Analysis of Implementation of RFID Technology in Retail Industry

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Summary

In today’s world cost optimization and better service are becoming the essential components of the retail supply chain. The thesis tries to contribute to the understanding of the RFID technology in the retail industry. The basic concepts and the research contribution of the various authors are briefed in the theoretical framework made for a better understanding to the readers. After gained the relevant theoretical knowledge, the interviews were conducted with the RFID expert and some retailers. The empirical data collected from the interviews and surveys are projected. With the empirical results and the relevant theoretical results, an analysis is made which explicitly gives the basis of implementation of RFID in the retail supply chain and its associated practical scenarios. Another outcome of the thesis is the result of the checkout analysis of the Willys retail store, and researchers try to show the potential benefit of adopting the RFID technology at item level at the point of sales, also cost estimation and savings are shown in the analysis. In a bird’s eye view, this research thesis work is a contribution to the implementation of RFID technology in the retail industry and its integration among the different entities of retail supply chain and improves the overall performance of supply chain and provide a framework for RFID implementation for the case company.
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1 INTRODUCTION

The first chapter of the thesis starts with introducing the background of thesis project. Following this the objective and research goals in the thesis work are presented and the delimitation at the end of the chapter

1.1 Background

Imagine, you are standing in front of your cabinet and thinking that one of your cardigans is quite worn off. With the help of your electronic advisor with touch-screen function built inside your cabinet you can see when you actually bought that cardigan. You have found that your cardigan is already about couple of years old, also you can find it already has lost 30% of its original color. With the help of your electronic advisor you search the same new product in your favorite stores or on the internet. You select some of the cardigans and order the stores to make those ones available for fitting in the store supposing you don’t like to order clothes through internet.

When you visit the store, you are welcomed by the big TV-screen without even showing your identity and loyalty cards. It automatically says your name and also informs you about some new offers as well that might you are interesting in and guide you the way to your ordered clothes. A small PDA (Personal Digital Advice) device attached to your shopping cart shows you the directions to the particular shelves. While trying some cardigans you can see information such as source of the wool, where and when was it produced and its expected life without losing its original color. After selecting one cardigan, the TV-screen shows offers to you of other products such as pants, shirts and socks that you would like to combine with you selected cardigan. It also informs you about some discounts if you combine it with the pants offered.

When you passed the check-out gate, a screen displays the clothes you bought and your ID verified automatically by the system and pay for the clothes with just one touch on the screen. Before taking on the clothes for the very first time, you want to have it washed so you put it into the washing machine which immediately recognizes the suitable washing temperature and quantity of detergent required for washing. All above mentioned looks bit strange but all could be possible with one technology, RFID. We don’t know exactly know all mentioned above will come true one day, only time will show which applications will be wanted and accepted by the public. Still it’s not clear how RFID will change our everyday life, but there is one thing we can said with certainty: RFID cannot be stopped anymore. “There is nothing permanent except the change”.

In this thesis work the authors have addressed the important issues related to the next big thing in worldwide retail and distribution, the RFID. RFID is a technology for tracking and information
which has existed for over 50 years, and Charles Walton from United States is considered as the
father of RFID (Takahashi, 2004), his work during the seventies is a basis for today’s RFID
technology. Here arises the valid argument that why we do not have RFID in wide use as it was
invented long back in 1970’s? Apart from Charles Walton and other scientists efforts for RFID,
during that time the technology was not enough advanced to use RFID on commercial basis
feasibly. It is only now possible with more development in electronic and microchip technology
to produce small RFID components, cheap and useful in sizeable levels.

Radio frequency identification (RFID) is a generic term, used to define a transmitting system
that identifies the object or person wirelessly, by means of radio waves. In mainstream
applications RFID is becoming the key technology that help speed the handling of manufactured
goods and material by the technology achievement in communications and microelectronics.
RFID identifies the object from a distance, unlike barcode technology’s line of sight
requirement. Uses of RFID technology can be found in several application areas such as supply
chain management, security, access control, etc. RFID system consists of three primary
components: a transponder (tag), a transceiver (reader) and a data collection device.

In today’s world, with heavily growing demand in the retail industry, there is an urge for material
availability, service and increasing competition. Due to increased speed in goods flow, greater
levels of automation and ever decreasing price and size of tags the importance and relevance of
RFID technology in worldwide logistics is substantial. Actually this is the functionality of RFID
that destined it to replace barcode soon. Also the Global competition between the retail stores
have forced the stores to rethink how they should provide the appropriate service to the
customers to sustain their place in the market.

Radio frequency identification technology has numerous potential applications and
accompanying technologies, and it depicts a subsequent incremental stage shift towards
improvements in retail business. Number of authors agreed that RFID has a bright future in the
retail industry as a replacement of barcode. Projects executed by the likes of Wal-Mart, Gillette,
Tesco and Procter & Gamble, etc shows admirable results and researches compared to current
scenarios lead us to believe that RFID implementation will drive us towards great changes in
future.
1.2 Thesis Objectives

Willys is a chain of retail stores that, like many other retailers in Sweden want to investigate the possibilities of using RFID in its various supply chain processes to enable a better and profitable flow of materials. After making contact with one of Willys store in Västerås (Erikslund), it was decided by the researchers to work on the basis for RFID implementation for Willys Sweden. (Kambil, 2002) argues that the problem with RFID is that implementations are relatively costly and that the actual efficiency improvements are often qualitative and therefore difficult to directly measure the financial values. Still it is beginning of RFID in Sweden retail market; this research shows generic results concluding the results after conducting interviews with the consultants in RFID and survey.

This research concentrates on the issues related to the implementation of RFID in retail market, possible benefits of RFID over barcode technology, hindrances in the implementation, main drivers, potential benefits of RFID both for the retailer and consumer sides, the current status of RFID in retail industry and also try to address the development and analysis of future scenarios where RFID technology can be used.

Also considering the item level tagging in Willys, for the sake of showing benefits from both retailer and consumer scope queuing analysis has done, which played an important role in calculating the payback period and costing. Conventionally in retail stores customers have to wait in the queue for checking out, we used queuing models to highlight the potential benefit of implementing RFID technology at the point of sales (POS).

1.3 Research Goals

1.3.1 First goal: Implementation of RFID technology in the Retail Supply Chain

In accordance to the thesis objective and to foresee a determined path to fulfill the objective, several research questions were framed. Also the research questions give a chance to know about the structure of the research work covered in the thesis.

- Why RFID is better than barcodes?
- Current status of RFID implementation in retail industry.
- Cost and benefits allocation among the retail supply chain.
- What are the major drivers for adopting RFID in retail supply chain?
- Area where RFID can be used in retail supply chain?

- What are the challenges faced in adopting RFID in retail industry?

1.3.2 Second goal: Evaluate the usage of RFID at Point of Sales (POS) in Willys Erikslund with the help of Queuing Theory.

1.4 Project Limitations

RFID usage in retail industry is an emerging area and hence not many research works could be found which integrates the stores supply chain. In our project we limit our scope to the retail section of RFID implementation, the field of RFID is very deep and demanding and there is a lot of potential in it. We have not work on the coding aspect of RFID as it doesn’t come under our area of work. The thesis has broader scope since we interviewed some representatives from Lidl KB, Ericsson Sweden. This is because the project initially started considering Willys in Erikslund was planned to have an in-depth study in supply chain but due to some permission issues we restrict it to the queuing calculations in Willys Erikslund. The interviews were carried out with people in relevant are to be possible extent. Also this research is kind of basics for pilot project for Willys; if Willys will ask us do more in future we can continue our work on implementing the RFID technology in Willys.

Research intention is to provide guidelines and general ideas about defined questions. Addressing all the possible situations and problems is not the intention of this research. Results shown by our research should be considered in research context and used as described in the chapters. Queuing and cost analysis should also be considered as a helping tool and not as perfect decision making tool.
1.5 Thesis Report Structure

This thesis will be organized as follow:

**Research Methodology**
Chosen research method discussion, tools used for carried out the study as well as the rules and recommendations were taken into account.

**Theory**
Analysis of primary resources considered useful for understanding techniques, calculations were relevant to the study and previous research and implementation that could be used for comparative purpose.

**Empirical findings and Results**
Collected information about the real scenarios through interviews and surveys.

**Analysis**
Interpretation of the empirical findings related to the information gathered in the theory section.

**Conclusions & Further study**
Results achieved through analysis and recommendations developed by analysis.

Figure 1 Thesis Structure
This chapter is written to present the research methodology that has been used to achieve the purpose of this thesis. Literature review of the thesis, the interview preparation and conducting of interviews are presented in this chapter.

2.1 Research Methods

Research is the systematic investigation of existing or new knowledge. It is used to establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories. (Sagar, 1999)

The first step is to present the situation in a specific research area and from there to find a problem that is relevant to investigate. The problem is something to be solved, illuminated or simply something where there is an interest to expand knowledge. The problem is formulated so that it leads to a general purpose describes what the study aims to achieve. The aim was to broadly examine how to implement the RFID technology in retail industry. The aim was then broken down to more specific questions. Furthermore, to determine the direction and limitations of the thesis previous studies analyzed and compared with the actual subject of the inquiry.

2.2 Research Approach

In every research, researchers need to decide which cognitive tool to use to help themselves in better understanding unknown and answering their research questions. Yin (2002) and Leedy (2000), define several different categories of research; descriptive, explanatory, exploratory, qualitative, quantitative, etc. In our research we chose both quantitative and qualitative method as per our requirements i.e., answering our research questions by analysis of different articles, conducting interviews and surveys and justifying our work by doing queuing calculation with the help of empirical data provided by the case company.

