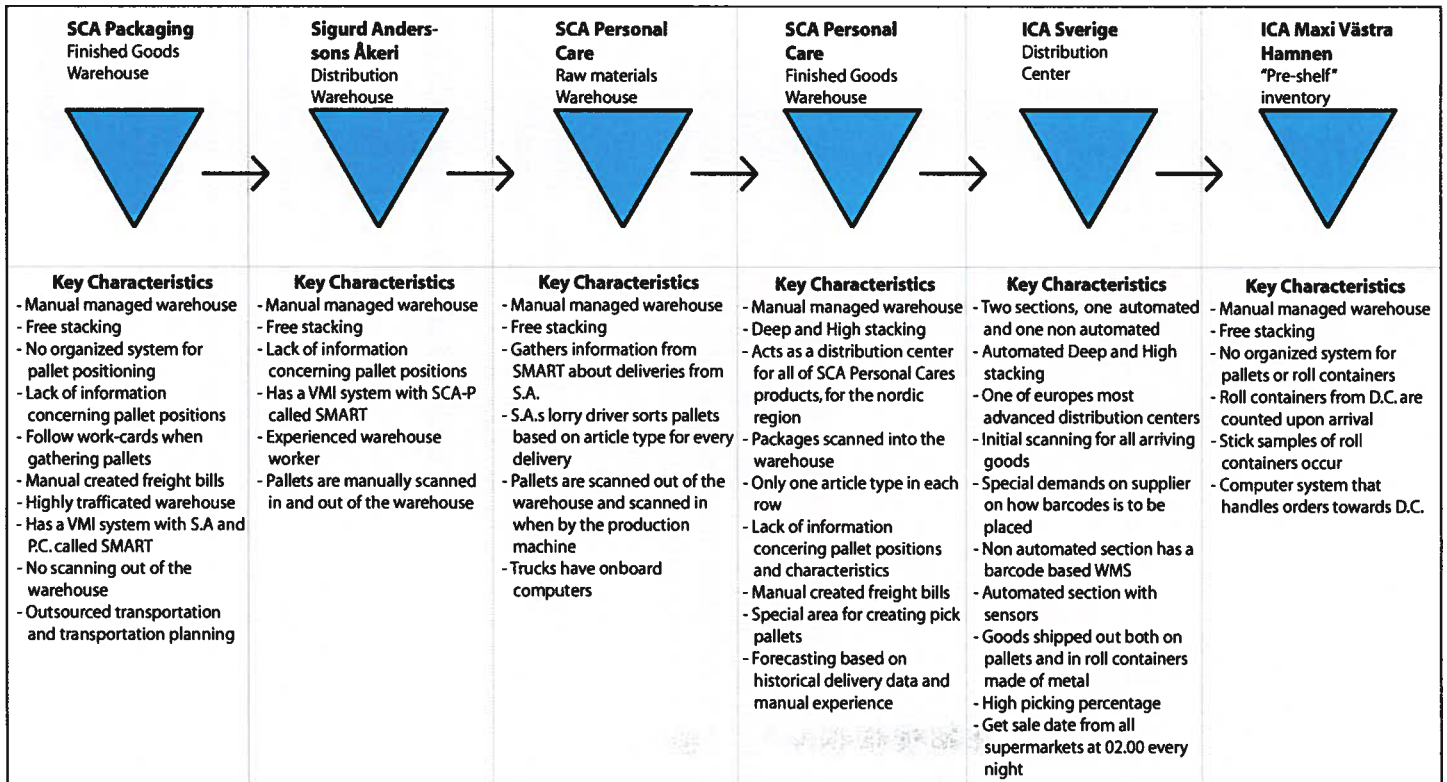

Figure 4.2: Key characteristics of the supply chain

5. Analysis

The Analysis chapter begins with an overview of the potential of an RFID implementation or improvement of the current barcode system on the supply chain as a whole and its components. Then it continues with handling general problems in demand management and how Auto-ID can become a solution. Finally, more profound descriptions of the improvement potentials in warehouse management of the different elements of the supply chain are made.

5.1 Supply chain management

An implementation of RFID or, a wider use of the current barcode system in the studied supply chain, will give improvements for both the supply chain as a whole, but also for the individual activities and processes in each company. There are several areas where Auto-ID can bring benefits to a supply chain or to an individual company. In this thesis two specific areas for potential improvement is concluded. These are; making better forecasts which would affect both the entire supply chain but also the individual companies and also the direct handling of goods, for example to find a certain pallet in a warehouse faster. Figure 5.1 illustrates where individual improvement potentials for each of the warehouses studied in the supply chain is thought to be located.

SCA Packaging Finished Goods Warehouse	Sigurd Anders-sons Åkeri Distribution Warehouse	SCA Personal Care Raw materials Warehouse	SCA Personal Care Finished Goods Warehouse	ICA Sverige Distribution Center	ICA Maxi Västra Hamnen "Pre-shelf" inventory
Warehouse Characteristics - Manual - Free stacking	**Warehouse Characteristics** - Manual - Free stacking	**Warehouse Characteristics** - Manual - Free stacking	**Warehouse Characteristics** - Manual - Deep and High Stacking	**Warehouse Characteristics** - Automated - Automated Deep and High stacking	**Warehouse Characteristics** - Manual - Free stacking
Scanning Proceeduers - Scan in (automated)	**Scanning Proceeduers** - Scan in - Scan out	**Scanning Proceeduers** - Scan in - Scan out x2	**Scanning Proceeduers** - Scan in (automated) - Scan out	**Scanning Proceeduers** - Scan in - Scanning throughout the entire process	**Scanning Proceeduers** - No scanning occurs
Improvement Potential - Stock keeping in real time - Stock taking - Localizing pallets faster - Improving shipping accuracy - Automizing paper handling - Reducing the bullwhip effect - Demand managing	**Improvement Potential** - Stock keeping in real time - Stock taking - Elimination of scanning time - Instant view of pallets position - Demand managing	**Improvement Potential** - Stock keeping in real time - Stock taking - Eliminaiton of scanning time - Demand managing	**Improvement Potential** - Stock keeping in real time - Stock taking - Elimination of scanning time - Higher utilization of storage capacity - instant access to information about pallet characteristics - Localizing pallets faster - Improving shipping accuracy - Automizing paper handling - Demand managing	**Improvement Potential** - More secure scannings - Stock taking - Improved tracking in the automated conveyor system - Demand managing	**Improvement Potential** - Demand managing - Stock taking

Figure 5.1: The improvement potentials for the specific warehouses in the supply chain

An area with a great potential is the possibility of using data from Auto-ID to obtain a better visibility of every unit, inventory, and of the demand. This work has begun between SCA-P and P.C., but an area with high potential, the connection between P.C. and ICA, is not yet realized. If information from Auto-ID is used to visualize the demand from the end-consumer and the inventory levels at the retailer, higher supply chain efficiency be can reached by the creation of more accurate demand forecasting and reduction of the bullwhip effect. This will lead to lower inventory levels and less obsolescence due to over-production of products that in reality have very low demand.

To get the most effective solution, and to get the best improvement, RFID is recommended, it is however not certain that RFID is the most beneficial solution in terms of economics. If RFID were to be implemented in the studied supply chain instead of fully exploiting the barcode technology benefits of elimination of scan time, higher durability, and potential of a higher degree of automation would be reached. The potential of elimination of scan time becomes greater for systems that require frequent scanning, for example a WMS.

The traceability in the supply chain is very good between P.C. and SCA-P, between P.C. and ICA the traceability is good enough especially since there are so few faults on the products that P.C. produces. Also, due to the scope of use for the products investigated, errors are not as critical as example for viands. However, if an RFID system was to be implemented, the traceability possibilities would become even greater and further benefits could be drawn. This would be possible if an RFID system with EPCglobal standard is used and connected to a database so that every company can interpret the information on the tag.

5.2 Forecasting

The bullwhip effect causes increased inventory costs, difficulties to organize and plan for future production and resources requirements, and costs of waste. Given that the cause for the bullwhip effect is insufficient demand management, the salvation is an information flow free from distortion and delay. This can be achieved by sharing information of the demand near the end consumer (ideally POS-data from Auto-ID) directly to the companies further up in the supply chain. These companies could then base their forecasting upon this data and thereby eliminate the complications of the bullwhip effect.

5.2.1 The bullwhip effect

In figure 5.2 below is the flow of products from P.C. to D.C. and also the exact same product flow from D.C. to the ICA stores over 2007 displayed. The product flow is summed up per week.

The output per week from D.C. has a standard deviation of 673 cartons for the entire flow. This can be compared to the corresponding flow into D.C. that has a standard deviation of 858 cartons. The difference in standard deviation between these two flows is 21.5 percent. The conclusion from this is that a bullwhip effect exists between D.C. and P.C.

If POS data could be accessed and displayed, would probably a further decrease be shown in the standard deviation. This since a store in essence has the same characteristics as a distribution central.

The most probable cause of the bullwhip effect is a combination between demand management and order batching. But to determine the relation between these two is very difficult. However, both causes are relatively easy to solve. Demand managing is insufficient due to that D.C. base their short term forecasts on data which is on average 12 hours old. This may not be perceived as much but put in relation to the 2-3 days of demand that is forecasted it is obvious that there is a potential for improvement. Order batching is another reason for the bullwhip effect due to that the outgoing deliveries to the stores are made more frequently, with smaller volumes per shipment.

