Project Dissertation Report on

RFID Implementation in Supply Chain

Submitted By

Gaurav Beniwal

2K18/MBA/095

Under the Guidance of

Mr. Yashdeep Singh

Assistant Professor

DELHI SCHOOL OF MANAGEMENT

Delhi Technological University

Bawana Road Delhi 110042

CERTIFICATE

This is to certify that the work titled Implementation of RFID in Supply Chain submitted by Gaurav Beniwal in this project report as part of 4th Semester in MBA (DSM, DTU) during January-May, 2020 was conducted under my guidance and supervision. This work is his original work to the best of my knowledge and has not been submitted anywhere else for the award of any credits / degree whatsoever. The work is satisfactory for the award of MGT-44 Term Project credits.

Mr. Yashdeep Singh
Assistant Professor
Delhi School of Management
Delhi Technological University

Prof. Rajan Yadav
Head of Department
Delhi School of Management
Delhi Technological University

DECLARATION

This is to declare that the work titled “Implementation of RFID in Supply Chain” in this Project Report as part of 4th Semester in MBA (DSM, DTU) during January-May, 2020 under the guidance of Mr. Yashdeep Singh (Asst. Prof.) is my original work to the best of my knowledge and has not been submitted anywhere else.

The report has been written by me in my own words and not copied from elsewhere. Anything that appears in this report which is not our original has been duly and appropriately referred / cited / acknowledged.

Any academic misconduct and dishonesty found now or in future in regard to above or any other matter pertaining to this report shall be solely and entirely my responsibility. In such a situation, I understand that a strict disciplinary action can be undertaken against me by the concerned authorities of the University now or in future and I shall abide by it.

Gaurav Beniwal

ACKNOWLEDGMENT

This project was supported by Mr. Yashdeep Singh who guided me throughout. The success of the project would not have been possible without his guidance, suggestions and inputs.

I would also like to take this opportunity to thank the faculty and my colleagues at Delhi School of Management, Delhi Technological University for inculcating in me a desire to explore this field and for helping me to learn and grow to my utmost potential.

Gaurav Beniwal

EXECUTIVE SUMMARY

Today's dynamic and competitive business environment puts an ever-increasing pressure on companies to innovate, redesign processes, and leverage the potential of partnerships along the supply chain.

One of the technologies offering a solution is Radio Frequency Identification (RFID). RFID can be used to automate and thus streamline identification processes, which means that more checkpoints along the supply chain can be established at decreased costs. But additionally, the technology can provide further benefits which make it superior to the currently widespread automatic identification (Auto-ID) technology of the barcode. However, as RFID is only a way to collect the data at the lowest level, the technology must be integrated with the supply chain management systems of the companies. Also, the various information systems along the supply chain must be integrated to allow for exchange and in order to give a meaning to the data.

Even though RFID technology has initially been developed decades ago, the use of RFID in large-scale supply chain operations has until now been prohibited due to the relatively high costs compared to other Auto-ID solutions. Recent studies on the integration issues of the technology reveal that there are still several technical, as well as rather political, barriers to be solved before widespread RFID deployment in supply chain operations can take place.

Therefore, this dissertation deals with RFID technology introduction and impacts on supply chain management systems in order to give an insight into the current issues and status of the technology. It examines five RFID projects carried out by companies operating in different industries. The presentation and discussion of the results will help to better understand what RFID can deliver, what deficiencies companies reveal and where its application in supply chain operations is sensible and likely to occur. Technology is providing companies with ways to become faster and more efficient in all areas of the supply chain, from the original equipment manufacturer down to the end consumer.

RFID Technology is a smarter way to track shipments, time deliveries, and keep inventories; this in turn makes processes faster, more efficient, and with less error. It goes beyond other systems because it encompasses more information than prior technologies. My research will explore, the methodology for obtaining information, a literature review on RFID technology and the supply

chain, definitions of supply chain management and radio frequency technology plus their history, components of RFID, industries that currently use the technology, the integration into the supply chain, the implementation process, the difference between RFID and the barcode, the benefits and challenges, and concluding remarks. RFID Technology and the supply chain were chosen because together they are making a large impact on one another. It is important to explore what is happening in business today in order to complete a better understanding. In part of doing this senior thesis, my goal is to further my knowledge as well as, help others to understand the importance what is currently taking place. This impact is something that is often overlooked or unknown, but is a large part of what is happening in many companies today. The methodology behind this paper provides the foundation for the topics and end conclusions.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 Background

RFID has been around for decades. The RFID concept was introduced during World War 2 to distinguish allied aircrafts from the enemy (Stockman, 1948; Want, 2006). But only recently have the convergence of low cost, increasing capabilities and the creation of electronic product code (EPC) made this technology more and more attractive.