2.2.1 Quantitative Research

Quantitative research is based on empirical data and present numerical results; hence they possess high validity and creditability. Quantitative research is able to answer questions related to “how many” and “how much”. According to Creswell (2002), quantitative approach is useful when attempting to test an explanation or identifying factors that influence results.
2.2.2 Qualitative Research

This research is more subjective and interpretive. According to Patton (1990), qualitative data are detailed description of situations, events, people, interactions, observed behaviors, direct quotations from people about their experiences, beliefs and case histories. Creswell (2002) also says that qualitative research is suitable for researching a phenomenon in that area research has not been done extensively. Many authors agree that both approaches can be combined in many instances.

Furthermore, Leedy (2000) explains, descriptive studies involve either identifying the characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena. For exploratory research, Yin (2002) state that exploratory studies seek to realize and clarify what is happening with the intension of developing new hypotheses and theories. Explanatory research aims to explain the research problem in greater detail and is mainly related to why and how questions.

2.3 Literature Review

Literature review is an analysis of the research work done in a specific domain. According to Hart (1998), literature review is the selection of available documents on the topic, which contains information, ideas, data and evidence. This selection is written from a particular standpoint to fulfill certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research is being proposed” (Hart, 1998).

Purpose:

The purpose of literature review is to manifest the scholarly ability to discover the relevant information for the scope of the work, build a supportive theoretical framework for the subject, defining the key words, definitions and terminologies, identifying previous research works and to rationalize the research topic.

Writing a review:

The writing starts with identifying the research questions followed by analyzing and locating the needed information. According to Hart (1998) the first step should be writing a draft considering the expectation and the needs of the readers. Next step is reworking the draft, considering about clarity and structure of the paper until obtaining a final draft. Finally, check the grammar and spelling, the literature review is done.

Before framing the interview questions a deep study has been performed within the research area of RFID, supply chain and retail industry along with the connected relevant literature. This study was performed to get a better understanding about the concept and also to make the discussions more interesting and interactive during the interviews.
2.4 Interview Preparations

The questions forms were designed according to the type of representative to be interviewed. Two types of questions forms were prepared in context of RFID and retail supply chain. The main objective of the question forms prepared is to know what are the perspectives of retailers in the field of RFID.

2.5 Questionnaire Preparation

The questions for the questionnaire were formulated in accordance to the objective of the thesis. The main requirement for questionnaire is to reduce the interview duration and to make the interview sessions easier and with better conclusive understanding. The questions framed have relevancy with the research questions stated. Some of the questions were given with multiple choices, some with rating (agree, somehow agree, and disagree) and respondents were also provided with an option of answering on their own. The interview and survey questions are available in Appendix section.

2.6 Conducting the interviews

Interview is the most common used method in qualitative research. Bryman (2001) mentioned many types of interview such as open interview, standardized interview, semi structured interview and so on. But most common types of interview are structured, semi-structured and unstructured (Bryman, 2001).

In this thesis work, the researchers have used semi-structured interview. Bryman (2001) defined that “Semi-structured interview is a term that covers a wide range of instances. It typically refers to a context in which the interview schedule but is able to vary the sequence of questions. The questions are frequently somewhat more general in their frame of reference from that typically found in a structured interview schedule. Also, the interviewers usually have some latitude to ask further questions in response to what are seen as significant replies”.

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3 THEORETICAL FRAMEWORK

This chapter explains the fundamentals of RFID such as history, origin, function, uses and related research. The chapter also includes the introduction of retail supply chain and queuing theory for the sake of investment decisions on RFID systems.

3.1 Barcode Technology

Automatic identification is used to identify people, animals, goods and products in motion (Finkenzeller, 2003). There are various techniques used for identifying in different application areas, including smart cards, optical character recognition (OCR) and biometric identification methods such as voice recognition. In this group RFID and the most widely used technology in the category bar codes are also included. Bar codes are popular because they are cheap and easy to use. Disadvantages and limitations however, meant that alternatives have been developed to meet the higher standards of transparency and security in a variety of applications.

Bar codes are composed of a binary code represented by different thicknesses of the black lines gap of variable size which is read by an optical laser directed toward the bar code and reflection of the laser determines the tagged object's identity (Finkenzeller, 2003). There are different types of bar codes based on different standards but the most common is the EAN (European Article Number), which consists of a set of numbers in a range of numbers. The most common standard the number ranges is EAN 13 (i.e. 13 digits of the serial) and it contains information about country of origin, company, manufacturer's part number and a final check digit. In the United States they use standard UPC (Universal Product Code) and then EAN is a development of the UPC, it has become subordinate EAN standard and are compatible with each other (Hunt, 2007). Advantages with the technique include that it is cheap and easy. Disadvantages are that the bar codes can hold some information must be read one by one and convenient and they do not work when they are dirty (Finkenzeller, 2003).

Figure 2 EAN 13 Barcode (Source: Gray, 2009)
3.2 RFID Technology

3.2.1 What is RFID?

RFID stands for Radio Frequency Identification and refers to the transfer of information via Radio frequency (Finkenzeller, 2003). RFID system uses wireless radio communication technology to identify tagged objects or people. The three basic components of RFID system are:

- **Tag**: Sometimes called a transponder and composed of a semiconductor chip and an antenna.

- **Reader**: Also known as an interrogator, and composed of an antenna, RF electronic module, and a control electronic module.

- **Controller**: Also known as a host, which most often takes in form of a PC running database and control.

The technique has many applications such as tracking of goods, automatic duty stations, the identification of newborns, the card to open doors or pay for public transport etc (Hunt, 2007).

RFID is compared mostly with barcodes because they both can be used in similar ways and in many similar areas, though RFID is a more advanced technology. An example of the differences is that an RFID reader can identify a large number of objects around the same time while barcodes can only be identified one by one.

A barcode must be placed visible just in front of the reader to be read while an RFID tagging or "tag" can be read at long distances away, through most materials and for a higher speed and precision. The disadvantages are that there are many different standards, implementation of an RFID system is complex and it is more expensive in the current situation (Banks, 2007).

![Figure 3 Different types of RFID Tags (Source: Nearfield, 2012)](image)
RFID
Barcode

<table>
<thead>
<tr>
<th>Data</th>
<th>Large amount</th>
<th>Small amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readability</td>
<td>Many can be read at once, they can be read at long distances, even if they are dirty and made by various materials.</td>
<td>One read at a time, they must be visible, clean and undamaged.</td>
</tr>
<tr>
<td>Implementation</td>
<td>More complicated</td>
<td>Easy</td>
</tr>
<tr>
<td>Cost</td>
<td>Higher per tag</td>
<td>Very cheap</td>
</tr>
<tr>
<td>Safety</td>
<td>Difficult to access data, almost impossible to copy and change</td>
<td>Very easy to read and possible to copy or change</td>
</tr>
</tbody>
</table>

Table 1 Comparison of RFID and Barcode (Source: Hunt, 2007)

3.2.2 RFID History

The technology behind RFID did not have a precise moment in history, and grew up with using a variety of other technologies and research. It started with a better understanding of electromagnetic energy in the late 1800s that led to the development of radio communications and radar systems (Hunt, 2007). The radar system was an anti-collision system (More signals can be read and receive simultaneously) and its use during World War II for identifying the enemies can be considered the first RFID use. The invention of the transistor in 1947 led to smaller and cheaper components could be manufactured and that is what makes RFID tags become cheaper every year.

Harry Stockman in 1948, invented how the radio waves could be sent away to a receiver, also power supply helped to send a signal back and that was the basis for today's passive RFID tags (Banks, 2007). Further research in radio frequency technologies led to several inquiries regarding applications and at the end of the 60s, RFID used for the very first time commercially (Hunt, 2007). A major problem with RFID was the size of the tags, but this began to change in 1971 when the first microprocessor came and then the tags could be smaller and more sophisticated. However, it was in the 1980s as the commercial uses of RFID increased and included key fobs, access cards, cattle marking, and some applications in rail transport.

1990 onwards came with a lot of RFID use, fairly due to IT technology had evolved so much and that there were opportunities to put together the network and manage information in a better way. But still material costs and lack of standards prevented the technology to have a greater impact than.
The prices of RFID was reached relatively low levels began in the 2000s and then RFID could actually replace bar codes in the long run. The U.S. armed forces and Wal-Mart have since the mid-2000s had raised the demands of its suppliers using RFID, but the complexity and cost is still an obstacle for many suppliers (Hunt, 2007).

![Figure 4, 5 Radar and Microprocessor technologies (Source: Shyshkin 2010 & Gangar 2009)](image)

### 3.2.3 RFID Working Principle

RFID system consists of tags or transponders (transmitters), interrogators (readers) and a controller (database) which is usually a computer connected to a network with middleware (software that controls how the system works). The purpose of middleware is to process large amounts of data, aggregate the data and sends it to the business system database.

The information which is received by the system, for example, cause the system to warn when hardware is not working properly or that a new order of a product is recommended because it is about to end in the store (Hunt, 2007).
The tags are comprised of a printed circuit board (PCB), an integrated circuit (or chip), and an antenna. The circuit board holds together the tag and may consist of different materials, depending on the use of the tag. The chip is a collection of components required to keep information and get the tag to function properly. The antenna is responsible for sending and receiving radio signals for the reader (Banks, 2007).

There are several types of tags with different advantages and disadvantages. The simplest and least expensive tag is the passive without an integral source of energy to transmit information. It
means that the energy the tags need to send back information is received through the antenna when the reader sends a radio signal.

The advantages are that they can be manufactured very small and that they are relatively inexpensive to manufacture. The disadvantages of passive tags are, reading must be taken in the short distance from them and they include a relatively small amount of information. Some more advanced tags that can read at a great distance and which holds much more information is known as active tags. They need a battery to power the tag's functionality and subsequently larger and more expensive (Hunt, 2007).