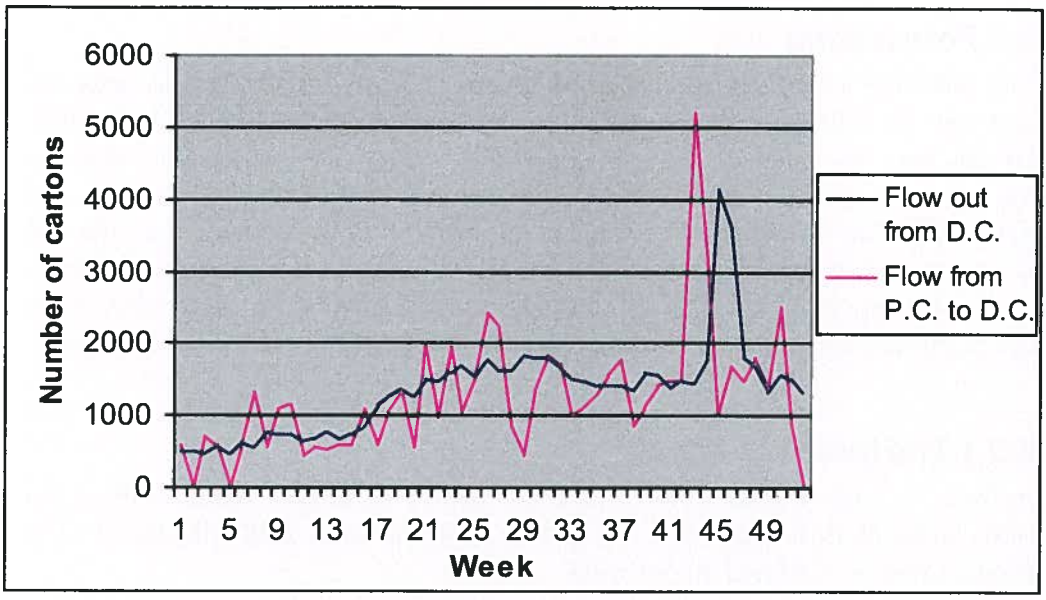

Figure 5.2 The flow of SCA Personal Care products out from P.C. to D.C. and further to the stores.

In figure 5.3 below is the flow of P.C.'s products to all of their customers displayed. The output per week has a standard deviation of 31 300 cartons for the entire flow. The variation divided to the total sum of cartons that left P.C. in 2007 is 86.8. This is quite high considering that the same index for the flow into D.C. is 11.4. From this it can be concluded that the bullwhip effect is probably greater for other customers that P.C. have, than for D.C. It is unlikely that the demand from other customers have a higher level of variation than D.C, due to that their stores have similar characteristics for example campaign activities, as the stores that are supplied by D.C.

Also, in figure 5.3 the flow of products from the RMW at P.C. to the FGW is shown. The output per week has a standard deviation of 41 000 cartons for the entire flow. This flow shows the production rate per week. The ideal is of course to remain on a high, stable utilization. The fact that the production has been upgraded and rebuilt during 2007 has certainly had its impacts on the appearance of the numbers. Because of this any reliable conclusions cannot be drawn from this data.

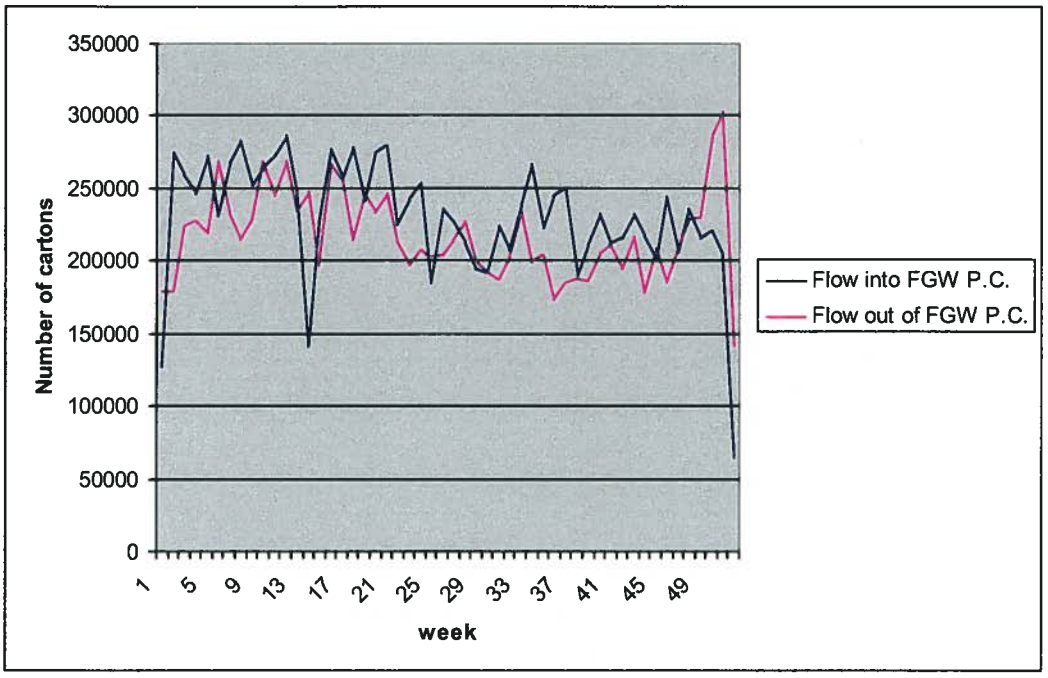

Figure 5.3 The flow of SCA Personal Care products in and out from the P.C. FGW.

In figure 5.4 below is the flow of cartons from S.A. to P.C. displayed. The output per week has a standard deviation of 41 990 cartons for the entire flow.

If this is compared to the flow into the FGW at P.C. in figure 5.3 it can be concluded that no bullwhip effect exist between these two flows. This is natural since the ordering from S.A. is made in close relation to the production and the lead time is very short.

Also, in figure 5.4 below the flow of products from the FGW at SCA-P to S.A. is shown. The output per week has a standard deviation of 62 770 cartons for the entire year of 2007. If this is compared to the flow on the other side of S.A., it can be concluded that the standard deviation is about 33.1 percent higher here. This can not be explained on differences in transportation behavior, since both transportations are made with full lorries. However, an explanation can be that SCA-P can identify two needs for the same article but at different times through the SMART system. If these time periods are close to each other, both needs are produced in one batch and sent to S.A. To quantify how much of the variation increase that originates from this is impossible. But it can be concluded that no additional bullwhip can exist between SCA-P and P.C. since the information from the forecasts is shared without distortion via the SMART system. On the other hand, the flow into S.A. must be influenced by bullwhipped data due to that the orders for this material is based on the forecasts that is based on data of the flow from the

FGW at P.C., which is influenced by the bullwhip effect. In this way the bullwhip effect is spread to parts behind the production of PC. This means that better forecasts will reduce inventory and waste, not only at the FGW at P.C., but upstream the supply chain as well.

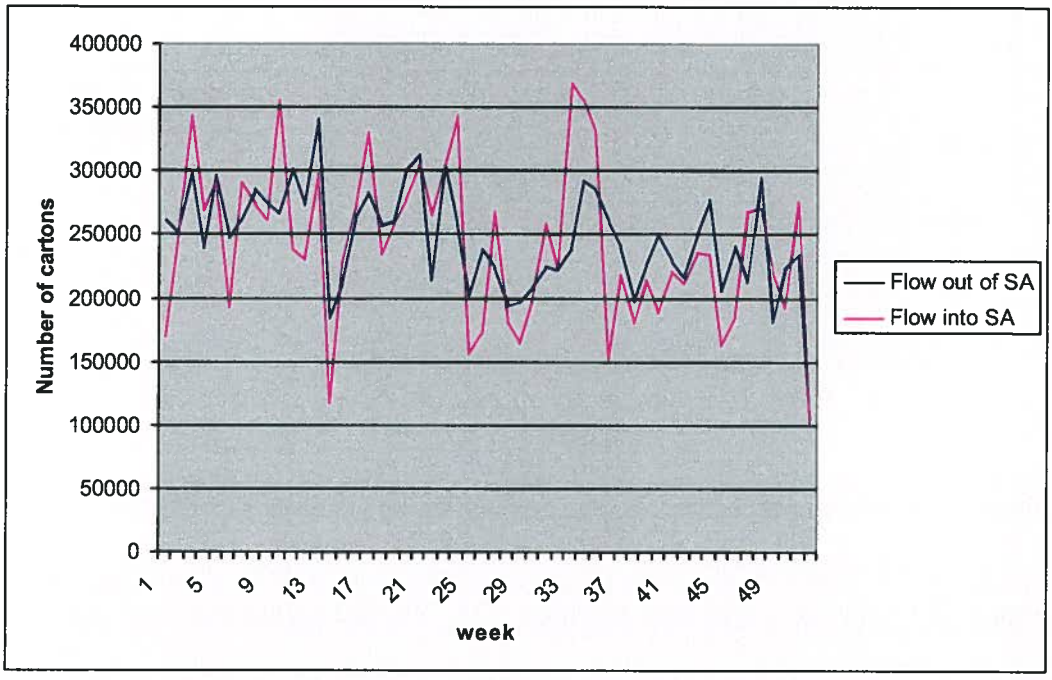

Figure 5.4 The flow of cartons in and out from S.A.

The complications with the bullwhip effect is in this supply chain costs for a high inventory and, perhaps losses, when products become obsolete because of high inventory levels and frequent changes of articles. These products are often sold to a reduced price. The unit where this is most tangible is the FGW at P.C. The production behind this unit should have a quenching effect because of its limited capacity. After this the bullwhip grows again until it is quenched again of the production of SCA-P. The bullwhip effect causes difficulties with organizing and planning the resources and matching the demand with supply. To manage this inventory levels are raised.