Technology is providing companies with ways to become faster and more efficient in all areas of the supply chain, from the original equipment manufacturer down to the end consumer. RFID Technology is a smarter way to track shipments, time deliveries, and keep inventories; this in turn makes processes faster, more efficient, and with less error. It goes beyond other systems because it encompasses more information than prior technologies.

In a simple manner, a supply chain is a flow of materials, information, money, and services from raw material suppliers through factories and warehouses to the end customers. There is no doubt that supply chain management is an integral part of the e-commerce business. It provides quick and effortless shopping experience; instead of traveling to the stores, standing in the long queues to pay the bill, customers can comfortably purchase the products at the tip of the finger and get deliver the products at doorstep. The reason behind this comfort is supply chain management. E-commerce, M-commerce business is completely dependent on SCM.

When a customer purchases from the online stores, they look for quick delivery in minimum time. And if the logistic department fails to deliver on-time, the customer may never use that particular store. So, in order to provide great user experience, the supply chain needs to track every operation.

Way back before decades, the SCM system used a barcode system to scan the data and in some supply chains, professionals use to enter the data manually. Both resulted in a tedious, slow, and error-prone process. Due to this, the system inventory didn't match physical inventory and ultimately resulted in inconvenience. The companies realized that manual scanning of barcodes of large volumes of item was becoming bottleneck and source of errors. Absence of real-time data leads to poor visibility which slowed down the decision making the process.

To stay at the top of the trends in the ever-growing complexity, companies needed innovative technology like RFID (Radio Frequency Identification Device) in supply chain management to identify the issues and streamline the operations. RFID technology possesses the capabilities to fully automate the product identification in the supply chain process.

A typical supply chain begins with the ecological, biological, and political regulation of natural resources, followed by the human extraction of raw material, and includes several production links (e.g., component construction, assembly, and merging) before moving on to several layers of storage facilities of ever-decreasing size and increasingly remote geographical locations, and finally reaching the consumer.

Many of the exchanges encountered in the supply chain are therefore between different companies that seek to maximize their revenue within their sphere of interest but may have little or no knowledge or interest in the remaining players in the supply chain. More recently, the loosely coupled, self-organizing network of businesses that cooperates to provide product and service offerings has been called the extended enterprise. As part of their efforts to demonstrate ethical practices, many large companies and global brands are integrating codes of conduct and guidelines into their corporate cultures and management systems. Through these, corporations are making demands on their suppliers (facilities, farms, subcontracted services such as cleaning, canteen, security etc.) and verifying, through social audits, that they are complying with the required standard. A lack of transparency in the supply chain is known as mystification, which bars consumers from the knowledge of where their purchases originated and can enable socially irresponsible practices. Supply-chain managers are under constant scrutiny to secure the best pricing for their resources, which becomes a difficult task when faced with the inherent lack of transparency. Cost benchmarking is one effective method for identifying competitive pricing within the industry. This gives negotiators a solid basis to form their strategy on and drive overall spend down. The Global Supply Chain Forum has introduced another supply chain model. This framework is built on eight key business processes that are both cross-functional and cross-firm in nature. Each process is managed by a cross-functional team including representatives from logistics, production, purchasing, finance, marketing, and research and development. While each process interfaces with key customers and suppliers, the processes of

customer relationship management and supplier relationship management form the critical linkages in the supply chain.

The American Productivity and Quality Center (APQC) Process Classification Framework (PCF) SM is a highlevel, industryneutral enterprise process model that allows organizations to see their business processes from a crossindustry viewpoint. The PCF was developed by APQC and its member organizations as an open standard to facilitate improvement through process management and benchmarking, regardless of industry, size, or geography. The PCF organizes operating and management processes into 12 enterprise level categories, including process groups, and over 1,000 processes andassociated activities.

In the developing country public health setting, John Snow, Inc. has developed the JSI Framework for Integrated Supply Chain Management in Public Health, which draws from commercial sector best practices to solve problems in public health supply chains.

In the 1980s, the term supply-chain management (SCM) was developed to express the need to integrate the key business processes, from end user through original suppliers. Original suppliers are those that provide products, services, and information that add value for customers and other stakeholders. The basic idea behind SCM is that companies and corporations involve themselves in a supply chain by exchanging information about market fluctuations and production capabilities. Keith Oliver, a consultant at Booz Allen Hamilton,is credited with the term's invention after using it in an interview for the Financial Times in 1982. The term was used earlier by Alizamir et al. in 1981.

If all relevant information is accessible to any relevant company, every company in the supply chain has the ability to help optimize the entire supply chain rather than to sub-optimize based on local optimization. This will lead to better-planned overall production and distribution, which can cut costs and give a more attractive final product, leading to better sales and better overall results for the companies involved. This is one form of vertical integration. Yet, it has been shown that the motives for and performance efficacy of vertical integration differ by global region.