A third type of tag is the semi-active, which contains a combination of passive and active functions. To save the battery switch the active portion of the tag in a sleep mode when not in use and is "awakened" to the passive tag for receives a signal. Semi-active tags have an advantage when there is a quick reading, but with long intervals between readings and the signal sent back from the tag needs to be able to reach rather longer (Banks, 2007). There is another way to divide the different tags and this is based on their memories. Generally, they can be divided into tags that can contain only the information printed at the first time and after that they are only readable, and the tags where information can be changed, they can be "reprogrammed" several times. The first type is obviously cheaper but both have areas where they are best suited (Hunt, 2007).

Readers have the function to read RFID tags (and adding energy if they are passive), data from the tag to the computer system, and where possible, they can also be used to enter new information on the tags. Readers also workout on these three parts: an antenna, a module to communicate with the tags and a module for communicating with the database. These are three additional features that readers need to be accommodated (Hunt, 2007).

![Figure 8 Different types of RFID readers (Source: Cisco, 2011)](image-url)
A problem with the use of RFID is that there are different standards for the technology to work. These standards describe how communication should work in RFID system and the information obtained from RFID infrastructure (Banks, 2007). Examples of how it will work are what frequencies to be used on radio signals and the manufacturing of the tags to be done. Regarding the information to be included in the tags, there are two major standards that dominate to become the new standard, EPC (Electronic Product Code) and ISO (International Organization for Standardization). However, it is still possible and common to use the simpler standards such as EAN and UPC in RFID tags (Hunt, 2007).

EPC provides a universal product code which is unique to every product manufactured around the world and is therefore known as EPC global, just as organization responsible for them. EPC codes are not available exclusively for the RFID technology, but its complexity makes it best suited for use in RFID tags (Heinrich, 2005). ISO is an organization providing a range of standards to help companies to do business with the help of common rules. This includes standards in many areas in addition to information standards such as environment, service, equipment and quality (Banks, 2007).

Figure 9 Example of an EPC global product code (Source: Hodder, 2003)

3.2.4 Research in RFID

A study by Alexander (2002) has revealed how Automatic identification and RFID improve efficiency in supply chain, revolutionizing the purchase of an organization and greatly increase standard of customer service. RFID considered increasing security against theft, reducing wastage and streamlining the planning process. For labeling at the item level are significant advantages in goods receiving, inventory and payment in cash is quicker and more efficient so that more resources can be put on such as customer service. A major problem can be solved by RFID technology is that items are out of stock, which in turn is due to new products not ordered in time when it was unclear which and how many were in stock. By comparing the implementation of RFID in 21 different companies in different industries, Ferrer (2009) concluded that there are four basic benefits of technology for the majority: reduce the amount of
work through automation, shorter cycle times, make use of self service and prevention of losses. Roh (2009) believes that there are three factors that influence when companies decide to implement RFID; the first is demand from customers, suppliers or competitors, the second is the benefits expected from the RFID into use, cost savings through less theft, less need for labor and equipment expenses, and transparency in the supply chain and the final factor is that new business processes and new products are created.

In a study of Montauti (2006), he explains how the development of RFID tag production is moving forward all the time, they become smaller, more durable, the increased data capacity and reduces in price. When the author believes that the cost is the deciding factor for many companies that are waiting of investing, it is only a short matter of time before RFID technology will be everywhere. Zhou (2009) determines that the automatic production of products with many components does not work with bar codes because of the difficulty of tracking all parts. He considers the need RFID to manage such a complex process and for traceability, but also safer and more efficient reading as many tags can be read simultaneously. He also points out in his studies that with RFID tags and readers on the shelves of a store can indicate the low quantities of a commodity detected earlier and results in fewer customers lost.

### 3.2.5 RFID in Sweden

The use of RFID in Sweden is extensive in many applications and industries. It used for example in libraries, as well as theft prevention and to more easily find books and sort them, but also for customers to borrow and return books on their own. There is also an increased efficiency factor in that you can borrow a whole bunch of books in one time (Edwards, 2008). Cattles that have to be labeled can have an RFID tag in the ear that simplifies the administrative work, allowing the monitoring of animal growth and allows tracking of the flesh origin up to the end user (Givens, 2004). Home care services use RFID on the employees and to be able to register during which time they have been out of the customer and partly because they can unlock the door if something has happened and the customer cannot open (Given, 2004). Just to use RFID technology to unlock the doors is something that is becoming increasingly common in houses, offices and laundry rooms (Given, 2004).
3.3 Supply Chain Management

3.3.1 Definition

Council of supply chain management professionals (CSCMP) defined supply chain as “Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales product design, and finance and information technology.” (Council of Supply Chain Management Professionals, 2001)

3.3.2 Retail Supply Chain

“Retailing is the set of business activities that adds value to the products and services sold to consumers for their personal or family use.” (Levy, 2001). However retailing is not only consists of selling products and services in stores but through many channels including internet, direct sales or advertisement sales. Retailers work as a link between the consumers and manufacturers of products and services. Competition increment and enhancement in the supply chain complexity are the now a day’s problems for retailers everywhere in the world. Business connectivity, global sourcing and advance technologies are the new challenges for the retailers that are increasing rapidly and it’s becoming mandatory for the retailers to manage their supply chain in a manner to stay competitive in the industry.

According to Sikander (2005), Retail supply chain consists of the entities – suppliers, manufacturer, distributor, retailer and consumer.

Figure 10 Retail Supply Chain Entities
A typical integrated retail supply chain has the following elements as listed in the table below:

<table>
<thead>
<tr>
<th>Merchandise Planning</th>
<th>It is an approach aimed at maximizing ROI through proper planning of sales and inventory. This approach is all about maintaining a balance between sales and inventory in order to increase profitability.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assortment Planning</td>
<td>Retailer’s planning for selection of merchandise (what and how much)</td>
</tr>
<tr>
<td>Sales Planning</td>
<td>Planning contain assessment of sales for a product in the market to reach the customers target.</td>
</tr>
<tr>
<td>Price Management</td>
<td>Process of improving, managing and improving processes of prices using forecast statistics and has direct impact on profits.</td>
</tr>
<tr>
<td>Promotion Planning</td>
<td>It is the process of managing promotions that drives demand and profit and depends on forecast data.</td>
</tr>
<tr>
<td>Replenish, allocation and scheduling</td>
<td>Process required to avoid Stockouts of products and has potential to reduce inventory and influence improved customer services.</td>
</tr>
<tr>
<td>Warehouse management</td>
<td>It is the process used to improve products distribution across different facilities and has potential to reduce inventory.</td>
</tr>
<tr>
<td>Distribution</td>
<td>Process of distributing accurate products to the corresponding destinations.</td>
</tr>
<tr>
<td>In-store operation</td>
<td>It is the process of managing operations including goods receiving, shelf stocking, and order placement of products for replenishment.</td>
</tr>
<tr>
<td>Sales</td>
<td>It manages the ‘sales’ process which is directly associated with the revenue generation.</td>
</tr>
<tr>
<td>Return</td>
<td>It is the return merchandise management.</td>
</tr>
</tbody>
</table>

Table 2 Elements of integrated retail supply chain (Source: Vargas, 2007)

### 3.3.3 RFID in Retail Supply Chain

Twist (2005) states that although the major advantage of RFID is achieved if the whole supply chain is involved, but there are tangible benefits to the retailers, for example, losses are reduced by two thirds with using an RFID system. According to a study by Gruen (2002), retailers lack an average of 8.3 percent of cases when might have sold to customers, and it depends on incorrect orders and forecasts in half the cases. In a quarter of cases, it depends on the problem earlier in the supply chain, such as delayed shipments and production fault. The last quarter is responsible for the shortage is that goods are in stock but that shelves are not replenished.
Chappel (2003) looks at the problems RFID can help both the dealers and customers. They can fix the deficiencies or can be avoided, fewer resources need to be on the receiving of goods, loading, payment and inventory and the wastage can greatly reduce. For customers' advantage avoid the long queues at the tills, goods are often in stock and if an item is at the wrong place in the store, it can still be easily found by using RFID. Further studies on how RFID affects customers have been made by Eckfeldt (2005), he points out that the potential for tracking of tags means that technology is a threat to privacy and to successfully implement RFID technology in consumer goods, a company needs to present the advantage that technology go beyond to some of private information that is visible.

A research conducted by Atah (2005) shows that the goods sold affect how demand is calculated, as theft and wastage allowance should be included to make the correct orders. Also the products that have passed its sell-by date and the products standing in the wrong place so that customers cannot find them. The introduction of RFID is considered to have two valuable properties: The first is that visibility means better view of the store's actual inventory and thus, more accurate orders and refills done. The second is that the more information about the store's inventory, losses and theft is reduced.

A completely different application of RFID in stores proposed by Zhou (2009) where the customer membership card contains an RFID tag and the prices of goods are updated depending on the customer previous purchasing behavior, and based on sale offers, discounts, etc. Customer-specific adaptation of this kind makes the prices can be added at levels appropriate to each client the best and through different offers to get them to come back more often and buy more. In a recent study by Çakıcı (2011) studied how the handling of drugs may be improved if a switch from bar codes to RFID is carried out. With the automatic inventory update in real time, losses are reduced sharply, leading to savings in inventory and lower shortage and ordering costs. According to the author the obstacles that must be regarded as the hindrance between RFID implementation should be disappear when more people are using RFID so that standards are set and costs go down. A number of studies have been made in inventory and what RFID can have on impact on it. Rekik (2008) focuses on the impact that RFID can have on inaccurate inventory levels due to products have been placed in the wrong place at the store. Gel (2010) argue that many stores inventory levels is not correct because the input from the sale of goods takes place at the wrong place and that RFID could eliminate that problem. In another study of Rekik (2008) examines the impact of the theft has been on wrong inventory levels and how RFID can reduce the amount of faults.
3.3.4 RFID Benefits

3.3.4.1 Retailer Benefits

Real time Inventory Information

With RFID, retailer can have real-time inventory information that can help to prevent stock outs, locate stock within a store to avoid shrinkage of inventories, and can help to enable retailer to use more yield effective pricing strategies.