Part of the solution to the problems with bullwhip is to create visibility of the demand, orders, and inventory levels. A great part of this solution is that the hardware already exists in form of barcode scanners, barcodes on the cartons, and computerized orders. The only problem that needs to be solved is the sharing of this information.

5.2.2 Forecasting with higher quality data

Forecasts are never better than the historical data that they are built upon. ICA bases their short term forecasts on POS data that is on average half a day old. This may not sound as much, but if it is considered that the forecasts is only made for about two or three days, then it is obvious that real time POS will have an impact. This is also confirmed by a supply chain manager at ICA.

P.C bases their long term forecasts on the data from the flow out of their FGW, which, as shown, is influenced by bullwhip effect. This makes the forecasting more ineffective and difficult to perform. During 2007, the forecasts had an average error at 24.7[209] percent on all products. One of the reasons for this is that the forecasts are made by the Key Accounts, who also acts as sales managers[210], and thus have sales goals to work against[211]. This often results in that the forecasts are to optimistic[212]. For the period of week one in 2007 to week nine in 2008 the sum of the forecasted volume was 10.4[213] percent higher than the sold volume.

Forecasting simulation

A simple study was conducted where five different products were forecasted by simple exponential levelling based on Auto-ID data from the FGW at P.C. and on data from the D.C. The two forecasting simulations, whose only difference was the sources of data gathering, where then compared to each other to quantify the eventual gain in the performance if the forecasting would be based on data of the flow nearer the end consumer.

All of the five forecast simulations showed an improvement when they were based on the data of the flow from D.C. The average of the improvements was 20 percent. In this study the weeks when zero cartons were shipped to D.C. were eliminated because of mathematics. This was in favour for the forecasts that were based on the data from the FGW at P.C. so the improvement is in reality larger than 20 percent. Further, if the forecasts were based on POS data the improvement would probably be even greater.

From the forecasting simulation a MAPE of 19.3 on average could be shown for the forecasting made with the data of the flow from P.C. This can be compared with the 24.7 that is PCs´ current performance on all of the volumes that is sold in Sweden. This would indicate that the manual forecasting method

---

[209] Karhunen (2008a)
[210] Bona (2008)
[211] Karhunen (2008b)
[212] Ibid
[213] Karhunen (2008a)

has a worsening effect. This can however not be determined by this simple analysis.

Potential improvement

It has been shown that the variation in the output from the FGW at P.C. is higher than the output from the D.C. This would be reduced if D.C. reduces its variation in their order behavior by using POS in real time for its short term forecasts. It is reasonable to expect that this would benefit warehouse management at both D.C. and the ICA stores, giving the perceived benefits that theory states from bullwhip reduction.

A bullwhip effect has also been detected between P.C. and SCA-P. If P.C. would have access to POS data from the ICA stores to base its forecasting on this also could be reduced. These actions should lead to a lower need for inventory in both P.C. FGW and D.C. and less waste at P.C. This would also benefit the RMW at P.C. and all the suppliers to P.C. since they are producing after the demand from P.C. that is determined from the forecasts[214].

If all actions to reduce the bullwhip effect between D.C. and P.C. and P.C. and SCA-P is taken, a decrease in standard deviation with 21.6 respectively 33.1 percent should be possible. Equation 5.1 below gives that the decrease in standard deviation is equal to the decrease in safety inventory (SI). This is only valid if the lead time and service level is the same after the change and if the error in forecasting is statistically independent.

$$\Delta SI = \frac{SI_{BeforeChange} - SI_{AfterChange}}{SI_{BeforeChange}} =$$

$$= \frac{K \times \sigma_{BeforeChange} \times L^{0.5} - K \times \sigma_{AfterChange} \times L^{0.5}}{K \times \sigma_{BeforeChange} \times L^{0.5}} = \frac{\sigma_{BeforeChange} - \sigma_{AfterChange}}{\sigma_{BeforeChange}}$$

Equation 5.1 Calculation of relative decrease in safety inventory.

This means that the decrease in safety inventory is equal to the reduction in standard deviation of the experienced demand for the P.C. FGW, P.C. RMW, and FGW at the suppliers of P.C. Given that the retailers that are supplied by P.C. on average do not have better performance than P.C., which does not seem to be the case in general as was discussed previously, the reduction can be more than 21.6 percent if POS-data is used. Data from all suppliers to P.C. has not been analyzed but the bullwhip effect should not be lower for the other

[214] Bergenheim (2008)

suppliers since P.C. and SCA-P share their sophisticated SMART system. This implicates that the reduction at the P.C. RMW and FGW at the suppliers could be reduced by at least 33.1 percent. However, not all bullwhip effect is due to demand management and not all bullwhip is necessarily uneconomic. If a 21.6 percent reduction is met, the cost savings would be 6 090 000[215] SEK annually in the FGW at P.C. However in the case of D.C. some bullwhip is due to FTL economics and therefore can not the entire amount be saved but only $21.6*C_2$., where C_2 is a factor of how much of the entire bullwhip effect that can be reduced by improved forecasting.

If the bullwhip effect is reduced, the advantages that are difficult to quantify, which were discussed above, will also be realized for all companies in the supply chain. Also, a carefully selected forecasting method should forecast volumes that are close to equal to the sold volume in a longer period. This is not the case for the present forecasting at P.C., which had forecasted 10.4[216] percent higher volume than was sold during 61 weeks. This leads to costs for scrapping, discounts, and delayed introductions of the new article when the articles are exchanged.[217]

5.3 Materials handling SCA Packaging

In this chapter an analysis of what potential an extended use of Auto-ID will have for SCA-Ps FGW is presented. Due to that the warehouse does not have an Auto-ID supported system such as WMS or stock keeping this analysis had a broad benchmark.

5.3.1 Finished goods warehouse

The workers in SCA-Ps FGW do not have good enough tools to support them in a sufficient way with their work. Everything in the warehouse is manually controlled and due to the problems mentioned in the empiric chapter, the workers can not perform their work with high accuracy and pace.

Incoming Goods

When pallets with packages arrive to the FGW, the workers have no system of where they should be placed, except for Pågens pallets which have a designated area in the FGW. The rest of the incoming pallets are placed where ever the workers can find free space to put them. This is not desirable since it creates difficulties when the pallets are to be gathered for delivery in the

[215] Appendix D – Data and calculations for P.C.
[216] Karhunen (2008a)
[217] Bergenheim (2008)

future. The difficulties emerges due to that the workers lack the necessary information of where the pallets should be placed so that they can be easily found, but also because of the lack of space in the FGW. It is crucial that the workers have this information, if the FGW is to be efficient, concerning the characteristics of the warehouse. Here a WMS can help the workers to get the necessary information, but also to create a better setup in the warehouse. If the FGW had a WMS that would inform the workers of where they should place incoming articles so that articles of the same type are located together, several benefits could be held. Such a benefit could be that the workers would have better working prerequisites due to that the pallets will be easy to locate once they are going out for delivery. This would in the end ease the stress that is on the workers with the current situation. The main saving for the workers, but also for the efficiency of the FGW, is that the gathering process will become easier and more efficient, which will be shown later in this chapter.

A problem that also exists in the FGW is that there is too much commotion in the warehouse. A reason for this is when, for example, someone that does not work in the warehouse needs to check a pallet for some reason. Then, this person must walk around and search the warehouse for that pallet. This becomes a stress factor for the forklift drivers in the warehouse that in addition to their regular work has to keep track of this person, which in the end creates an unsafe work environment. If this person could get a hold of the information via an advanced WMS instead or at least be able to find the pallet as quickly as possible, the warehouse would become safer.

Distribution

One of the biggest areas for improvement in the FGW is when pallets are to be gathered for delivery. This is due to that the workers currently do not have information about the location of the pallets that are to be delivered. This has the effect that the workers have to search the FGW for the pallets, and this is a time consuming process that also creates a working environment which is reflected by stress and frustration. With an Auto-ID supported WMS the time of searching for pallets could be reduced to almost zero and even if a pallet is in the middle of a row the system can inform the worker of this. An implementation would not only lead to that time can be saved in the gathering process but also that SCA-P can increase their shipping accuracy. This would also help to increase SCA-Ps reputation amongst their customers. Even though SCA-P seldom misses their time for delivery, it can happen that they have to rearrange the transports in the last minute if some pallets cannot be found. The savings that can be obtained from implementing an Auto-ID supported WMS by decreasing the search times comes up to 91 000 SEK[218]. The savings that

[218] Appendix B – Data and calculations for SCA-P

can be gained from always delivering the correct pallets and not having to change the deliveries in the last minute and thereby improving good-will is difficult to quantify into money since it does not cost SCA-P anything. Another saving that is obtained from this is that the time that is saved from searching does not only affect SCA-P but also the transportation company that has a lorry and a driver there waiting for the pallets to be found. The time that the lorry and its driver waits for the pallets to arrive also costs money and this could also be saved with an Auto-ID supported WMS. The cost for the time that drivers with lorries have to wait while the warehouse worker is searching is 175 000[219] SEK per year.