Since the product design dictates multiple requirements on the supply chain, as mentioned previously, then once a product design is completed, it drives the structure of the supply chain, limiting the flexibility of engineers to generate and evaluate different (and potentially more cost-effective) supply-chain alternatives.

Figure 1.1: Supply Chain Management Functions

In commerce, supply chain management (SCM), the management of the flow of goods and services, involves the movement and storage of raw materials and of finished goods from point of origin to point of consumption. Interconnected, interrelated or interlinked networks, channels and node businesses combine in the provision of products and services required by end customers in a supply chain.Supply-chain management has been defined as the "design, planning, execution, control, and monitoring of supply-chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally." SCM practice draws heavily from the areas of industrial engineering, systems engineering, operations management, logistics, procurement, information technology.

Although it has the same goals as supply chain engineering, supply chain management is focused on a more traditional management and business based approach, whereas supply chain engineering is focused on a mathematical model based one.

Supply-chain management is a cross-functional approach that includes managing the movement of raw materials into an organization, certain aspects of the internal processing of

materials into finished goods, and the movement of finished goods out of the organization and toward the end consumer.

Organizations increasingly find that they must rely on effective supply chains, or networks, to compete in the global market and networked economy. In Peter Drucker's (1998) new management paradigms, this concept of business relationships extends beyond traditional enterprise boundaries and seeks to organize entire business processes throughout a value chain of multiple companies.

Many researchers have recognized supply network structures as a new organizational form, using terms such as "Keiretsu", "Extended Enterprise", "Virtual Corporation", "Global Production Network", and "Next Generation Manufacturing System". In general, such a structure can be defined as "a group of semi-independent organizations, each with their capabilities, which collaborate in ever-changing constellations to serve one or more markets in order to achieve some business goal specific to that collaboration".

The importance of supply chain management proved crucial in the 2019-2020 fight against the coronavirus (COVID-19) pandemic that swept across the world. During that event, governments in countries that had in place an effective domestic supply chain management had enough medical supplies to support their needs and enough to donate their surplus to front-line health workers in other jurisdictions. Some organizations were able to quickly develop foreign supply chains in order to import much needed medical supplies.

Supply-chain management is also important for organizational learning. Firms with geographically more extensive supply chains connecting diverse trading cliques tend to become more innovative and productive. Circular Supply-Chain Management (CSCM) is "the configuration and coordination of the organizational functions marketing, sales, R&D, production, logistics, IT, finance, and customer service within and across business units and organizations to close, slow, intensify, narrow, and dematerialize material and energy loops to minimize resource input into and waste and emission leakage out of the system, improve its operative effectiveness and efficiency and generate competitive advantages". By reducing resource input and waste leakage along the supply chain and configure it to enable the recirculation of resources at different stages of the product or service lifecycle, potential economic and environmental benefits can be achieved. These comprise e.g.

decrease in material and waste management cost and reduced emissions and resource consumption.

The projected benefits and impacts of the RFID implementation are summarized in the following table:

Table 1.1: Benefits and impacts of RFID Implementation

Supply-chain factor	**Current state**	**RFID opportunity and challenges**
Type of demand	Predictable	Improve leanness capabilities
Contribution margin	5 to 20%	Early adopters can increase the margin, need cheap tags
Product variety	Low (10 to 20 variants per category)	Suitable to track products by pallets or cases
Average margin of error in demand forecast	10%	Room to improve forecasting through visibility of inventory and demand.
Average stock out rate	1 to 2%	Opportunities for reducing stock out and increase margin significantly.

The prototype system developed by e-Smart Source in a supply chain RFID pilot showed the following benefits:

• Data accuracy in the supply-chain. The project resulted in 99.9% accuracy of inventory where all the links of the supply-chain were RFID enabled. As a result the stock-out rate in those stores was reduced to less than 0.1% over a period of several months.

• Profit margin Preliminary analysis shows that the product line profit margin is expected to increase by over 20%.

RFID technology has been available for many years. Recently, its application to improve visibility in supply chain has demonstrated significant value for companies. The amount of research and development dollars being invested will enhance capability and reduce cost continually going forward. RFID as a major component of supply chain solutions is here in force. Those companies implementing RFID early will gain competitive advantage. However, implementation must be undertaken correctly by defining clearly the process and ensuring the right technology is applied to the opportunity.

In a simple manner, a supply chain is a flow of materials, information, money, and services from raw material suppliers through factories and warehouses to the end customers.

There is no doubt that supply chain management is an integral part of the e-commerce business. It provides quick and effortless shopping experience; instead of traveling to the stores, standing in the long queues to pay the bill, customers can comfortably purchase the products at the tip of the finger and get deliver the products at doorstep. The reason behind this comfort is supply chain management. E-commerce, M-commerce business is completely dependent on SCM.