Decreased Labor Costs

RFID technology provides practical elimination of the need for human checking of stock. Labor reductions will be realized in the following areas of retail operations; receiving, stocking, check out, cycle counting and physical counting.

Prevention of Theft, Shrink and Inventory Write Offs

In retail industry ‘Shrinkage’ is a term used to describe inaccurate inventory counts as a result of customer theft, employee theft, inaccurate inventory counts due misplaces items, and stock reordered because items are on a display shelf in another area of the store. RFID technology has the potential to alert staff when items are being removed illegally, or when they have been misplaced within the store. This can assist in theft reduction and also provide real-time accurate inventory counts automatically.

Integrated Opportunities

The RFID technologies will offer retailers new and unlimited marketing opportunities. The tracking of customers’ purchases before they leave the store offers retailers information that can immediately be used for the cross selling other related products. In-store suggestive selling allows retailers to communicate with shoppers while they are shopping in an effort to encourage them to buy an additional and complimentary item (USA Strategies, 2005).

3.3.4.2 Consumer Benefits

Consumer Savings

Most notably, consumer savings will result due decreased costs in the supply chain. Currently, companies approach supply and demand in the only way that they know how. They produce goods in the hope that customers will buy them. Of course, historical information and trends are utilized, but it is by no means an exact science. Conversely, RFID will allow companies to better match up supply and demand. Manufacturers will not produce vast quantities of product that will not sell and retailers will not overstock excessive amounts of product destined to sit on store
shelves gathering dust. RFID will enable companies to more quickly identify goods that can need to be discarded or replenished. This in turn will give the customer access to a better and fresher product. In the long term, this will also lead to a decrease in pricing for the consumer.

**Authenticity and Improved security of prescription drugs**

RFID can also be used to distinguish genuine products from counterfeit products. It is a key consumer benefit given that counterfeits could potentially contain decreased dosages and elements as opposed to the genuine. Currently, consumers have no fool proof method of vetting their prescriptions which could lead to potential health issues associated with ingesting counterfeit drugs.

**Efficient Recalls will reduce Deaths and Injuries**

More reliable and faster product recalls along with proved food safety. RFID can be used to identify and recall outdated products, which will further enhance consumer safety (USA Strategies, 2005).

### 3.3.5 RFID Implementation Challenges

Successful RFID implementation strategy takes time and effort. A full-fledged system implementation in a large manufacturing company can cost $10 to $25 million (Mohsen, 2012). Considering the initial costs of RFID, there is no return on investment (ROI) for companies that implement the technology if compliance is the only pursuit.

RFID technology faces numerous implementation challenges. The major challenges include technological maturity, global standardization, government regulations and cost as summarized in table below

<table>
<thead>
<tr>
<th>Levels</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental</td>
<td>- High capital costs.</td>
</tr>
<tr>
<td></td>
<td>- Challenges in finding the ROI</td>
</tr>
<tr>
<td></td>
<td>- Challenges in finding the “drivers” for adoption</td>
</tr>
<tr>
<td>Technical</td>
<td>- Imperfect read-rates</td>
</tr>
<tr>
<td></td>
<td>- Unproven systems</td>
</tr>
<tr>
<td></td>
<td>- Problems with assembling low-cost tags</td>
</tr>
<tr>
<td></td>
<td>- Uncertainty about the role of the middleware</td>
</tr>
<tr>
<td></td>
<td>- Lack of in-house experts to implement RFID</td>
</tr>
<tr>
<td>Security</td>
<td>- Concerns regarding the compromise of data</td>
</tr>
</tbody>
</table>
| Privacy Issues / Government Regulations | during wireless transmission  
|                                         | - Uncertainty around security of data storage and physical security of storage site  
|                                         | - Privacy concerns and the potential for legislation  
|                                         | - Uncertainty around standards |

Table 3 Challenges in implementing RFID (Source: Mohsen, 2012)
3.4 Queuing Theory

Generally all of us do not like to wait, usually high investments are required to reduce the waiting times in the queues. For making decision whether or not to invest, most important is to study the effect of the investment on the reduction of waiting time. For this particular purpose models and queuing techniques are used.

“Queuing models provide the analyst with a powerful tool for designing and evaluating the performance of queuing systems.” Banks (2001). Usually customers arrive at a service facility and wait to have a desired service. It is up to the customer to choose a queue of server according to some mechanism i.e. shortest queue or shortest workload. (Adan, 2000)

3.4.1 Queuing Process

Customers’ service requirements are fulfilled over the period of time by the input source. A service mechanism performed and handled the whole process, after that customer leave the queue. According to Babbar (1996), there can be three types of models, model with a single queue and single server (figure 11), model with single queue and multiple servers (figure 12) and a model with multiple queues and multiple servers (figure 13)

![Figure 11 single queue with single server, Model 1 (Source: Babbar, 1996)](image-url)
In the above models, three sub-processes can be distinguished:

**Arrival process** includes the number of arrival of customers, types of customers, customer demand types, arrival distance and intensity of arrival.

**Waiting process** includes queue length, nature of service (First in first out).

**Server process** includes server type, rate of service and service time.

<table>
<thead>
<tr>
<th>Sub-process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival process</td>
<td>Arrival process includes the number of arrival of customers, types of customers, customer demand types, arrival distance and intensity of arrival.</td>
</tr>
<tr>
<td>Waiting process</td>
<td>It includes queue length, nature of service (First in first out).</td>
</tr>
<tr>
<td>Server process</td>
<td>Server process includes server type, rate of service and service time.</td>
</tr>
</tbody>
</table>

Table 4 Sub-processes of queuing model
Usually the queuing model is labeled as M/M/c/K, where first M represents Markovian exponential distribution of inter-arrival times, second M represent Markovian exponential distribution of service time, c represents the number of servers, and K is the specified number of customers in a queuing system. This general model contains only limited number of K customers in the system. However if there are unlimited number of customer exist, which means K= infinity, then our model will be labeled as M/M/c (Hillier, 2001).

3.4.2 Queuing Models parameters

- **n** Total number of customer in the system
- **C** Number of servers
- **λ** Arrival rate of customers
- **μ** Service rate of server
- **cμ** Service rate ( when c>1)
- **p** Utilization factor = \( \frac{λ}{cμ} \)

3.4.3 Notations for Queuing models

**\( P_o \)** Steady-state Probability of idle servers in the system,

\[
P_0 = \left( \sum_{n=0}^{c-1} \frac{λ^n}{n!} + \frac{γ c^c}{c!(1-γ)} \right)^{-1}
\]

Where \( γ = \frac{λ}{μ} \)

**\( P_n \)** Steady-state Probability of n customers in the system

\[
P_n = \frac{λ^n}{c!c^{n-c}μ^n} P_o \quad n > c
\]

**\( L_q \)** Average number of customers in the waiting line

\[
L_q = \frac{γ c^c}{(c)! (1-γ)^2} \times P_o
\]

**\( W_q \)** Average waiting time the customer spends in the queue excluding the service time

\[
W_q = \frac{L_q}{λ}
\]
Due to the complexity of multiple queues networks (figure 13), no predefined formulas can be used for the solution. Simulation is use for solving the networks with multiple queues and the above formulas we can use for solving the problems with the models shown in (figure 11) and (figure 12)

3.4.4 Queuing cost

Queuing system designing usually involves on one or the combination of the following decisions:

- Number of servers
- Servers efficiency
- Number of service facilities

Trade-off decision is the problem in virtually every queuing situation. We have to weigh the added cost of providing rapid service i.e. more checkout counters, service staff, against the inherent cost of waiting. For instance, if employees are doing data entry manually and spending all their time in it, so we would have a process improved by comparing the cost in investing in barcode scanners against benefits of increased productivity. Similarly, if customers are leaving the queues due to insufficient number of customer support employees, we can compare the cost of hiring new personals to the value of increased revenues and maintaining customer loyalty.

Relationship of queuing cost and service capacity can be depicted graphically (figure 14). We can observe initially the cost of waiting in the queue is at a peak position when the service capacity is at minimal. As the service capacity increases, number of customers in the line and their waiting times reduce as well, which overall decreases the queuing cost. Ideally the optimal total cost is found at the intersection between the service capacity and the waiting line curves.
Mathematically the total cost can be calculated by following expression:

\[ E(TC) = E(SC) + E(WC) \]

Where,

\( E(SC) \) is the cost of service

\( E(WC) \) is the cost of waiting

### 3.4.5 Use of simulation in queuing models

It is a method that analyze how system utilize the limited resources to the elements waiting to be served, while waiting elements may show discrete variability in demand, arrival times and processing levels.

Queuing systems with classification of M/M/c structure shows more than one queue or multiple queues providing number of customers in the system and in a queue is finite, for solving those models computation and calculations are difficult. Analytical computation of service rate is very difficult or almost impossible, Monte Carlo simulation is applied to get estimations. “A standard Monte Carlo simulation algorithm fix a regenerative state and generate a sample of regenerative cycles, and then use this sample to construct a likelihood estimator of state” (Nasroallah, 2004).

Figure 14 Graph showing the cost of queuing (Source: Operation research, 2009)
Even though supermarket sales do not have regenerative situation but simulation here is used to generate estimated solutions.

3.5 Investment Assessment

There are hard and soft values in an investment, the hard is easier to assess based on whether cost data and data on flows of goods are available. In the case of the soft values may be either reasonable estimates can be made or taken decisions on expectations.