When a delivery is due, the forklift drivers follow work-cards that states the amount of pallets and which article that a specific order contains. Green Cargo, which handles the transportation planning, has then planned which orders that is to be delivered in which lorry. Instead of having to use work-cards and to plan the deliveries due to the measurements of the pallets and other requirements, an Auto-ID supported computer system, which would communicate this information directly to the forklift drivers via onboard computers, could be used. Another advantage would be that with Auto-ID the worker can get confirmation directly if it is the correct pallet that has been gathered. With this confirmation combined with that the pallet is scanned out of the FGW when it is loaded onto the lorry could much paper work can be saved. The workers in the FGW currently have to create freight bills by going into an office and scan or manually type in every work card. This is not an efficient or secure way to create freight bills since it is still dependent on that the forklift driver that has gathered the pallets or that the lorry driver that loads the lorry has not made a mistake. If an Auto-ID based WMS was to be used instead, then a confirmation that the correct pallets have been loaded onto the lorry could be sent automatically. The creation of freight bills could be done automatically with such a system, due to that the system would sense what has been loaded into the lorry, and when the loading is complete, a worker could print out the freight bills to a printer near the loading gate and at the same time send a notice to the customer for example to S.A. that the shipment is on its way. With a system like this, SCA-P could save up to 95 000 SEK[220] annually.

Shipment errors

As stated earlier, the only control of that it is the correct pallets that are loaded into a lorry is done manually. By having an Auto-ID based WMS this uncertainty could be avoided by having everything scanned or read before the pallets go into the lorry, and thereby knowing exactly what it is that leaves the

[219] Ibid
[220] Ibid

FGW. SCA-P currently has about 70 shipment-errors every year and this costs them about 245 000 SEK[221] every year. With an Auto-ID based system this cost can be decreased to close to zero every year. It can not be stated that the cost disappears completely since even with RFID the readability is not 100 %. If an Auto-ID based system would be implemented it would also bring benefits such as that SCA-P's customers feel that SCA-P have secure deliveries that customers can depend on. When it comes to the studied supply chain the saving potential is that great since S.A. keeps packages in stock for SCA-P and that SCA-P sends a notice which informs S.A. that a shipment is on its way and what it contains. When the shipment has arrived at S.A. a scanning of all the goods is performed and a confirmation is sent to SCA-P via the SMART system on what was actually sent. If these do not match what SCA-P stated in their notice, a change can be made for both SCA-P's inventory levels and S.A.'s, and the problem can be solved in the next shipment. However, other customers to SCA-P do not have such close relationship with SCA-P, and therefore miss-shipment costs occur and differences in their own inventory levels between the actual and the inventory system levels appear.

5.4 Materials handling Sigurd Anderssons Hauler

The warehouse that S.A. uses for SCA-P's products is fairly modern and well organized mostly due to the experienced work staff. This combined with that there already exists a barcode based system that keeps track of the goods eliminates the chance of finding further potential using barcodes. The savings that can be found are in areas where the RFID technology can reach benefits that barcode technology can not or where RFID are more efficient.

Before a new shipment is to arrive the worker in the warehouse receives a fax from SCA-P that states which articles that are arriving and how many pallets there are of each one. The worker then checks if there are any other of these articles in the warehouse and, if so, where they are located. This search costs S.A. about 3 600 SEK[222] every year and it is such a small sum that it is not worth investigating further. Even if the entire sum could be saved it would not be of any greater effect on the overall result for S.A.

When pallets arrive or when they are to be shipped out of the warehouse, they are scanned by the warehouse worker with a hand held barcode scanner and inventory is increased respective decreased system-wise. If an RFID system were to be implemented instead, this scanning could be replaced with interrogators at the gates at the loading docks and an automatic identification

[221] Appendix C – Data and calculations for S.A.
[222] Ibid

of the pallets would be done instead, and the same result would be given. The time to read the RFID tags on the pallets would be significantly less than the time for driving the pallets on or of the lorry, which in reality means that it would not require any extra time for registration. With the current barcode system the cost of scanning is 24 000 SEK[223] per year and this cost can be reduced with an RFID system, but this sum is too small to affect S.A.'s overall result and therefore no further investigations are necessary.

When a delivery is due and the worker has planned how the pallets are to be delivered to P.C., the inventory is searched for the pallets. This search costs S.A. 9 400 SEK[224] annually. This cost is too small to support further investigations.

5.5 Materials handling SCA Personal Care

In this chapter an analysis of what potential an extended use of Auto-ID will have for P.C. is presented. Due to that part of P.C. does not have an Auto-ID supported system such as WMS or stock keeping this analysis had a broad benchmark.

Also, the fact that the P.C. factory is under a massive upgrading process of their entire machine park, has influenced some data. This is considered to the extent that if a result is clearly affected by this upgrading process it will be stated and a discussion on what effect the upgrading processes has had on the result will be presented.

5.5.1 Raw Material Warehouse

The RMW only keep pallets in stock for the next few upcoming days' production, which means that the inventory levels are relatively small. There are two separate sections in the warehouse where pallets are stored, both physically and system-wise. This in combination with that the forklifts in the storage have on-board computers linked to the inventory system and that the drivers are experienced, decreases the benefits of a WMS supported by Auto-ID that specifies the location of the pallets. The savings that could be obtained in the RMW by reducing the search time would not mean any difference for the overall result of the factory.

---

[223] Appendix C – Data and calculations for S.A.
[224] Ibid

In- and Out-coming Goods

When shipments arrive to the RMW from S.A., no scanning has to take place, since S.A. has already created a shipment file in SMART. The lorry driver sort the pallets into rows based on what article they contain. This makes an implementation of RFID unnecessary since the only time saved will be the time that the driver uses to see which kind of article a certain row is. This time saving can be disregarded even over an entire year.

When pallets are to be delivered from the RMW into the "production stock", the pallets are scanned both when they are collected and when they are delivered to the machine. Here an RFID implementation can bring benefits by reducing the manually performed scannings and be replaced by an automated tag reading procedure that would save time. The total cost of all the scannings over a year is 24 000 SEK[225], this is not an insignificant amount, but put in relation with P.C.s turnover, is it not a sum that supports further investigations.

5.5.2 Finished Goods Warehouse

Due to the upgrading process at P.C., they now have their normal "in-house" warehouse and five external warehouses for finished goods, whereas they normally only have one external warehouse in addition to the "in-house" warehouse. Their theoretical maximal capacity is [redacted] pallets at the moment, under normal circumstances however they only have a theoretical maximum of [redacted] pallets.[226] This, in combination with that these values do not reflect the actual maximum of their storage capacity, makes it difficult to calculate good results that are representative for P.C. in their normal state.

Since P.C. only has one article type in each row in their warehouses there is room for better space utilization by knowing exactly where certain articles are. If a production batch is done of a certain article that is already in stock, the newly produced articles can easily be placed with the already existing ones if an Auto-ID based WMS would exist. This is due to that the location of the existing pallets would be known. Another advantage with a WMS is that the forklift drivers can get information on where they should gather pallets so that pallets are gathered from one row at the time and not from different rows. This would bring savings for the space utilization and thereby lowering costs. The value of the space savings that can be achieved by an Auto-ID based WMS, if it where to be implemented into all of P.C.s current warehouses, would be X SEK[227].

---

[225] Appendix D – Data and calculations for P.C.
[226] Lundin (2008e)
[227] Appendix D – Data and calculations for P.C.

Distribution

When a new delivery is due and the lorry has arrived, a list is printed out of which pallets that the forklift drivers in the FGW should gather from the warehouse, and bring to the loading area. Since the warehouse does not have a WMS, the warehouse workers have to search the warehouse for the pallets. Over a year the cost of this searching will come up to 1 240 000 SEK[228] and almost the entire sum can be saved with an Auto-ID based WMS. Not the entire sum can be saved due to that faults can always occur, either that a scanning goes wrong or that a glitch emerges in the system. Other costs that would be saved due to that the search time would decrease, are that P.C. would not have to pay lorries for waiting while the warehouse workers search the pallets and also that the cost of blocking a loading gate for that search time. The cost for the time that lorry drivers have to wait comes up to 3 480 000*C[229] SEK, not the entire sum can be saved due that lorry drivers can load the lorries as the workers load the lorries. The cost for the occupation of the loading dock is harder to measure, but if the search times would decrease a better utilization of the loading gates could be obtained.

Another thing that the workers have to search the FGW for is pallets of different heights. Every day lists are printed out that informs the warehouse workers of which pallets they should search for in order to see if some pallets have to be repacked, so that deliveries for the actual and upcoming day can be met. A search has to be performed due to that the warehouse system in the FGW does not have information about which height the pallets have. These searches are done two times per day and it corresponds to a cost of 59 000 SEK[230] every year. This could also be eliminated by an Auto-ID supported WMS which could keep track of how many pallets of a certain height and article there are in the warehouse.

Another benefit that a WMS could bring is that the work of creating freight bills and decreasing the inventory levels could be done automatically instead of manually. This work costs P.C. about one full time employment which is equivalent to 357 000 SEK[231] per year. The reason why not the entire sum can be saved is that if something goes wrong, somebody would still have to be able to fix it, but since there are four members of the staff that currently handles this, amongst their other duties, this can be solved easily.

If a WMS is to be implemented, it can be based upon RFID or on barcodes. An RFID system is more stable and the scanning process becomes more

---

[228] Ibid
[229] Lundin et al. (2007)
[230] Appendix D – Data and calculations for P.C.
[231] Lundin (2008c)

secure. With an RFID system, interrogator gates can be installed in affiliation to the loading gates so that every pallet that is loaded onto a lorry could be registered. With a barcode system the scanning would have to be done manually, this is however already done for some deliveries, which means that P.C. already has knowledge about this technology and therefore do not have to do as much research if a barcode system would be implemented.