When a customer purchases from the online stores, they look for quick delivery in minimum time. And if the logistic department fails to deliver on-time, the customer may never use that particular store. So, in order to provide great user experience, the supply chain needs to track every operation.

Radio frequency identification (RFID) has been used since the Second World War for defense strategies, but is now more accessible and being implemented in industries such as pharma, retail, logistics, travel, and agriculture. RFID can be used in many different ways to create value. In this blog post, we will present the most interesting and widely used applications of RFID.

RFID is a system that uses small radio frequency identification devices for tracking purposes. RFID touts advantages such as the lack of human intervention needed and reduces costs for some industries.

When RFID is implemented in supply chain management, stock is more easily managed and logistical costs can be minimized. The world's largest retailer, Wal-Mart uses RFID for improving supply chain efficiency and to ensure that products are in stock to meet customer demands. Wal-Mart has also implemented automation of just-in-time product shipments. The warehouse management system can locate the products in the warehouse based on the initial scan, and automatically moves them to a loading dock for shipping to the retail outlet.

Manufacturing RFID can be used for tracking parts and work during the manufacturing process. By implementing this system, companies can reduce the number of flawed products, increase movement and manage the production of different versions of the same product. This is found mostly in the car and automotive industry. For example, AM General uses an active RFID for its new golf cart assembly line to cut the time it takes to build each vehicle (from 88 minutes to about 46 minutes).

Pharma Implementing RFID in this industry has been a new challenge that started with medical centers wanting to improve stock controls. It then was implemented in other ways such as adapting the system for ensuring that FDA guidelines are met and supporting the use of RFID with biologics. For example, Hanmi Pharmaceutical tags 60 million products each year, streamlining operations, preventing fake products and maximizing traceability throughout their supply chain.

The applicability of the RFID is extensive and is still targeting new industries. RFID helps companies increase the credibility and the shelf life of their products, and makes food and pharma industries more safe and the automotive industry more productive.

1.2 Problem Statement

It has been observed with the era of evolution the supply chain management is getting advance day by day and with the implication of RFID in supply chain, it has taken the supply chain management to a new level.

When RFID is implemented in supply chain management, stock is more easily managed and logistical costs can be minimized. The world's largest retailer, Wal-Mart uses RFID for improving supply chain efficiency and to ensure that products are in stock to meet customer demands. Wal-Mart has also implemented automation of just-in-time product shipments. The warehouse management system can locate the products in the warehouse based on the initial scan, and automatically moves them to a loading dock for shipping to the retail outlet.

Manufacturing RFID can be used for tracking parts and work during the manufacturing process. By implementing this system, companies can reduce the number of flawed products, increase movement and manage the production of different versions of the same product. This is found mostly in the car and automotive industry. For example, AM General uses an active RFID for its new golf cart assembly line to cut the time it takes to build each vehicle.

RFID has the ability to provide far more information than bar-coding. This information can be used to improve inventory management at the retail store and along the supply chain.

Implementing a successful RFID strategy takes time and effort. Implementing a fullfledged system in a large manufacturing company can cost $10 to $25 million. 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."

Table 1.2: RFID Implementation challenges

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

IBM recently surveyed nearly 400 supply chain executives at companies located in 25 countries and serving 29 separate industries. The study revealed that supply chain visibility is still a major issue. The technology best poised to improve supply chain visibility is RFID that can collect and deliver real-time data regarding every facet of an interconnected supply chain.

There are many success stories of effective implementation of RFID technology in this sector. For example, the U.S. Army is using a Global Sentinel Unit (GSU), which is mounted onto a truck and acts like RFID tags and communicates via satellite and cellular communications to ensure troops

in Iraq receive their necessary supplies. More accurate visibility, helps the military keep supplies from running out, and prevents overstocking.

RFID technology could be an extremely powerful tool for improving efficiencies, especially when used as an infrastructure for many applications. A few companies, such as Airbus, have already adopted this infrastructure approach, and have been successful.

1.3 Objectives of Study

- To study the various implementation of RFID in supply chain management.
- To study the factors hindering the performance.
- To study the issues and challenges being faced in implementation of RFID technology in supply chain management.
- To conduct a research with various experts from different sectors to get their perception on RFID in industry.
- To look forward for moderations that can be made in the system.

1.4 Scope of Study

- A actual insight of all the factors which are hindering the performance of the supply chain management will be analyzed.
- The challenges and issues that are affecting the growth of RFID technology will be studied.
- The perception of the experts from various sectors will be used for analysis of RFID in the industry.
- The upcoming modifications being introduced will be evaluated.