3.5.1 Investment calculation

There are several ways to count on an investment. The most common are capital values (present value method), the payback method, annuity method, internal rate of return method and the Return on Investment (ROI). All methods require that the company's cash flow is known that all payments made at the end of the year and that money is stable throughout the investment period (Olsson, 2011).
4 EMPRICAL RESULTS

This chapter is divided into two parts; the first part presents the findings about RFID implementation in retail industry through interviews and second part shows the survey results regarding RFID implementation.

4.1 Findings through Interviews

In order to validate and check if the findings or this research are in line with what is really happening in day to day implementation and exploitation of RFID technology, few experts from the field and retailers were contacted and interviewed. The intention of the interview was not necessarily to gain any new knowledge in the part of RFID as a technology and its implementation shortcomings it was more to found out if the practical side of the business aligns with what researchers are doing and forecasting. Six interviewee were contacted from different companies and different parts of the RFID spectrum for increasing the scope of interview process and to allow more complete picture at the end of the research. All interviewed persons have retail supply chain background and the common focus has been maintained through the interviews and different perspectives were gained on the same issue, which were then compared for common factors. The selected experts do not represent any kind of majority of RFID experts or a general opinion, but they do show that these problems exists in real life and thus some sort of solution would be appreciated.

The following individuals were interviewed:

<table>
<thead>
<tr>
<th>Interviewee Name</th>
<th>Company</th>
<th>Designation</th>
<th>Interview Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emil Engstrom</td>
<td>Willys</td>
<td>Store Manager</td>
<td>27-08-2012</td>
</tr>
<tr>
<td>Hamid Munir</td>
<td>Ericsson</td>
<td>Business Analyst</td>
<td>06-09-2012</td>
</tr>
<tr>
<td>Jonas Hane</td>
<td>Lidl KB</td>
<td>Goods Receiving Manger</td>
<td>14-09-2012</td>
</tr>
<tr>
<td>Erfan Choudary</td>
<td>Lidl KB</td>
<td>Senior Quality Controller</td>
<td>13-09-2012</td>
</tr>
<tr>
<td>Moiz Iqbal</td>
<td>Tesco</td>
<td>Research Assistant</td>
<td>20-09-2012</td>
</tr>
<tr>
<td>Asher Altaf</td>
<td>Agility Pvt Limited</td>
<td>Fleet Manager</td>
<td>28-09-2012</td>
</tr>
</tbody>
</table>

Table 5 List of Individuals interviewed
4.1.1 Retail Supply Chain with RFID

Hamid (Ericsson) describes a vision for what technology can be used, leaving it to the companies to implement the technology, he counts from manufacturers, retailer’s warehouses and retailers. The main advantages for manufacturers are that they can smoothly locate all the goods and know exactly where everyone is, and how many they have sent away. For retailers warehouses there are large gains by the introduction of RFID technology, when the cargo arrives or leaves warehouses, RFID reading frames at the doors of the docks recognizes what it is and where it should be placed. The inventory and picking process is facilitated by RFID technology as well. It involves a range of possibilities, including knowledge of the products’ exact location, quantity, durability, and a variety of other useful information. This can be done automatically instead of manually doing all the work of reading the barcodes, it reduces the workload and makes working with the registration of the goods time efficient, safer and more reliable. (Hamid, Ericsson)

The stores face similar challenges that of retailers’ warehouses. An important part is ensuring that the right products reach the right place and in the right quantity. In addition to that the tags can act as point of sale facility, now it is possible in stores where customers can pack the goods in the cart, and system read the cart when the customer passes the checkout. This could mean significant staff reductions. (Hamid, Ericsson)

GS1 Sweden looks at longer-term interactive RFID technology will also help the customers in the stores. When a product is picked from the shelf, information about related products and services presented to customers. While the home may be part of the chain of information with refrigerator inventory itself and will notify you when the milk has become old. (GS1, 2012)

4.1.2 Implementation level of RFID in retail industry

Hamid believes that it should be manufacturers’ job to apply RFID tag to the product or its packaging, also what type of information that is stored and how it will be used will determine the tag attached. Attached Information is useful for the end users, such as price and content, stored in tags at the product level. Information for other parties in retail chain attached to boxes or pallets.

According to Jonas (Lidl) Pallets will be labeled with RFID tags within 2-2.5 years. At product level, grocery stores more hesitant about the technology will have an impact and a potential impact is far in the future. Erfan (Lidl) says in Sweden, the development of RFID is not as in Germany and the USA, the Metro Group and Wal-Mart put the requirements of on their suppliers but in Swedish market, retailers do not have a direct impact on their suppliers.

RFID technology can lead to improved ordering system. When inventories throughout the value system automates the various actors along the chain early to see what will be in demand in the
future and to regulate their activities to meet the demand of goods, instead of the estimated demand. The whole system becomes more flexible with reduced costs. (Hamid, Ericsson)

M.Iqbal, research assistant at TESCO, identify three areas where RFID technology may lead to improvements, these are elimination of error-handling organization, reduction of capital and unnecessary stock. M.Iqbal (Tesco) believes that grocery chains with large flows of goods can save millions of dollars with RFID tags instead of barcodes, as it is in practice today. M.Iqbal (Tesco) argues that if companies adopt RFID-technology instead of barcodes, the number of unreadable units decrease to very low levels. This could lead to that the mishandling organization, which include buffer and safety stock, would be eliminated.

According to A.Altaf (Agility), logistics companies see benefits of RFID in traceability of goods, and the security it brings high and see great potential in this. Traceability means better control and less wastage. Further benefits that RFID technology will be able to carry is that goods will not be needed read optically and can be read by radio waves. This means among other things that the readers can be installed in such doors and all cargo that passes these ports read and recorded. Information on cargo exact position is also expected to facilitate the work of logistics groups. The management of freight would become more rational. A.Altaf (Agility Services) said logistics companies do not see any cost savings in the implementation of RFID technology. For them it’s just a competitive tool and the logistics companies which are not directly couple with their chains will not implement it.

Jonas (Lidl) thinks that the losses they are bearing on cargo between the warehouses and shops will be drastically reduced if they fitted with RFID tags. It could be tracked and the high costs that entails reduced wastage. In addition, the labeling of load carriers also means that the full control is available on how many packages available in specific locations. Jonas (Lidl) also sees the benefits of labeling on the product level. This would lead to the inventory facilitated by the so-called "smart shelves".

Emil (Willys) sees RFID technology simpler and but expensive than the barcodes. He argues that the greatest benefits may be the technology in central warehouse where pallets come from different vendors and to be reloaded for further transportation to the stores. He believes that RFID technology will have an impact on the product level in the stores.

4.1.3 Factors affecting the implementation of RFID

Hamid (2012) sees difficulties in the implementation of RFID technology. He argues that it is difficult to introduce a technology to be used by multiple players, but where should be the major governing. Hamid also believes that value system for packaged foods, as a whole, can benefit from the introduction of RFID, but he does not believe that any individual players will benefit from it. What costs and benefits will be distributed among the various players in the current
situation is still unclear. Negotiations and decisions that will clarify this are complex and will be surrounded by problems and policies.

Hamid (2012) also believes that there are those who have knowledge and those who are carrying out tests of RFID technology in the current situation is on power and is better prepared for future negotiations on value distribution. According to A.Altaf (Agility), relations between logistics companies and their customers is characterized largely by long-term partnerships and relationships. For example, they have long-term relationships with their customers as an explicit strategy. Other argues that cooperation may vary based on different clients. Some customers will only see the price and select logistics accordingly. Even the type of goods being transported affect relations. Low-and high-value goods demand various partnerships, where companies with goods (low values) tend to look at the price only and companies with goods (high values) evaluates other phenomena. The relationships may be affected if disagreements arise as to who will bear the costs and who will get the benefits of RFID technology. A.Altaf (Agility) argues that the strongest player in the retail supply chain is the retail stores and agrees that they will have to introduce RFID if their customers have this requirement. However, this will be the subject of agreement. It would be better if the tags applied to the goods early in the chain so that everyone can enjoy the benefits of the technology makes possible.

The two of the retailers we interviewed agreed that they (retailers) are the strongest player in the retail supply chain, but Erfan (Lidl) points out that everyone in the retail supply system influences and argue that providers can set standards and cites Procter & Gamble and Gillette as examples. These are great players and can take advantage of economies of scale.

Emil and Erfan (Willys, Lidl) agreed that the tags should be applied to the products of those who manufacture and supply products. But who will bear the cost of the tags is unclear. The general consensus seems to be that those who apply the tag will bear the cost initially, but this would lead to price increment implemented throughout the entire system to the end consumers who ultimately bear the costs. Jonas (Lidl) argue that cost sharing should be analyzed and those who get the most out of the use of RFID to take the biggest costs.

4.1.4 Issues in implementing RFID

Hamid (2012) believes that in Sweden retail stores can afford RFID technology and have knowledge of implementations; however the problem is the lack of acceptance of the technology of the other actors in the retail supply chain. A requirement from a customer can start the process.

A major problem is however the price of the tags to be. The cost of tags and application are high in relation to the packaging they produce. Therefore packaging companies cannot take this cost without raising the price of their products. Two key problems that must be overcome mentioned
is the price of tags and unification around a standard. Jonas (Lidl) says that the tags have to be much cheaper for the technology to proceed in the company and an estimated price drop on the tags to 0.10 SEK will be sufficient to start tagging at the product level. In the current situation the price drops slowly, but it will drop quickly when trade picks up. Both Jonas (Lidl) and Emil (Willys), suggest that not only is the price of the tags that determine the adoption of the technology, even readers, cash registers and other RFID-related expensive goods, leading to high costs for those who want to implement RFID technology. A retail sale is the different issue that must be resolved before the possible introduction of RFID technology. Common is that they do not have any information on what it would cost to implement RFID technology in enterprises. To figure this companies consider being difficult. Erfan (Lidl) argue that a standard is needed, but this will be resolved by the industry jointly by GS1.