Error in Shipments

Since P.C.s distribution process depends on manual handling the human factor comes into play. If for example, a scanner would be used to scan out goods, the workers would get a confirmation that is in fact the correct article and that the right amount of pallets have been gathered. With the current situation, the workers have to count the pallets and take notes, usually this works fine, but sometimes the human factor comes into play and mistakes happen which leads to miss-shipments. The administrative costs of handling these miss-shipments comes up to 1 010 000 SEK[232] per year. There are also costs for extra pallet handling, for example if pallets are returned to P.C. or extra shipments has to be made. These shipments also cost extra and most of the costs mentioned could be saved if an Auto-ID based system would be implemented where the system confirms that it is the correct pallets and quantities that are shipped with the lorries. These savings were however difficult to quantify due to that there were difficulties when gathering the necessary data.

Pick Pallets

When a pick pallet is to be created the worker that creates it has to search the pick pallet section in the FGW to gather all of the packages that is to become the pick pallet. The worker has no information of what is in the section and in a worst case scenario a search could be made for an article type that has been emptied and not been refilled. The cost that P.C. has for searching for pallets in the pick pallets section comes up to 217 000 SEK[233] per year. With an Auto-ID based WMS this section could be separated from the FGW. Information about what is in the section and where exactly the pallets are located could then be obtained and most of the search costs could thereby be saved.

5.6 Warehouse Management for ICA Distribution Center

The D.C. has a high level of automation and it is based upon barcodes which makes it difficult to find potential for improvement by using this technology.

---

[232] Appendix D – Data and calculations for P.C.
[233] Ibid

The areas that can be analyzed are those where RFID have properties that barcodes does not have or where RFID can do the work more efficient or more secure.

5.6.1 The Colonial Warehouse

The studied part in the D.C. is the colonial warehouse and in this warehouse the automation level is one of the highest in the entire D.C., whence the improvement potential is decreased even more. The warehouse is also still in a period where the machinery and the processes are adjusted, which leads to that the efficiency is improved continuously. This leads to that it is difficult to measure data that will be of relevance when the D.C. runs with its true maximal capacity in the future. There is however some advantages that can be analyzed in some of the processes in the colonial warehouse. However, no estimation of what the savings can be will be done due to the reasons above.

Receiving Goods

When pallets are coming in to the warehouse they are loaded onto a conveyor where the pallets are scanned with a barcode scanner. At the moment there are problems with this scanning, it is getting better but there is still too many that do not work and the scanning has to be done manually or in the worst case a worker must replace the barcode etiquette and write in the data manually into the system. There is also the risk that a barcode is miss-read and that the system does not react. These activities can be made more secure and efficient with RFID. The problems with that the scanning does not work will be decreased almost to zero and the risk that the wrong code is read will also almost be eliminated. The cost savings that can be done here are not measured because of that there is still too much uncertainty of how efficient and how many miss-readings there will be in this process when it runs as planned. Another aspect of why this is not considered is that if an RFID solution is to be implemented all of the goods that are coming in to the D.C. have to be tagged with RFID. This is because that ICA does not want two different information systems doing the same thing since this will be cumbersome and not economically feasible to implement and manage.

Handling in the non-automated section

In the section where the handling is not automated but done by humans is a barcode supported WMS used. This makes it possible to find savings with RFID in the picking process, for example would no scanning have to be performed, but due to the scale of this inventory and that there already is a modern barcode supported WMS, are the savings that is expected to be found

small. Also, as described above, ICA does not want to combine two different kinds of Auto-ID technologies. This make a detailed investigation and analysis unnecessary since if RFID is to be used here, all of the products will have to be tagged with RFID in the entire D.C.

Handling in the automated section

In the automated section of the colonial warehouse there is also, as for the other sections, little room for improvement. The potential, that could be found, that RFID could bring instead of barcodes, is for the conveyor system that is a little uncertain at the moment with the sensors that keep track of the movements of the goods. This uncertainty could be avoided with RFID technology and a more secure conveyor system would be obtained. The fact that the processes are not finely tuned, combined with the savings that can be held is not expected to be very high since the system is new and works fairly well leads to that no investigation has been done on potential savings in this area.

5.7 Warehouse Management for ICA Maxi Västra Hamnen

Auto-ID can bring improvements for most supermarkets that exist today. The form of Auto-ID that would bring the best efficiency is if RFID tags were to be put on the consumer packages. Stock taking could be done automatically for both the inventory and in the actual store if an advanced system were implemented. The store could also use the tagging as theft protection. To do further investigations on such system is not focused upon in this thesis due to that there is no interest from the companies in the supply chain due to the costs that such an implementation would bring. Having a tag on every product in a supermarket is still unrealistic in the authors opinion but sometime in the future there is a potential to be found here.

To put tags on pallets or secondary packages can also bring some benefits for Maxi but this is uncertain due to that a lot of the goods in the pre-shelf inventory have part of metals and contain water which would block the RFID tags from being read. This would prevent the possibilities to locate certain packages in the inventory. Also, there is no need to put tags on pallets since they can easily be located due to that the inventory is divided and that it is a relatively small inventory. The search times for pallets are not high and therefore no further investigation was performed. Further, as were discussed in the empiric chapter, no scanning into the store is preformed. The inventory in the store is increased system-wise when the goods are scanned out of the D.C. This makes investigations about scanning procedures into the store impossible.

Savings can be found by implementing an Auto-ID supported WMS but this would not give any major benefits since the warehouse is to small and if a WMS is to work in a proper way a structure has to exist in the warehouse and this is not the case here. So no further investigations about what a WMS could accomplish has been made. The first and most important thing to do in Maxis warehouse is to create and organize a system for the handling of goods. After this is done, investigations about implementing a WMS can be done.

5.8 Taking stock in the supply chain

The stocktaking cost for SCA-P, SA, and P.C. combined, is 76 000[234] SEK per year. Some of these operations might be made more efficiently and secure with RFID but the total earning is so small in relation to these companies size that this has not been analyzed further.

[234] Appendix E – Data and calculations for stock taking

6. Discussion

In this chapter the results from the analysis are generalized and discussed. The purpose has been to make the results applicable and useful on the areas outside of the studied supply chain.

The results from the analysis depend upon certain characteristics that the studied supply chain has. So the results can first of all be used for other supply chains, where one or more of the companies in the studied supply chain are involved. They can however also be used by other supply chains that have similar characteristics, such as that they handle pallets the same way. For example the results found for SCA-P and P.C. can be acknowledged for all SCA Packagings' and Personal Cares' factories with the same characteristics. If the results from the analysis are to be implemented into another supply chain, the results that this gives may differ greatly from the results in this thesis. Factors that affect this can be; the size of the warehouses studied, how many different articles that are handled, etc.

The results considering the material flow between *SCA-P – S.A. – P.C.* depends on specific circumstances, such as that they already have the SMART system between them. This has the effect that the savings from an Auto-ID solution that could be found for this specific flow, is not representative for the other flows that these companies have. An example is that SCA-P has an extraordinary high percentage of correctly delivered goods towards P.C., due to that they have S.A. in between as a buffer. For other customers where SCA-P does not have such a buffer, problems like; miss-shipments or that pallets can not be located and have to be replaced, becomes more noticeable. Here an Auto-ID supported WMS would bring great benefits, due to that information would exist on where the goods are, and thereby SCA-P would be able to deliver the correct pallets in a higher extent, to all of their customers. Another effect that the SMART system has on P.C., is that they do not have to scan in arriving goods from S.A., although this has to be done for their other suppliers. This scanning could, for example, be eliminated if all of P.C.s' suppliers and P.C. themselves were to use RFID instead of barcodes. The flow between *SCA-P – S.A. – P.C.* is in many senses a school example of how a bullwhip effect can be reduced with its constant order batching and SMART system that enables demand visibility. Despite this a rather high bullwhip effect was measured and it is likely to be even higher in the material flows from the other suppliers of P.C due to the poorer prerequisites to reduce bullwhip.

The flow between P.C. and D.C. can be viewed upon as a general flow out of P.C. to a customer. In this case it is ICA that is the customer and they have set up tough demands upon P.C. for when the goods should arrive etc. In this

specific case they have also regulated how the pallets should be marked so that they can be read in the D.C. If however an RFID system would be used, then there would be no problems with customers such as ICA that has demand concerns on how etiquettes are to be placed. Since the flow between P.C. and D.C. represent a regular customer relationship for P.C., the results concerning forecasting from the analysis can be postulated to apply for all other customers as well.

Since a part of the studied supply chain is the D.C., not so many benefits could be found in the last two parts. This is due to that it is a state of the art, a one of a kind distribution center. If a different supply chain would be studied instead, one that did not consist of that specific distribution center, much more benefits would arise in the two last parts of the supply chain. An example could be, if the distribution center did not have a WMS, then most of the saving areas found for P.C. could also be found for that distribution center. Since the picking of goods in the D.C. is done either by robots or by personnel that have support of a modern WMS, the correct pick percentage becomes very high. For other distribution centers this is not the case however. If the goods are picked by hand in a warehouse without a modern WMS, the number of miss-shipments is higher than for the D.C. This has the effect that the distribution center gets extra handling costs, etc., but also that the supermarkets have to have a more rigorous control of the arriving goods. Since the goods, in ICA's case, arrive in roll containers made by metal, the potential that exist by using Auto-ID is to get a secure control of what was in the container. This could be done both by barcodes or RFID since the goods, either way, have to be taken out of the container for reading. This process could however be done in the distribution center if it has a WMS and the goods could be scanned out when they were put into the containers.