CHAPTER 2: LITERATURE REVIEW

According to Bowersox and Daugherty (1995) and Currie (1993), benefits of supply chain management can be reached by the use of "information technology and the construction of integrated supply chain information systems" (Narasimhan & Kim, 2001). Concerning the use of information systems (IS) to integrate business processes across the supply chain, various studies have shown that an internal integration should precede the external integration with suppliers and customers (Narasimhan & Kim, 2001; Bowersox, 1989; Byrne & Markham, 1991; Hewitt, 1994). Edwards, Peters, and Sharman (2001) found that among the companies which they researched, the ones exploiting technology to integrate trading partners and redesign business models were more successful than others.

Stadtler (2002) introduces the "House of SCM" in which the coordination of information in the supply chain is one of the building blocks. He states that information and communication technology is essential to efficiently automate processes and coordinate information flows along the supply chain. Schlegel and Smith (2005) argue that technology is a key for the success of SCM systems and indicate that the successful supply chain integration positively influences the companies' stock market performance. Nevertheless, they state that all projects which aim at enhancing the supply chain performance must be understood as part of the larger initiative of supply chain integration. Therefore, they introduce a model of the "Dynamic On-Demand Supply Chain" which among two other principles is based on technology integration.

An overview of the historical developments in supply chain management systems is given by Busch, Dangelmaier, Pape, and Rüther (2003). They outline the evolution of planning systems from the beginnings in the 1960s with the concept of Material Requirements Planning (MRP) and explain the development towards Enterprise Resource Planning (ERP) systems which are based mainly on the concept of Manufacturing Resource Planning (MRP II). Furthermore they introduce current functionalities and particularities of Advanced Planning and Scheduling (APS) systems and how these systems can be extended to collaborative supply chain management systems. Finally, they present the results of a market survey. Gronau (2004) also describes the evolution of supply chain management systems.

Whereas Busch et al. (2002) and Gronau (2004) maintain a vendor-independent view, Mehlich (2005) demonstrates the latest developments in supply chain management systems on the basis of

the mySAP SCM solution offered by SAP. She presents problems which often occur during integration of new SCM system modules and then gives recommendations on how to overcome these. Moreover, she points out certain limitations of my SAP SCM, for instance that a focus on specific industries is not yet realised and that for some customer requirements the computing power is not sufficient.

Finkenzeller (2003) gives a general introduction to RFID as an automated ID technology as well as sample applications such as Container Identification for the chemicals industry or in waste disposal and tool identification in industrial automation. Hodges and Harrison (2003) provide an overview of the RFID components used in the EPC architecture framework of the Auto-ID Center. They cover the physics, different types of systems, and the standardization issues at the time of writing (which are outdated by now). The RFID technology used in supply chain operations is described by Sarma (2002). He not only illustrates the physical and technical principals but also outlines how current production techniques can be developed in order to produce transponders at very low costs (at around 5 US cents).

By outlining a generic supply chain building block, they evaluate potential impact on supply chain operations. From the results they propose both short-term deployment and opportunities for re-engineering of supply chain processes with the use of RFID as automatic identification technology. Regarding the benefits of RFID systems, Kambil and Brooks (2002) expect that early implementations will be likely to only hold proprietary benefits whereas the full potential lies in the collaborative use of open systems and applications. Heinrich (2005) states that RFID systems will improve flows in supply chains. But he points out that the benefits are heavily dependent on the system integration and how the automatically collected data is used by the supply chain management systems. Further more he finds that before implementing RFID technology, a company must be aware of its business goals and then should map RFID technology onto these goals. To facilitate implementation success, top management commitment as well as a clearly defined scope are suggested. As RFID technology introductions bear risks that the companies must be aware of, Kopalchick III and Monk (2005) identify four domains of risk, namely engineering/technical risks, business environment risks, process risks, and technology risks.

Angeles (2005) presents cases of RFID applications and information which support the adoption of RFID technology. She states that RFID enables supply chain visibility but also states that further research should be undertaken to evaluate if the technology lives up to the high

expectations and find out which factors make implementation strategies effective. Because RFID provides benefits in logistics operations, impacts on supply chain facilities such as warehouses are foreseeable. Twist (2004) describes how the technology impacts facility operations and concludes that especially cross-docking warehouses will gain significance as products spend less time on shelves and loading and unloading processes are optimised. As RFID technology might interfere with privacy rights of end customers, Flint (2005) reports on current legal issues discussed by a British working party established to address EU-conforming RFID privacy guidelines. He comes to the conclusion that informed consent for now is a practicable way for RFID applications but that the privacy standards in the EU are far more developed than in other parts of the world where the customers may suffer from exploitation by the companies.

In addition to the above mentioned publications, there is also relevant research of the Auto-ID lab which is a federation of research universities and is developing an open standard architecture (Auto-ID labs, 2005). Joshi (2000), for example proposes "a framework to achieve information visibility in the supply chain using radio frequency tags, tag readers, product identification codes, an object description language, and the internet". By evaluating the supply chain performance with simulations of different information visibility levels and forecasting functions, he proves that information sharing and information visibility increase supply chain performance and reduce costs across the entire supply chain.