4.2 Findings through Survey Questionnaires

In order to get a general idea about importance of RFID in retail supply chain, certain questions were asked to the respondents are presented below:

- **Main drivers for adopting RFID in retail industry.**

This question gave us an opportunity to have view of respondents over the basic cause and mindset of experts over implementing RFID. Benefits are the main reason for implementing RFID, most of respondents suggested. Some explained it all started with the big giants in retail industry (Wal-Mart, Metro). Expert from RFID software designing said it is due to the decreasing cost of RFID tags and readers but some suggest security is the main reason for implementing RFID in retail supply chain.
Will RFID soon replace the barcode as the primary means of conducting retail business in Sweden?

This question was asked only to the respondents in Sweden and as the figure below shows over 80% was of the opinion of “No”. Majority agreed that future of RFID in Sweden is bright but from to have a proper RFID technology in retail stores is far away.

**Figure 15 Key drivers for implementing RFID in Retail industry**

**Figure 16 RFID vs. Barcode Technology**

**The largest cost item in your company’s RFID or adoption.**

**Figure 17 Largest cost item in adopting RFID**
- **Compelling reasons to adopt RFID in the industry.**

![Figure 18 Compelling reasons to adopt RFID](image)

- **What are the key hindrances to RFID adoption?**
Note. The scale in the chart indicates the level of opinion 1 (Disagree) to 5 (Agree).

- **To what extent would** Figure 19 Key hindrances in implementing RFID **vong areas?**

### Key hindrances in implementation

- Lack of industry standards
- Technical issues
- Security issues
- Privacy issues
- Compliance issues
- Manpower issues
- Cost issues

![Key hindrances in implementation chart]

Note. The scale in the chart indicates the level of opinion 1 (Disagree) to 5 (Agree).

- **Rate of expected benefits to be derived by your company from RFID adoption**

![RFID affects on business processes chart]

Note. The scale in the chart indicates the level of opinion 1 (Disagree) to 5 (Agree).

Figure 20 Affects of RFID on business processes

- Rate of expected benefits to be derived by your company from RFID adoption
In this chapter the theory is analyzed and discussed in relation to the gathered results from the interviews and survey about the RFID. This chapter also includes the result of queuing analysis at the POS of Willys.

5.1 Implementation of RFID technology in the Retail Supply Chain
5.1.1 Benefits of RFID over barcode technology

To start discussion on benefits of RFID over barcode technology we have drawn a simple store layout showing front store, point of sale, back-room, fitting room, receiving section and exit gates. The barcode revolution brought the illumination of sales and speed up the Point-of-Sales (POS). Barcode technology has a lot interesting strengths which made it very useable in retail stores. It is quite inexpensive, and showed strengths which are doing faster data entry by hand or by cash register and it is based on the printing technology, this technology was quite effective and widely adopted all over the world. But barcode technology has limitation such as line of sight requirement, one at a time requirement, range limitation, limited data factor and no proper security is available in case of barcode technology. So far barcode technology is mainly effective at only the point of sale (POS) in the retail stores and rest of the areas of the retail store need high consideration for savings. We have compared that with RFID technology that covers all the areas of the retail store, because RFID basically gives you better visibility between the receiving section and the exit gates.

5.1.2 Usage of RFID in retail supply chain
Supply chain management is the process of managing raw materials and information from the point of acquisition to the point of consumption. Most of the companies today rate supply chain management as their key priority for survival and success. The use of RFID in the retail supply chain for tracking and tracing products can lead to reduced inventory and better collaboration among different players in the supply chain. Most of the major retailers today see potential of the RFID technology to better integrate their supply chain and improve their efficiency by reducing error rates which can cut down overall cost of operations significantly.

Looking at the figure above, we can see that most of the dominant RFID benefits concentrate at the lower end of the supply chain. The potential it has on the other aspects of the supply chain are somewhat neglected. Since the benefits are not standalone they can leverage from one another to their own advantage. Also if the benefits are well dispersed across all the entities of the supply chain it will meet the incentives of a wider range of stakeholders (suppliers, manufacturers, retailers and consumers).

5.1.3 Conditions for implementing RFID in Retail industry

In order to understand the timeline for the implementation of RFID adoption at the unit level in the retail supply chain, we first have to consider the economic condition necessary for the implementation of RFID technology throughout the supply chain:
If the conditions shown in the figure above met across the entire retail supply chain, the adoption of RFID would become feasible and widespread. Also in order to find out the time for the implementation of RFID we can look to the implementation of barcode technology in their adoption rate. History reveals the adoption of barcode technology almost took 15 years to become truly efficient. But today’s commercial and more technology oriented environment is much more ready to adopt new technology. Jonas (Lidl) predicts that RFID will not see widespread adoption at the unit level for at least 8 to 10 years. Tag costs and middleware softwares issues are stalling the unit-level adoption of RFID technology.

In our research we have analyzed the role of the retailer and other members of retail supply chain, RFID technology has been in existence since the 1970s, still today’s adoption of RFID in the retail environment is being inspired by global retail companies; not by the inherent benefits of the technology. They are retailers who pushed on manufacturing sector to integrate RFID to make their supply chain more effective.

Integrated RFID technology not only provides supply chain cost savings, but also provides retailers with integrated marketing opportunities, and the ability to speed up the service experience in stores. Although truly valuable, neither of these benefits can be realized until RFID tags appear at the unit level. As a result, we conclude that widespread adoption of RFID technology will require an evolution in the market place ultimately a shift from retailers pushing this technology to manufacturers demanding RFID.
As the manufacturing sector adopts RFID and integrates its technology within their existing systems they will achieve economies of scale, which will reduce RFID tag costs and middleware costs. This evolution of the retail marketplace is best illustrated in the following diagram:

Today top tier retailers are forcing major manufacturers to adopt RFID. However, going forward there needs to be an evolution in the marketplace where manufacturers fully adopt this technology. This will start to push the second tier retailers to also seek these cost savings. The process will continue throughout the retail supply chain until the full adoption of RFID becomes a reality.

Although the supply chain benefits of RFID are not the only driver for this technology, we believe it is the starting point. When retailers or manufacturers increased profits outweigh the variable and fixed costs associated with implementation of RFID, adoption will occur throughout the industry.

Figure 25 RFID Network in retail industry
5.2 Analysis of Point of sales service in Willys

In the Willys Erikslund sales checkout service has 6 waiting lines in the form of parallel cash counters and customers are served on first in first out (FIFO) basis. The data was collected for two out of six servers. The sales checkout unit has six parallel counters out of which 2 were observed (for each counter there is an individual sale to serve the customers waiting in the queue), it might be possible that some of the checkout units are idle. The collected data was tabulated in a spreadsheet for calculating the required parameters of queuing theory analysis.

5.2.1 Queuing Calculations
We have found the expected queue length by using empirical data. In the store, we have observed the number of customers waiting in a queue, therefore the average of that number in a system is \((1+2+3+\ldots+1+1)/55 = 1.87\) or 2 customers per minute on average waiting in a queue in a system within 40 minutes of data collection time.

From the collected data, we have found that customers arrive at an average of 80 per hour, and on an average of 48 customers served per hour by a salesperson.

### Results for Queuing model 1

Assuming the steady-state condition, the parameters in Queuing Model M/M/1 are:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of servers</td>
<td>(c = 1)</td>
</tr>
<tr>
<td>Arrival rate</td>
<td>(\lambda = 40) customers per hour</td>
</tr>
<tr>
<td>Service rate</td>
<td>(\mu = 48) customer per hour per server</td>
</tr>
</tbody>
</table>
System utilization: $P = 0.833$ or 83.3 %

Probability of server idle: $P_\varnothing = 0.169$ or 16.9%

Average number of customers in the queue: $L_q = 4.204$ customers

Average waiting time in the queue: $W_q = 0.105$ hours

Table 6 Queuing results for Model-1

The sales checkout service performance is sufficiently good; we have observed that servers’ utilization is .833. Average number of customers waiting in a queue is 4.204 customers. Also the waiting time in a queue is 0.105 hr or 6.307 minutes.

Results for Queuing model 2

Assuming the steady-state condition, the parameters in Queuing Model M/M/2 are:

<table>
<thead>
<tr>
<th>Number of servers</th>
<th>$c = 2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival rate</td>
<td>$\lambda = 80$ customers per hour</td>
</tr>
<tr>
<td>Service rate</td>
<td>$\mu = 48$ customer per hour per server</td>
</tr>
<tr>
<td>Service rate for both servers</td>
<td>$c \mu = 96$ customers per hour</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System utilization</th>
<th>$P = 0.833$ or 83.3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of all servers idle</td>
<td>$P_\varnothing = 0.090$ or 9%</td>
</tr>
<tr>
<td>Average number of customers in the queue</td>
<td>$L_q = 3.730$ customers</td>
</tr>
<tr>
<td>Average waiting time in the queue</td>
<td>$W_q = 0.046$ hours</td>
</tr>
</tbody>
</table>

Table 7 Queuing results for Model-2
The sales checkout service performance is sufficiently good; we have observed that servers’ utilization is .833. Average number of customers waiting in a queue is 3.730 customers per 2 servers. Also the waiting time in a queue is 0.046 hr or 2.76 minutes.

For multi-queue models in closed form it is not possible to obtain solution by solving a set of equations, but they can be obtained easily with simulation methods. We have run the simulation for the same data as for model 2, by using the software WinQSB for Queuing system simulation.