Even if P.C., or any other of SCA's factories, do not have a lot of customers that today use RFID, they might do so in a time period of five to ten years. If this seems likely, then the choice between barcodes and RFID becomes an important factor, and also the timing of that choice. Another important aspect is to see how SCA's reputation would change if an implementation would be done with one of these technologies. If RFID becomes the most common form of Auto-ID in the future, then major benefits can be found by being an early supplier of RFID tagged goods. For example in the scenario if not so many of SCA's competitors can deliver goods with RFID tags, SCA can probably gain market shares. On the other hand, if RFID does not reach the big market and SCA has made large investments in this technology, it would have great negative effects on SCA's economics, but it will also have a negative effect on their reputation. There are several aspects like these that SCA has to take into account.

To be able to get a grip on how large the savings are that were found in the analysis chapter was the total stock value for P.C. calculated to [redacted][235] SEK. This is a large number but that is partly because of that P.C has extra stock due to the upgrade of the manufacturing machines and that they act as a distribution central for the entire Nordic region. The savings found represent between 2 – 4.5 percent of the total stock value annually. The savings found for SCA-P compared to their total stock value which is 13 percent[236]. These savings are the minimal savings. For example for SCA-P are not the safety stock reduction taken into account because of that the necessary data for such a calculation does not exist. Another saving that has not been taken into account is that all the quantitative savings lead to that capital is saved, which in it self is a saving.

All of the savings and possibilities that have been found in the analysis chapter are not dependent on what kind of products that is manufactured. This makes the results interesting for other companies outside of the investigated supply chain, provided that they have similar characteristics in their processes. If so, they are able to benchmark the results onto them selves.

This thesis is an initial investigation on what benefits Auto-ID can bring for a supply chain. All of the benefits and savings found, need investments of different size and sorts if they are going to be held. The next step that should be taken is to investigate the costs together with vendors that can supply the suggested solutions.

[235] Appendix D – Data and calculations for P.C.
[236] Appendix B – Data and calculations for SCA-P

7. Conclusion

In this chapter are the results found in the analysis presented. The purpose is to give a short and summarized presentation of the results so that they can easily be overviewed.

This thesis has two main purposes which were presented in chapter one, the first one was to compare different kinds of Auto-ID technologies against each other and investigate if the achieve their theoretical potential. The other purpose was to identify the improvement potential and present the results in quantitative or qualitative terms.

During the process of gathering and analyzing data, it has shown that barcodes still holds great potential for managing goods in different kinds of warehouses. Barcodes can even compare well against RFID which is a newer form of Auto-ID. RFID brings certain advantages that barcodes do not have but in some cases can this be solved by using more than one barcode etiquette. However, in certain environments is RFID a better option than barcodes as for example in the D.C. where ICA has chosen barcodes instead. For that warehouse would RFID be a better choice but as mentioned in the analysis are there problems with that ICA's suppliers can not deliver goods with RFID tags on them. Thereby was barcodes the natural choice since ICA only wants one form of Auto-ID in the D.C. For the rest of the supply chain can both barcodes and RFID tags bring great efficiency improvements and therein cost savings. Even here can RFID bring the greatest improvements, one example of this is that scanning processes would not be necessary since it can be done automatically via interrogator gates. However, the conclusion from the analysis is that barcodes despite this seems like the best alternative due to; that RFID still costs much more than barcodes, that SCA have some experience with barcode systems from their work with SMART and also that ICA demands it for the products that are going to the D.C.

All of the results from the analysis are presented in Figure 7.1 and it shows that a lot of the biggest improvement potentials found can be done in areas where barcodes almost have or even have the same potential as RFID. The results presented in the figure shows the "best of worlds" savings i.e. when the system fulfills a hundred percent of the theoretical potential. The results and the analysis show that an implementation of an Auto-ID supported WMS in the different warehouses at P.C. and SCA-P holds a great potential. This combined with using information from Auto-ID to create better forecasts would bring considerably cost savings for the entire supply chain and therein for all the companies that it includes. The figures in Figure 7.1 can be put in

relation with the stock value in the FGW at SCA-P and P.C. which is [redacted][237] respective [redacted][238] SEK.

Also other improvement potentials have been found that could not be quantified. Some of these savings should not be neglected such as the time saving that the delivery companies that delivers goods from the factories withholds from decreased search times. Another example is the improvement of the different companies´ reputation that they for example deliver the correct goods at the right time. The effect of such a reputation improvement is difficult to measure but it is still valuable.

[237] Appendix B – Data and calculations for SCA-P
[238] Appendix D – Data and calculations for P.C.

SCA Packaging Finished Goods Warehouse	Sigurd Andersons Åkeri Distribution Warehouse	SCA Personal Care Raw materials Warehouse	SCA Personal Care Finished Goods Warehouse	ICA Sverige Distribution Center	ICA Maxi Västra Hamnen "Pre-shelf" inventory
Warehouse Characteristics - Manual - Free stacking	**Warehouse Characteristics** - Manual - Free stacking	**Warehouse Characteristics** - Manual - Free stacking	**Warehouse Characteristics** - Manual - Deep and High Stacking	**Warehouse Characteristics** - Automated - Automated Deep and High stacking	**Warehouse Characteristics** - Manual - Free stacking
Scanning Proceeduers - Scan in (automated)	**Scanning Proceeduers** - Scan in - Scan out	**Scanning Proceeduers** - Scan in - Scan out x2	**Scanning Proceeduers** - Scan in (automated) - Scan out	**Scanning Proceeduers** - Scan in - Scanning throughout the entire process	**Scanning Proceeduers** - No scanning occurs
Qualitative saving potential - Good-will due to improved shipping accuracy - Less trafficated warehouse area - Demand Managing	**Qualitative saving potential** - Stock keeping in real time - Demand Managing	**Qualitative saving potential** - Demand Managing	**Qualitative saving potential** - Good-will due to improved shipping accuracy - Demand Managing	**Qualitative saving potential** - More efficient and reliable scanning - Improved automation - Demand Managing	**Qualitative saving potential** - Demand Managing
Quantified saving potential - Decreased search time = 91 000 SEK - Automated/decreased paper handling = 95 000 SEK - Reduced shipment errors = 245 000 SEK - Costs saved for lorry drivers waiting time = 175 000 SEK	**Quantified saving potential** - Reduced scanning time = 24 000 SEK - Reduced preparation time for arriving goods = 3 600 SEK - Reduced search time for outgoing goods = 9 400 SEK - Reduction of safety inventory = 33.1 percent	**Quantified saving potential** - Reduced scanning time = 24 000 SEK	**Quantified saving potential** - Reduced search time = 1 240 000 SEK - Reduced search time for pick pallets = 220 000 SEK - Reduced shipment errors = 1 010 000 SEK - Automated paper handling 357 000 SEK - Easier determination of pallet characteristics = 59 000 SEK - Cost saved for lorry drivers = 3 480 000 x C1 SEK - More efficient space usage = X SEK - Reduced safety inventory = 6 090 000 x C2 SEK	**Quantified saving potential** - No quantified results	**Quantified saving potential** - No quantified results
Total quantified savings = 606 000 SEK	**Total quantified savings = 37 000 SEK**	**Total quantified savings = 24 000 SEK**	**Total quantified savings = 2 886 000 + 3 480 000 x C1 + 6 090 000 x C2 SEK**	**Total quantified savings = 0 SEK**	**Total quantified savings = 0 SEK**

Figure 7.1 The results from the analysis on an annual basis for the specific warehouses in the supply chain

8. References

To write this thesis several kinds of sources has been used such as books, reports, internet and verbal sources as well.

8.1 Books

Arbnor I., Bjerke B. (1994): *"Företagsekonomisk metodlära"*, Studentlitteratur, Lund, Sweden

Aronsson et al. (2003): *"Modern logistik"*, Författarna och Liber AB, Lund, Sweden

Axsäter, Sven (1991): *"Lagerstyrning"*, Studentlitteratur, Lund, Sweden

Chopra, Sunil, Meindl, Peter (2007): "*Supply Chain Management – Strategy, Planning, & Operation*", Pearson Education, Inc., Upper Saddle River, New Jersey, United States of America

Hunt, V. Daniel, Puglia, Albert, Puglia, Mike (2007): "*RFID A guide to radio frequency identification*", John Wiley & Sons, Inc., Hoboken, New Jersey, United States of America.

Kvale, Steinar (1997): *"Den kvalitativa forskningsintervjun"*, Studentlitteratur, Lund, Sweden

Merriam, Sharan, B. (1994): *"Fallstudien som forskningsmetod"*, Studentlitteratur, Lund, Sweden

Poirier, C. Charles (2006): *"RFID - Strategic Implementation and ROI – A Practical Roadmap to Success "* , J. Ross Publishing, Inc., Fort Lauderdale, Florida, United States of America.

Schary, Philip B., Skjött-Larsen ,Tage (2003): *"Managing the Global Supply Chain"*, Copenhagen Business School press, Copenhagen, Denmark.

Van Weele, Arjan J. (2005): *"Purchasing & Supply Chain Management: Analysis, Strategy, Planning and Practice"*, Thomsom Learning, London, United Kingdom

Wallén, Göran (1996): "*Vetenskapsteori och forskningsmetodik*", Studentlitteratur, Lund, Sweden.

TFK (2002): *"Materialhantering"*, Nya Almqvist & Wiksell Tryckeri AB, Solna, Sweden

8.2 Reports

Fink, R., Gillett, J., Grzeskiewicz, G (2007): "Will RFID Change Inventory Assumptions?", *Strategic Finance*, Vol. 89(4), pp. 34-40

Jabjiniak, B. and Gilbert, G. (2004): "RFID Warrants a Strategic Approach", *Business Integration Journal*, vol. jan (2004), pp. 29-31.

Jones, P., Clarke-Hill, C., Hillier, D., & Comfort, D. (2005): "The benefits, challenges and impacts of radio frequency identification technology (RFID) for retailers in the UK", *Marketing Intelligence & Planning*, vol. 23(4), pp. 395-402.