Based on these facts he then develops the RFID Auto-ID solution which can provide the necessary information visibility. Joshi's research represents a forerunner of the EPCGlobal Architecture framework which consists of several technologies around RFID Auto-ID solutions. The different parts of the EPCGlobal Architecture Framework have been developed initially by the members of the Auto-ID Center. Brock (2001) describes the naming scheme for the individual identification of items along the supply chain, called Electronic Product Code, in 64 and 96 bit versions. Engels (2003), however, finds that these formats hold practical limitations and thus presents a 256 bit version of the Electronic Product Code which allows far greater numbers of "objects, services, assemblies, and groupings that may be uniquely identified".
Because the EPC only contains the identification number of an item, the object name service (ONS) is used to connect the item with the corresponding information. The ONS "provides a

lookup service to translate an EPC™ number into an internet address where the data can be accessed" (Harrison, Moran, Brusey, & McFarlane, 2003) and is described by Uo, Suzuki, Nakamura, and Murai (2004).

The actual information on an item, such as EPC-number, time stamp, barcode data or sensor data, is recorded using the Physical Markup Language (PML), which is based on XML and described by Brock, Milne, Kang, and Lewis (2001). However, they point out that the PML only records how the data is communicated. Harrison, Moran, Brusey, and McFarlane (2003) provide further information on PML server development. Goyal (2003) introduces Savant, a hierarchical system in which lower level Savants "process, filter, and digest events" (p.4) and "To reduce network traffic, a Savant may just forward events of interest or event summaries to higher level Savants". The savants build the foundation for the exchange of data collected by the reading devices.

Regarding the problems in the standardization for RFID applications, Edmonson (2005) reports on the current issues and attitudes of the two competing standardization bodies, the EPCGlobal incorporation, an organization formed by technology vendors as well as RFID-deploying companies, and the International Standards Organization (ISO). He concludes that both standardization bodies are trying to reach a common goal but also that the users of the technology fear that the competition between the standardization bodies may increase and ultimately result in two incompatible standards.

Gross and Lo (2003 provide the "Change Readiness Guide" for Auto-ID projects in order to assess impacts on the organisation, its processes, and employees. It provides project managers of Auto-ID projects with generic guidelines in order to assess which cross-organisational as well as cross-functional areas are impacted by Auto- ID applications. Serving as an introductory reading before RFID projects are started, the article provides useful information but the generic level prevents the expedient use in a concrete Auto-ID application which mostly contains various particularities which must be considered.

Morán, Ayub, and McFarlane (2003) examine the impacts of Auto-ID in a use-case approach in order to determine its impact on existing procedures and information systems in a retail company. They come to the conclusion that the impact on information systems is rather limited and that

adoptions can be carried out incrementally as radical functionality changes are not needed "as long as early applications allow for extension and have strategic value".

The origins of Supply Chain Management date back to the 1950's and 1960's when U.S. manufacturers were employing mass production techniques to reduce costs and improve productivity. During this time-period, there was little focus on creating supplier partnerships, improving process design and flexibility, and/or improving product quality. Development of new products was slow because manufacturers relied on inhouse resources, technologies, and capacities. Sharing of technology and expertise was non-existent in creating strategic relationships and there were large investments made in work in process inventory to keep machinery running and maintain balanced material flows (Wisner, Tan and Leong).

In the 1960's and 1970's, material requirements planning systems and manufacturing resource planning systems were developed. The importance of effective materials management was realized and the amount of impact that high levels of inventories had on manufacturing and storage costs. Computer capabilities became more sophisticated resulting in an increase of inventory tracking software, which made it possible to reduce inventory costs. This also created an improvement with internal communication with need for purchased parts and supplies emphasized (Wisner, Tan and Leong).

In the 1980's, SCM became increasingly popular as global competition increased, which created a demand for lower-cost, higher quality, and higher levels of customer service. Manufacturers utilized Just-in-time (JIT) inventory and total quality management (TQM) strategies to improve quality, efficiency, and delivery times. No matter the length of the definition or the differences in terminology, my studies have taught me that supply chain management is cutting costs, maintaining efficiency and quality, and providing value-added services from the original equipment manufacturer all the way down to the end consumer. SCM focuses on the customer and making sure that they are fully satisfied with any products or services provided, while building a trusting relationship that can be beneficial for both partners now and in the future. A large part of this today is technology; this is something making a large impact on the supply chain, which is why it is important to discuss its role as supply chain enabler.