**Results for Weekday applying Queuing model 3**

<table>
<thead>
<tr>
<th>SERVER 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean interarrival time</td>
<td>0.75 min</td>
</tr>
<tr>
<td>Mean service time</td>
<td>1.25 min</td>
</tr>
<tr>
<td>System utilization</td>
<td>83.3 %</td>
</tr>
<tr>
<td>Customer served</td>
<td>68</td>
</tr>
<tr>
<td>Average number of customers in the queue</td>
<td>$L_q = 15.7686$ customers</td>
</tr>
<tr>
<td>Average waiting time in the queue</td>
<td>$W_q = 11.6577$ min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SERVER 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean interarrival time</td>
<td>0.75 min</td>
</tr>
<tr>
<td>Mean service time</td>
<td>1.25 min</td>
</tr>
<tr>
<td>System utilization</td>
<td>83.3 %</td>
</tr>
<tr>
<td>Customer served</td>
<td>86</td>
</tr>
<tr>
<td>Average number of customers in the queue</td>
<td>$L_q = 26.4315$ customers</td>
</tr>
</tbody>
</table>
Simulation process has shown the sales checkout service performance of two servers with their corresponding queues. Simulation was run for 50 hours and servers found to be quite busy (83.3%). The average number of customers waiting in the queue is 42.2001 and the average time customer spends in the queue is 13.9877 minutes which is quite a time in a busy life. Such a long queue can be reduced to zero by having a RFID enabled exit gates.

### 5.2.2 Queuing Cost Estimation

For calculating queuing cost we have used the graph for finding out the optimal number of servers for providing appropiate service to the customers. For calculating the total cost we need to have cost of waiting per customer in the queue, in our case we have used the estimated waiting cost per customer i.e. 250 SEK per customer per hour and the cost of server is 150 SEK per hour. Considering the steady state condition we have started analysing by using atleast 2 servers (arrival rate = 80 customers per hour, service rate = 48 customers per hour)

<table>
<thead>
<tr>
<th>No of servers</th>
<th>Number of customers in the queue ($L_q$)</th>
<th>Cost of waiting in the queue ($L_q \times \text{waiting cost}$)</th>
<th>Cost of server (c * cost of 1 server)</th>
<th>Total Cost</th>
</tr>
</thead>
</table>

Table 8 Queuing results for Model-3
We can see that the total cost is at its peak in case of using 2 server and decrease rapidly while using 3 servers. Further increment in the number of servers shows again increment in the total cost of waiting i.e. 659.25 SEK and 773 SEK respectively. In that case the optimal option would be using 3 servers.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.730</td>
<td>932.5</td>
<td>300</td>
<td>1232.5</td>
</tr>
<tr>
<td>3</td>
<td>0.442</td>
<td>110.5</td>
<td>450</td>
<td>560.5</td>
</tr>
<tr>
<td>4</td>
<td>0.237</td>
<td>59.25</td>
<td>600</td>
<td>659.25</td>
</tr>
<tr>
<td>5</td>
<td>0.092</td>
<td>23</td>
<td>750</td>
<td>773</td>
</tr>
</tbody>
</table>

Table 9 Total waiting cost estimation with using different number of servers

Figure 27 Graph showing the total cost of waiting in the queues

5.3 Cost Analysis of Implementing RFID at POS

In this section we have tried to find out the expected savings on implementing RFID at the Point of Sales (POS) in the Willys Erikslund. As we have discussed earlier in the Analysis section for
implementing RFID technology, profit needs to be greater than the fixed and variable costs. In calculating the Return on Investment (ROI) the cost of tags is so far the biggest concern and needs to be minimized. By contacting some suppliers on internet we were able to found out the price of item tags which is about 0.49 SEK. As we have discussed earlier that according to the experts and retailers the cost of tags need to be low as 0.10 SEK to be able to introduce it in the industry. But here this issue would be justified we could include the benefits gain by RFID in the back door inventory, shelf replenishment, better visibility etc. In our RFID implementation estimation at POS we have not included these savings and have focused only on the savings on wastages due to POS mishandlings which are about 0.49% of total sales generation per month.

After interviewed the expert and contacting some suppliers we have found that the initial cost of implementing RFID readers at the POS is about 175000 – 200000 SEK. The average number of customers visit Willys Erikslund is 54000 every month and they shop 12 items on average per visit. Also Willys is paying 30,000 SEK/employee (including income tax) to their staff working at POS and the monthly turnover of Willys Erikslund is about 9.3 million SEK.

Table below shows the amount of initial investment, tagging cost, employee reduction savings and savings on wastages, all costs are in (Swedish kroner):

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Investment (Including setup cost i.e. placement of readers, antennae, integration of softwares and devices etc)</td>
<td>200,000</td>
</tr>
<tr>
<td>Tags cost / month</td>
<td>317,520</td>
</tr>
<tr>
<td>Employee reduction savings / month</td>
<td>150,000</td>
</tr>
<tr>
<td>Savings on wastage due to POS mishandling /month</td>
<td>40,025</td>
</tr>
</tbody>
</table>

Table 10 Cost investment and savings

After analyzing above table it is numerically impossible to calculate the return on investment and payback period as the investment is more than the savings. Here average monthly tag cost (0.49 SEK * 12 items * 54000 customers) is more than the perceived benefits in the form of employee savings and savings on wastage due to POS mishandling per month.

5.4 An overview of Implementing RFID at POS
After doing the queuing analysis we have found that on average customer waits 2.8 minutes in the checkout queues, which is quite a time in this fast pace environment. Since on average 1800 customers visit Willys Erikslund and if we multiple the number of customer per day with the average time customer waits, it becomes (2.8 minutes * 1800) 84 hours every day and (84 hours * 30) 2520 hours every month. As we have used 250 SEK per hour as the average cost of waiting for every customer, in that scenario it becomes quite a big amount of money (250 SEK * 2520 hours) 630,000 SEK, which could be saved in the case of RFID enabled checkouts. In the figure 28, we have tried to show the possible change in the Point of Sales (POS) of Willys Erikslund, in the figure 28, first we have shown the current six checkout counters and the customers waiting in the long queue, then we have shown the single queue of customers passing throw the RFID checkout readers without waiting for the checkout servers for giving service.
6 CONCLUSION AND FURTHER STUDY

This chapter is divided into two parts where the first discusses about the outcome of the research and the next part is about further study.

6.1 Conclusion

The main objective of the thesis has been to contribute to the understanding of RFID implementation in the retail supply chain, how it contributes and improves the supply chain, the impact of RFID over the supply chain and about its integration among the different entities of retail supply chain. A theoretical framework is made so as to have a good understanding about the concepts and research work in the relevant area. The empirical results have been done to examine their work practices within the related field and initiatives.

The results from the thesis are the following:

With the help of literature, in depth study of RFID, retail supply chain and the related work helped us to gain knowledge about various perspectives. The empirical findings are the strong feature of this thesis work and the knowledge gained through interviews was helpful for a better analysis. The research goals with their justification are presented below:

First goal: Implementation of RFID technology in the Retail Supply Chain
From the empirical study and literature review we have found the basis of implementation of RFID in retail sector and following are the research questions with their respective justifications.

- **Why RFID is better than barcodes?**

RFID is increasing its creditability in the supply chain processes rapidly; it is showing its potential benefits and improvements in the retail sector too. With the help of RFID, in the field of retail supply chain number of improvements can be made i.e. reducing the time of receiving goods, searching of particular item in the warehouse, tracking of number of items in one time and also the more discussed topic efficient checkouts in the retail stores. All these benefits are the major aspects of considering RFID technology over barcodes.

- **Current status of RFID implementation in retail industry.**

We have found by empirical findings (interviews) that RFID will be the next big thing in the retail supply chain, however retailers have not been started using it entirely, its benefits are compelling the retailers to start implementing it and for the sake of be competitive in the market. So far retailers are planning to use RFID on pallet level, LIDL KB in Sweden also have plans to start using RFID at pallet levels in their good receiving section of warehouse in coming 2 to 3 years. Its shows that implementation of RFID at item level in Sweden will take some time, may be over 5 to 6 years from now.

- **Cost and benefits allocation among the retail supply chain.**

Cost and benefits allocations are so far the main reason that stuck the process of possible implementation of RFID in retail industry. So far there is no proper distribution of benefits and costs among the different retail supply chain entities. But we have concluded through the empirical findings that retailers should bear the cost of RFID tagging as they suppose to get benefited most by it. But in that case cost will be forwarded to the customers and end result will be in the overall price increment of goods. So for the technology to be successfully implemented the cost of tags need to be minimized, which is minimizing day by day.

- **What are the major drivers for adopting RFID in retail supply chain?**

Benefits are the main drivers for adopting RFID and 78% respondents agree with this statement. Firms like Wal-Mart and Metro Group also contribute to some extent in this progress.

- **Area where RFID can be used in retail supply chain?**

RFID is useful mainly in the warehouse, distribution and retail outlet operations, areas including goods shipment, goods receiving, shelf replenishment, employees tracking, better security and
quick checkouts. As the technology progress, it will surely find the more potential usage in the retail industry.

- **What are the challenges faced in adopting RFID in retail industry?**

Our survey shows that cost issues are one most important factor while implementing the RFID, and then come the lack of industry standards for implementing RFID, technical issues and manpower planning factors. As we have tried to calculate the possible cost for implementing the RFID and its return of investment, but have not succeed in calculating the return on investments (ROI) as the cost of tags are still very high in the market as compared to the savings in the form of efficient working.

**Second goal: Evaluate the usage of RFID at Point of Sales (POS) in Willys Erikslund with the help of Queuing Theory.**

In the second goal of our thesis work, we have analyzed the performance of checkout service of our case company, with the help of queuing models we have found the current performance of sales checkout. Our analysis shows that the overall system at the checkout performs well, but the cost can be reduced if the number of servers increased.