Lee et al. (1997): "Information distortion in a supply chain: The bullwhip effect", *Management Science,* Vol. 43 (4), pp. 546-559

Lundin et al. (2007): "Pre-study on an RFID assisted Warehouse Management System", Department of Shipping and Marine Technology, Division of Shipping economics and transportation, Chalmers University of Technology, Göteborg, Sweden

Nayyar, Deepak (2006): "*Globalisation, history and development: a tale of two centuries*", Cambridge Journal of Economics, vol. 30, pp. 137-159.

Vijayaraman, B. S. & Osyk, B. A. (2006): "An empirical study of RFID implementation in the warehousing industry", *The International Journal of Logistics Management*, vol. 17(1), pp. 6-20.

Wyld, C., David (2006): "RFID 101:the next big thing for management", *Management Research News*, Vol. 29(4), pp. 164

8.3 Internet

Ala (2007): http://www.ala.org/pla/plapubs/technotes/rfidtechnology.cfm 2007-11-05

Bridgefieldgroup (2008): http://bridgefieldgroup.com/bridgefieldgroup/glos1.htm 2008-03-29

BMWI (2008): http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/rfid-prospectives-for-germany,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf 2008-05-14

Fileblogs (2008): http://fileblogs.com/Barcode-Scanner--How-Does-it-Work &article_28301

Future Store (2007): http://www.future-store.org/servlet/PB/show/1003924/off-RFIDnet-IC-Booklet-IC-engl_04-10-21.pdf. 2007-10-08

GS1 (2008): http://www.gs1.se/sv/Om-GS1-systemet/Identifiering/Kollinummer/ 2008-02-28

Howstuffworks (2008): http://electronics.howstuffworks.com/upc1.htm

Idautomation (2007): http://www.idautomation.com/rfid_faq.html. 2007-10-31

Inventoryops (2008): http://www.inventoryops.com/warehouse_management_systems.htm 2008-02-13

Major projects (2007): http://www.majorprojects.org/pubdoc/680.pdf 2007-11-19

Rockford consulting (2007): http://www.rockfordconsulting.com/scm.htm 2007-11-19

OSD Comptroller iCenter (2007): http://www.defenselink.mil/comptroller/icenter/learn/iscm.htm 2007-12-03

SCA (2008 a): http://www.sca.com/en/About_SCA/SCA_in_Brief/, 2008-05-13

SCA (2008 b): http://www.sca.com/en/About_SCA/Our_business/Personal_care/ Personal care, 2008-01-14

SCA Packaging (2008): http://www.scapackaging.com/company/Who-we-are/Facts-and-figures/, 2008-02-19

Science direct (2008) : http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V92-3Y9RMNX-8&_user=745831&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000041498&_version=1&_urlVersion=0&_userid=745831&md5=37186f12904a49e65a1beed772bd95fe, 2008-03-26

Techtarget (2007): http://searchsap.techtarget.com/general/0,295582,sid21_gci1125310,00.html?tr 2007-11-20

Techtarget (2008): http://expertanswercenter.techtarget.com/eac/expertAnswer/0,295208, sid63_gci1153220,00.html 2008-15-14

The Impact Of Automatic Identification On Supply Chain Operations (2003): web.mit.edu/sheffi/www/selectedMedia/genMedia.sheffi-McFarlane.pdf, 2008-01-03

http://www.trumpuniversity.com/learn/trump360article.cfm?id=71 2007-11-19

8.4 Verbal sources

Andréasson, Hans, Executive Administrator, Sigurd Anderssons Hauler AB, 2008-01-18

Bergenheim (2008), Eva, production planner at SCA Personal Care AB, 2008-03-27

Bona (2008), Christian, Key Account Manager, SCA Personal Care AB, 2008-03-04

Carlsson (2008a), Hans, Warehouse Distribution Team Leader, SCA Packaging AB, 2008-02-11

Carlsson (2008b), Hans, Warehouse Distribution Team leader, SCA Packaging AB, 2008-03-20

Engström (2008), Pär, Distribution Manager, SCA Personal Care, 2008-06-16

Franvin (2007), Michael, Material Supply Manager, SCA Personal Care AB, 2007-12-20

Franvin (2008a), Michael, Material Supply Manager, SCA Personal Care AB, 2008-02-20

Franvin (2008b), Michael, Material Supply Manager, SCA Personal Care AB, 2008-02-27

Forklift drivers (2008), Discussion with a shift team of forklift drivers, SCA Packaging, 2008-03-20

Hansson (2008b), Eva, Demand Chain Development Manager, SCA Packaging AB, 2008-03-04

Holm (2008a), Bo, Warehouse Worker, Sigurd Andersson Hauler AB, 2008-01-18

Holm (2008b), Bo, warehouse worker, Sigurd Andersson Hauler AB, 2008-02-20

Hydblom (2007), Olle, CTO, RFID Constructors AB, 2007-11-27

Johansson (2007), Folke, Market Assistant, SCA Packaging AB, 2007-12-20

Johansson (2008a), Folke, Market Assistant, SCA Packaging AB, 2008-02-11

Johansson (2008c), Bengt, Team Leader Goods Receiving, SCA Personal Care AB, 2008-02-27

Karhunen (2008b), Susanna, Customer Service Manager, SCA Personal Care AB, 2008-03-27

Landenberg (2008a), Peter, Supply Chain Manager, ICA AB, 2008-01-29

Lundin (2008a), Alexander, Project Manager, SCA Personal Care AB, 2008-01-18

Lundin (2008c), Alexander, Project Manager, SCA Personal Care AB, 2008-02-20

Lundin (2008e), Alexander, Project Manager, SCA Personal Care AB, 2008-05-08

Rösler (2008), Johan, Manager Production Technique, ICA AB, 2008-06-23

Sjulander (2008a), Fredrik, Process Developer, ICA AB, 2008-01-29

Sjulander (2008b), Fredrik, Process Developer, ICA AB, 2008-02-26

Sjulander (2008c), Fredrik, Process Developer, ICA AB, 2008-05-09

Sjulander (2008d), Fredrik, Process Developer, ICA AB, 2008-05-19

Stockenberg (2008), Calle, Store Manager, ICA MAXI Västra Hamnen AB, 2008-02-29

Strand (2007), Niklas, Design Centre Manager, SCA Packaging AB, 2007-12-20

Svensson (2008), Conny, Warehouse Worker, SCA Packaging AB, 2008-02-11

Tengå (2008), Per, Market Area Manager for Inter Modal, Green Cargo Roads AB, 2008-06-03

8.5 Data sources

Hansson (2008a), Eva, Demand Chain Development Manager, SCA Packaging AB, 2008-02-05

ICA (2006): The annual report of ICA 2006

Johansson (2008b), Folke, Market Assistant, SCA Packaging AB 2008-03-05

Karhunen (2008a), Susanna, Customer Service Manager, SCA Personal Care AB, 2008-03-07

Landenberg (2008b), Peter, Supply Chain Manager, ICA AB, 2008-03-20

Lundin (2008b), Alexander, Project Manager, SCA Personal Care AB, 2008-02-04

Lundin (2008d), Alexander, Project manager, SCA Personal Care AB, 2008-03-07

Lundin (2008f), Alexander, Project manager, SCA Personal Care AB, 2008-06-02

Appendix A - Sample of the forecasting simulation

Product: Libresse classic 50-pack				
Week:		***1***	***3***	***4***
Auto-ID information from P.C.[239]		**18**	**36**	**36**
Forecasting		27	(1-0,1)*27+0,1*18 = **26,1**	(1-0,1)*26,1+0,1*36 = **27,1**
Error			(((25-26,1)/25)^2)^0,5 = **0,044**	(((29-27,1)/29)^2)^0,5 = **0,066**
MAPE	(0,044+0,066)/2 = **0,055**			
Auto-ID information from D.C.[240]		**25**	**25**	**29**
Forecasting		25	(1-0,3)*25+0,3*25 = **25**	(1-0,3)*25+0,3*25 = **25**
Error			(((25-25)/25)^2)^0,5 = **0**	(((29-25)/29)^2)^0,5 = **0,14**
MAPE	(0+0,14)/2 = **0,07**			
Improvement in percentage	(0,055-(-0,07))*100 = **-1,5**			

Comment to Appendix A

The purpose of the table above is to show the mathematics behind the forecasting simulation. The improvement is in this sample negative which means a worsening. Note that the second week is missing since no shipments from P.C. to D.C. took place during that week in 2007.

[239] Lundin (2008d)

[240] Landenberg (2008b)

Appendix B – Data and calculations for SCA-P

Reduced searching with a WMS:
Mean time to search = 1,7 minutes
Number of full shipments = 4000[241] full truckloads per year
Mean number of searches for every full truckload = 4[242] times
Cost for one hour of labor time for a SCA Packaging forklift driver = 201[243] SEK
Wait cost for lorry with driver = 275[244] SEK per every started half hour
Factor of actual waiting time for lorries = 70%

$$\frac{1,7}{60} \times 4000 \times 4 \times 201 = 91\,000 \; SEK \; per \; year$$

$$\frac{1,7}{60} \times 4000 \times 4 \times (275 \times 2) \times 0,7 = 175\,000 \; SEK \; per \; year$$

Comment to the measurement of searching time
This time was approximated by measurements at two different times. At the first occasion was the warehouse space highly utilized and the mean searching time was measured to 1,8 minutes. On the second occasion was the warehouse space less utilized, which lead to shorter searching times, 1,5 minutes. However, since the warehouse space seldom is less utilized will the first measurements receive a higher weight.