In order for companies to become successful in the supply chain, they must fully integrate all departments and partners, rather than certain areas. If full integration does not take place, the

company will not see full results and will most likely fail due to inadequacies. Full integration is much easier today then it was twenty years ago and this is because of technology. Technology is an "enabler" for supply chain management systems and better efficiency, because of the automation that it creates. Although technology can solve a problem and identify a need, it should not take over the supply chain completely. A large part of supply chain management is customer service, which is not something technology can provide alone. The systems can provide increased accuracy, better inventory tracking, and a reduction of costs, which are all characteristics that partners and customers enjoy, but speaking with them is a good way to maintain the relationship so they keep coming back. Many consumers are already in fear that technology will take over and yes it enables to do a lot more with a lot less, but companies need to remember communication is the key to all relationships. Technology has enabled use to create better systems for our supply chain and below are a few that have become quite popular in SCM and relate well to RFID.

Radio frequency identification (RFID) is a technology that enables large amounts of information to be stored on chips (tags/transponders) that can be read at a distance by readers, without requiring line of sight scanning (Wisner, Tan and Leong). RFID is a smarter barcode that will one day replace the barcode that we are familiar with today (or so it is thought). RFID is an innovative technology that will make the supply chain faster and efficient with less human error. The technology is affecting the supply chain in many different industries from retail to pharmaceuticals to government defense and security to agriculture. The technology has had a slower growth than predicted, but the value added benefits are beginning to defeat the challenges. Below is a diagram of a typical RFID system; the tag is placed on an item such as, the pallet (hold many boxes), a box (holds many items), or a single item. After the tag is placed on an item, the reader then transponds the information to the RFID software that then processes the information into the communication network or database used by the supply chain partners.

Supply chain management has one distinct goal; to create value for the services and products that are provided to the end-consumer and in return, companies will benefit from the supply chain network. In order for this to happen, companies must integrate activities internally and then with their trading partners. This is ultimately known as supply chain integration, but what does that mean? Supply chain integration is the sharing of information and coordinating resources to

collaboratively manage a process (Wisner, Tan and Leong). All of this can be achieved through the use of RFID technology in the supply chain network.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Method

Due to the fact that the use of RFID technology in supply chain operations is a rather new application it became clear in the planning process that the research methodology must be suitable for the analysis of qualitative data as it could not be expected to find a representative sample of participants for a quantitative analysis. Therefore, a combination of secondary and primary sources provided qualitative data for this study. In a first step literature about supply chain management and supply chain management systems provided the basis for an introduction into the history, development and classification of supply chain management systems. The need for efficient data acquisition methods is elaborated and the fundamentals of RFID technology are introduced based on standards, company whitepapers and studies. Additionally, a description of an RFID integration solution with existing enterprise resource planning or supply chain management systems visualizes the combination of both.

The nature of the research questions demanded that they were answered through multiple case studies in order to be more representative than one single detailed case study (Yin, 2003). Therefore, the goal was to find, analyze and compare current cases of RFID technology in several companies and to study the impacts on SCM systems. For this reason, a survey and interview were conducted and analyzed by the means of descriptive statistics and especially thematic analysis.

The following four steps were carried out for the study:

- Select individual reports relevant to the issues to be studied.
- Collect data within individual sites using a range of qualitative methods.
- Analyze the data within individual sites using appropriate quantitative and qualitative methods of analysis—for example, descriptive statistics, thematic analysis of qualitative data.
- Compare data analyses across sites to draw more general conclusions.

Additionally, findings from literature were used to compare the results with other research.

3.2 Justification of Choice of Methodology

The interdisciplinary nature of the research topic brings with it two different backgrounds and languages which are to be combined. Therefore, it is necessary to provide a common language and to understand how these to fields are combined and how they interact. As the combination of RFID and SCM systems is still in its infancy it is vital to present the historical development as well as elaborate the standards and classifications of RFID technology. In this way RFID technology used in supply chain operations can be delineated from the general technology.

In order to achieve a higher accuracy of the gathered data, multiple data sources were used. This approach is also referred to as triangulation. According to Knight (2002), this strategy allows for a greater certainty of the accuracy of the data because it reduces the risks of individual bias and enables a validation through crosschecking the data.
For the second part of the project, the case study methodology "seeks to answer questions of how and why, instead of who, what, where, how much, and how many" (Brock, Kukulski, & Tanis, 2002, p. 1). Accordingly, most of the questions in the questionnaire and during the interview were of the nature of 'how' and 'why'. This approach allowed for the collection, analysis and interpretation of the sought data with regard to RFID technology introduction and its impacts on supply chain management systems.

The questionnaire and the interview questions and notes can be found in the appendix of this document. The use of a semi-structured interview provided direct answers in the nature of the research questions but also allowed for flexibility to ask subsequent questions to extend the view and understanding of the researcher by being responsive to the interviewee.