Primary objective of the second part is to calculate the time that customers wait in the checkout queues and try to analyze it with the possible implementation of RFID at checkout counters. But the implementation of RFID at the checkout counters connected with the other factors of the supply chain and its implementation cost at the checkout counters cannot be justified lonely. For this we have to consider the other areas of retail supply chain too.

**6.2 Further Study**

Since we had five months for completing our study, if we compare it with the field of RFID we would have need more time to analyze the thorough process of implementing RFID in retail sector. Further proceedings with this thesis work would be analyze the other areas of retail stores as well, such as shelf replenishment and ordering, this further study could encourage the retail stores in the Sweden to focus more and think over implementing RFID and contribute for the cost effectiveness of the process and customer service.
7 REFERENCES


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8 APPENDIX

8.1 Appendix I

About the Case Company

Willys was started in Gothenburg back in 1975 by Lars Lundin. Willys is Sweden's leading discount chain. Today they have approximately 6,000 employees working to provide their customers with Sweden's cheapest retail offers. Willys has approximately 170 stores, of which about forty are based on our convenience stores called Willys Home. Willy’s stores are found all over the country in shopping malls and other locations just outside the city centers, but also in city centers. The stores' selling space is for Willys between 1100 and 4700 square feet and number of items in the store is about 9000th Sell the surface of the Willys Home stores are between 300 and 1200 square feet with approximately 5,000 articles.

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Stores Willys</td>
<td>128</td>
<td>120</td>
</tr>
<tr>
<td>Number of Stores Willys Home</td>
<td>44</td>
<td>42</td>
</tr>
<tr>
<td>Number of employees</td>
<td>5500</td>
<td>5500</td>
</tr>
<tr>
<td></td>
<td>18904</td>
<td>18613</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Turnover (million)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit (million)</td>
<td>775</td>
<td>772</td>
</tr>
<tr>
<td>Operating Margin (%)</td>
<td>4.1</td>
<td>4.1</td>
</tr>
</tbody>
</table>

8.2 Appendix II

Interview Questions

1. Do you have knowledge of RFID?

2. What do you consider the primarily RFID factor?

3. Are you using RFID technology in your company?

4. Do you have any plans to conduct tests or introduce RFID?

5. If you have to use RFID, how will you use it?

6. What benefits would RFID mean you?

7. At what level goods would be labeled with RFID tags to have the greatest benefits?

8. What cost of tags do you think is feasible for implementing in your company?

9. When will RFID take the place of barcode technology?

10. How do you rate the importance of relationship between other retail supply chain entities?
11. How has the main responsibility of implementing RFID technology in retail supply chain?

12. Where do you think the appropriate tags should be applied?

13. Who will bear the cost of the tags?

14. Do you have knowledge about the pilot projects of RFID implementation by companies like Wal-Mart and Metro Group?

15. Have you received any request from the client to provide goods with RFID tags and at what level?

16. What is the basic requirement to start using RFID technology in your company?

17. Would you like to add any other information about RFID?

8.3 Appendix III

Questionnaire

1) How you would like to rate the importance of RFID in retail industry?

<table>
<thead>
<tr>
<th>None</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>o 1</td>
<td>o 2</td>
<td>o 3</td>
</tr>
<tr>
<td>o 4</td>
<td>o 5</td>
<td></td>
</tr>
</tbody>
</table>

2) In your opinion, will RFID soon replace the barcode as the primary means of conducting commerce?

   o Yes
   o No
3) Which of the following situations best describes your company's knowledge of RFID (please choose one)?

- Fully conversant with all aspects of RFID
- Understand most of the concepts of RFID
- Understand the principles of RFID
- Little knowledge of RFID principles but the system works for us.

4) What is the current status of your company's business case/plan for the adoption of RFID (please choose one)?

- No business case exists
- Business case in development
- Business case in approval process
- Business case approved

5) Which of the following represents the largest cost item in your company’s RFID plan or adoption?

- Tags
- Readers
- Middleware
- Applications
- Services

6) Which of the following are the compelling reasons to adopt RFID?

- Lack of product visibility
- Stockouts.
- High inventory costs
- Missed fulfillment commitments
- Lack of demand visibility
- Low inventory turns
- Return processing costs
7) In which of the following areas do you see the most use of RFID in your industry?

- Business-to-business logistics
- Internal operations
- Business-to-customer marketing and logistics
- Business-to-customer after-sales service

8) At what product level is your company considering RFID adoption?

- Item level
- Case level
- Pallet level
- Container level
- Other (Please specify)

9) Use the scale provided, please indicate the extent to which the following are the key drivers for RFID adoption.

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Moderate</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top management support</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Availability of IT infrastructure</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Financial readiness/affordability</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Perceived RFID benefits</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Actual RFID costs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Perceived RFID standards</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
### 10) Using the scale provide, to what extent do you consider the following to be key hindrance to RFID adoption?

<table>
<thead>
<tr>
<th>Hindrance</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer privacy</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Competitive pressure</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Government support</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Global expansion</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cost issues</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Manpower (skills) issues</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Compliance issues</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Privacy issues</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Security issues</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Technical issues</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lack of industry standards</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

### 11) Using the scale provided, to what extent would RFID affect your business processes in the following areas?

<table>
<thead>
<tr>
<th>Area</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Accounts payable/receivable</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Product management</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Logistics and distribution</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Trading partner management</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Procurement</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Order management</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

12) Using the scale provided, rate the degree of expected benefits to be derived by your company from RFID adoption.

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>V.Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved availability</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Cost reduction</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Transaction accuracy</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improved visibility</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improved supply chain planning</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Sales improvement</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Reduction of inventory</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Faster receiving time</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Reduce out of stock items</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Transportation efficiency</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Labor savings</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

13) To what extent is your company aware of the RFID standards being developed by EPC global?

- Have never heard of EPC global and its standards.
- Have heard of EPC global but not considering membership
- Have heard of EPC global and is considering membership
- Already a member of EPC global but not fully aware of its standards.
- Already a member of EPC global and fully aware of its standards.

14) Please provide any additional information about your company that you believe would be useful for us.

8.4 Appendix IV

Spreadsheet for Queuing Calculations

<table>
<thead>
<tr>
<th>Arrival Time</th>
<th>Interarrival Time</th>
<th>No of Customers</th>
<th>Departure Time</th>
<th>Service Time</th>
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<tbody>
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<td>15:50:00</td>
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<td>15:51:00</td>
<td>0:01:00</td>
</tr>
<tr>
<td>15:51:00</td>
<td>0:01:00</td>
<td>2</td>
<td>15:53:00</td>
<td>0:02:30</td>
</tr>
<tr>
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<td>0:02:00</td>
<td>3</td>
<td>15:55:00</td>
<td>0:02:00</td>
</tr>
<tr>
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<td>2</td>
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<td>0:01:00</td>
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<td>15:56:00</td>
<td>0:01:00</td>
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<td>0:01:00</td>
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<tr>
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<td>Time</td>
<td>Delay</td>
<td>Jacket</td>
<td>Time</td>
</tr>
<tr>
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<td>-------</td>
<td>-------</td>
<td>--------</td>
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<td>1</td>
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<td>0:00:00</td>
<td>1</td>
<td>16:25:30</td>
</tr>
</tbody>
</table>
Mean Arrival Time = 0:00:45 seconds or 0.75 customers per hour

Arrival rate = 80 customers per hour
Mean serving time = 1.25 minutes per customer

Service rate = 48 customers per hour

Data Collection time = 40 min

8.5 Appendix V

Software used for Queuing calculations

Selection of Components
Data Input

Simulation of the data input
### Results of simulation from 0 to 50 hours

<table>
<thead>
<tr>
<th>10-24-2012</th>
<th>Result</th>
<th>Customer1</th>
<th>Customer2</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total Number of Arrival</td>
<td>68</td>
<td>86</td>
<td>154</td>
</tr>
<tr>
<td>2</td>
<td>Total Number of Balking</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Average Number in the System (L)</td>
<td>15.7686</td>
<td>26.4315</td>
<td>42.2001</td>
</tr>
<tr>
<td>4</td>
<td>Maximum Number in the System</td>
<td>29</td>
<td>47</td>
<td>76</td>
</tr>
<tr>
<td>5</td>
<td>Current Number in the System</td>
<td>29</td>
<td>47</td>
<td>76</td>
</tr>
<tr>
<td>6</td>
<td>Number Finished</td>
<td>39</td>
<td>39</td>
<td>78</td>
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<tr>
<td>7</td>
<td>Average Process Time</td>
<td>1.2500</td>
<td>1.2500</td>
<td>1.2500</td>
</tr>
<tr>
<td>8</td>
<td>Std. Dev. of Process Time</td>
<td>5.166048E-10</td>
<td>5.166048E-10</td>
<td>5.166048E-10</td>
</tr>
<tr>
<td>9</td>
<td>Average Waiting Time (Wq)</td>
<td>10.4077</td>
<td>15.0677</td>
<td>12.7377</td>
</tr>
<tr>
<td>10</td>
<td>Std. Dev. of Waiting Time</td>
<td>6.4225</td>
<td>8.4263</td>
<td>7.8456</td>
</tr>
<tr>
<td>11</td>
<td>Average Transfer Time</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Std. Dev. of Transfer Time</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Average Flow Time (W)</td>
<td>11.6577</td>
<td>16.3177</td>
<td>13.9877</td>
</tr>
<tr>
<td>14</td>
<td>Std. Dev. of Flow Time</td>
<td>6.4225</td>
<td>8.4263</td>
<td>7.8456</td>
</tr>
<tr>
<td>15</td>
<td>Maximum Flow Time</td>
<td>21.9802</td>
<td>30.2819</td>
<td>30.2819</td>
</tr>
</tbody>
</table>

Data Collection: 0 to 50 hours

CPU Seconds = 0.5460