The factor for the actual waiting time for lorries, exists due to that the lorry drivers load the lorry a part of the time when forklift drivers search the warehouse. The value of 70% comes from observations at the FGW.

Reduced paper handling with a WMS:
Time for handling work-cards and creating freight bills = 2,5 minutes per shipment
Total number of shipments per day = 45[245]
Number of working days in 2007 = 253 days
Cost for one hour of labor time for a SCA Packaging forklift driver = 201[246]

---

[241] Johansson (2008b)
[242] Forklift drivers (2008)
[243] Johansson (2008b)
[244] Tengå (2008)
[245] Carlsson (2008b)
[246] Johansson (2008b)

$$\frac{2,5}{60} \times 45 \times 253 \times 201 = 95\,000\ SEK\ per\ year$$

Comment to the measurement of time required to create freight bills
When the forklift drivers were asked how long time on average it took for them to walk into the office and create a freight bill they answered 3 minutes. This time was also measured on a day with unusual low loading frequency to 2 minutes on average. The time 2,5 minutes was concluded by comparing the forklift drivers approximation with the measured time and considering that the forklift drivers some times has to wait for accessing the computers on a busy day.

Reduced shipment errors with a WMS:
Cost for one return transportation = 2000[247] SEK
Cost for changing the bills = 1500[248] SEK
Number of inaccurate shipments per year = 70[249] PCS

$$(2000 + 1500) \times 70 = 245\,000\ SEK\ per\ year$$

Stock value
Number of pallets in the FGW = [redacted][250] PCS
Number of cartons per pallet = [redacted][251] PCS
Value per carton = [redacted][252] SEK

[redacted]

Minimal savings compared to the stock value
Stock value = [redacted] SEK
Minimal savings = 606 000 SEK

[redacted] $= 13\ percent\ per\ year$

[247] Johansson (2008b)
[248] Ibid
[249] Ibid
[250] Svensson (2008)
[251] Johansson (2007)
[252] Johansson (2008a)

Appendix C – Data and Calculations for S.A.

Reduced scanning time with RFID:
Time to scan one pallet = 6,2 seconds
Number of pallets scanned per year = 82800[253] PCS
Cost for one hour of labor time for a SCA Packaging forklift driver = 166 SEK

$$\frac{6{,}2}{60 \times 60} \times 82806 \times 166 = 24\,000\ SEK\ per\ year$$

Comment to the measurement of scan time
The time for scanning one pallet was measured at two occasions and is an average of 97 pallets.

Reduced searching with a WMS:
Time to prepare for an incoming article = 0,59 minutes
Number of articles received at different times = 2225[254] PCS
Cost for one hour of labor time for a forklift driver = 166 SEK

$$\frac{0{,}59}{60} \times 2225 \times 166 = 3\,600\ SEK\ per\ year$$

Comment to the measurement of time required to prepare an incoming article
The time required to prepare for an incoming article was never actually measured but the procedure is about the same for the forklift driver as for the outgoing article, which can be seen below. Another reason for that this time was never measured is the small potential for improvement in this area.

Time to search for an outgoing article = 0,59 minutes
Number of articles received at different times = 5734[255] PCS
Cost for one hour of labor time for a forklift driver = 166 SEK

$$\frac{0{,}59}{60} \times 5734 \times 166 = 9\,400\ SEK\ per\ year$$

---

[253] Hansson (2008a)
[254] Ibid
[255] Ibid

Appendix D – Data and Calculations for P.C.

Reduced storage room in the FGW with a WMS:
Maximum capacity = [redacted][256] pallet spaces
Utilization of inventory space = [redacted][257] percent of the maximum capacity
Mean number of pallet spaces in one row = 35[258] pallet spaces
Number of articles = [redacted][259] articles
Costs per pallet space = [redacted][260] SEK per pallet space and year

[redacted] = -190 000 SEK

Since SCA does not mix articles in the rows will on average half of the row for every article remain unused.

Comment to the calculation of reduced storage room in the FGW
As can be seen the result for the possible reduction of storage room is negative. This is most likely due to that the factor [redacted] percent utilization is incorrect. This factor has also been attempted to be calculated manually, also with a negative result. The calculation is presented in the thesis to show that a potential exists although the quantity could not be concluded.

Reduced scanning time with RFID in the RMW:
Time to scan one pallet = 5,4[261] seconds
Number of pallets scanned per year = [redacted][262] PCS
Cost for one hour of labor time for a SCA Personal Care forklift driver = [redacted][263] SEK
Number of scanning operations per pallet = 2 PCS

[redacted] = 24 000 *SEK per year*

---

[256] Lundin (2008f)
[257] Engström (2008)
[258] Lundin (2008c)
[259] Lundin (2008f)
[260] Lundin (2008e)
[261] Lundin et al. (2007)
[262] Hansson (2008a)
[263] Lundin (2008a)

Reduced searching with a WMS in the FGW:
Saved time per year = [redacted][264] hours
Cost for labor time for a SCA Personal Care forklift driver = [redacted][265] SEK per hour
Wait cost for lorry with driver = 275[266] SEK per every started half hour
Factor of actual waiting time for lorries = C_1%

[redacted] $= 1\,240\,000$ *SEK per year*
[redacted] $= 3\,480\,000 \times C_1$ *SEK per year*

Comment to the measurement of searching time
The factor for the actual waiting time for lorries, exists due to that the lorry drivers load the lorry a part of the time when forklift drivers search the warehouse. This factor could unfortunately not be concluded or estimated with such accuracy that it could be presented.

Reduced searching for Pick Pallets with a WMS in the FGW:
Time to search for one picking pallet on average = [redacted][267] minutes
Number of picking pallets that are created per day = [redacted][268] pallets per day
Number of working days per year = 350 days
Cost for labor time for a SCA Personal Care forklift driver = [redacted][269] SEK per hour

[redacted] = 220 000 SEK

Reduced shipment errors with a WMS:
Number of complaints due to errors in shipments = [redacted][270] complaints per year
Cost per complaint for at least five years ago = [redacted][271] SEK per complaint

[redacted] $= 1\,010\,000$ *SEK per year*

Determination of pallet characteristics

---

[264] Lundin et al. (2007)
[265] Lundin (2008a)
[266] Tengå (2008)
[267] Lundin (2008e)
[268] Lundin (2008a)
[269] Ibid
[270] Lundin et al (2007)
[271] Ibid

Since the FGW at present does not have a WMS the forklift drivers must take stock of which pallets that has a certain height.

Time for stock taking per year = [redacted][272] hours per year
Cost for one hour of labor time for a forklift driver = [redacted][273] SEK

[redacted] $= 59\,000\ SEK\ per\ year$

Reduced safety inventory due to less variation in output
Average safety inventory = [redacted][274] weeks of output
Average output = [redacted][275] cartons per week.
Average safety inventory = [redacted] cartons.
Average number of cartons per pallet = 31.3[276] PCS
Capital interest = [redacted][277]%
Pallet value = [redacted][278] SEK per pallet
Fixed cost for one pallet space = [redacted][279] SEK per month
Handling cost for one pallet = [redacted][280] SEK per month
Reduction of standard deviation = 21.6 percent

Total storage cost for one pallet
= [redacted] $SEK\ per\ year$

[redacted] $= 6\ 090\ 000 \times C_2\ SEK\ per\ year$

Comment to the calculation for reduced inventory due to less variation in output
The standard deviation can not be reduced with as much as 21.6 percent. Please follow the discussion in chapter 5.2. C_2 is a factor of how much of the entire bullwhip effect that can be reduced by improved forecasting.

---

[272] Lundin et al (2007)
[273] Lundin (2008a)
[274] Franvin (2008c)
[275] Lundin (2008b)
[276] Lundin (2008b); Lundin (2008f)
[277] Lundin (2008f)
[278] Ibid
[279] Lundin (2008e)
[280] Ibid

Stock value

Maximum capacity = [redacted][281] pallet spaces

Utilization of inventory space = [redacted][282] percent of the maximum capacity

Pallet value = [redacted][283] SEK per pallet

[redacted] *SEK*

[281] Lundin (2008f)

[282] Engström (2008)

[283] Lundin (2008f)

Appendix E – Data and calculations for stock taking

Stock taking in SCA-Ps FGW
Time per occasion = 3[284] hours
Number of occasions = 1[285] occasion per year
Number of persons that perform the stock taking simultaneously = 4[286] persons
Cost for one hour of labor time for a forklift driver = 201[287] SEK

$$3 \times 1 \times 4 \times 201 = 2\,400 \; SEK \; per \; year$$

Stock taking in S.A.
Time per occasion = 8[288] hours (inclusive transportation from Värnamo)
Number of occasions per year = 2[289] occasions
Number of persons that perform the stock taking simultaneously =2[290] persons
Cost for one hour of labor time for a forklift driver = 201[291] SEK

$$8 \times 2 \times 2 \times 201 = 6\,400 \; SEK \; per \; year$$

Stock taking in Personal Care FGW:
Number of times stock taking is taken = [redacted][292] times per year
The time required for this activity = [redacted][293] hours per time
Cost for one hour of labor time for a forklift driver = [redacted][294] SEK

[redacted] $= 67\,000 \; SEK \; per \; year$

---

[284] Carlsson (2008a)
[285] Ibid
[286] Ibid
[287] Johansson (2008b)
[288] Andréasson (2008)
[289] Ibid
[290] Ibid
[291] Johansson (2008b)
[292] Lundin et al (2007)
[293] Lundin et al (2007)
[294] Lundin (2008a)

www.plog.lth.se

LUNDS UNIVERSITET