3.3 Data Collection

As already stated above, the data used in this study was gathered through three sources, namely a review of secondary sources, a survey and a semi-structured interview. In order to locate relevant literature, several internet databases were used. Among them were EBSCO and Emerald Insight. But to a greater degree, several libraries in the area of the researcher were visited and used. Among

them was the ‘Deutsche Bibliothek’ in Frankfurt am Main which is “responsible for the collection, processing and bibliographic indexing of all German and German-language publications issued since 1913” (Die Deutsche Bibliothek, 2001). In order to include relevant English publications as well, the library of the European Business School in Oestrich-Winkel and the Supply Management Institute in Wiesbaden were also utilized. In case publications were not available in either of the libraries or via the databases, the document service of other libraries was used. Apart from the hardcopy version of books in libraries, also the electronic library services from Unitec provided access to several publications. Therefore, it is necessary to provide a common language and to understand how these to fields are combined and how they interact. As the combination of RFID and SCM systems is still in its infancy it is vital to present the historical development as well as elaborate the standards and classifications of RFID technology. In this way RFID technology used in supply chain operations can be delineated from the general technology.

Nevertheless, these sources where mainly used for information on supply chain management systems whereas the information on RFID technology found here was rather outdated. The technological advantages and creation of standards in recent years seem to outpace the publishing processes. But still, both German and international journals could be found which contained timely articles on RFID technology. However, especially on the website of EPC Global, a standardization body which emanated from the Auto-ID centre at the Massachusetts Institute of Technology, several publications were identified and examined. The internet was also used to locate studies, governmental publications on RFID (regulations) and to research standardization status.

The questionnaire was sent out via email and collected either by email. The questions of the survey were primarily aimed at answering the research questions but additionally, basic demographic information of the participants was collected as well. The questionnaire and the interview questions and notes can be found in the appendix of this document. The use of a semi-structured interview provided direct answers in the nature of the research questions but also allowed for flexibility to ask subsequent questions to extend the view and understanding of the researcher by being responsive to the interviewee.

The following people were interviewed for carrying out the research:

Table 3.1: List of people interviewed

S. No.	NAME	DESIGNATION	ORGANIZATION
1	Mr. Rohan Malik	Program Consultant	Dell Technologies
2	Mr. Prafull Kumar	Group Manager	Wipro Private Limited
3	Ms. Monika Malik	Lead, Quality Assurance	Nagarro Software
4	Mr. Deepak Kumar	Business Operations Manager	Touchdown Gurus
5	Mr. Amritanshu Pandey	City Lead, Operations	Dunzo
6	Mr. Vishal Jha	Supply Associate	BYJU'S
7	Mr. Amit Dutta	CEO	The Circle.work
8	Ms. Vanshika Garg	Software Engineer	Accenture
9	Mr. Rajat Sharma	Co-Founder & Data Architect	RMgX
10	Mr. Nipun Bhalla	Associate Software Engineer-Data Sciences	Eye Care Leaders Pvt. Ltd.

3.4 Ethical Considerations

Due to the fact that this research involved the collection of business information about the introduction of a new technology and the strategic character of such projects, the data needed to be treated accordingly. Prior to the collection of data, the researcher examined the Policies and Procedures of the Research Ethics Committee as well as the NZ Privacy Act 1993 “which, amongst other things, requires that data can only be collected for the purpose for which it is stated, must be kept securely, must only be kept for as long as is necessary, and must be destroyed at the end of the project“(Coard, 2004). The form ‘Is Ethical Approval Needed for my Research; Checklist and

Declaration' which is contained in the appendix was completed and approved by Unitec's Research Ethics Committee for non-contentious student-led research.

In order to ensure that the participants where informed about the purpose of the study and that their participation was voluntarily they received a cover letter as an email and an Informed Consent Form which was sent along with the email containing the questionnaire. The collected data has been stored securely with password protection and encryption during the entire project. Therefore, only the researcher can identify the participants and the gathered data is presented anonymously. As soon as this master's dissertation is examined, the data identifying the participants will be destroyed.

3.5 Data Management, processing and Analysis

Creswell's (2003) six step method was used to guide the data management, processing and analysis :

Data organization and preparation

The collected data from the questionnaire was copied directly from email answers into a Microsoft Excel spreadsheet and answers from questionnaires were typewritten to allow for an equalized view. The notes from the interview were also included in the spreadsheet but marked with a different color.

Developing an overall picture

With the harmonized display of the answers to allow for the development of an overall picture the questionnaire and interview answers were read several times to code for emergent themes. Trace (2001) states: "This approach ensures that any unanticipated themes are given the opportunity to emerge from the data and that no undue weight is given a priori to any preconceived themes."

Data analysis

Emergent themes were then highlighted and categorized. Different phraseologies of the same themes were examined for different meanings. This was necessary as the answers differed in length and circumstantiality's. Nevertheless, all participants answered in uncompleted phrases throughout the questionnaire. This provided data which was rich in content and information but also difficult to interpret.

Description and categorization of the collected data

In order to classify the emerging and identified themes, the themes were examined again, notes were taken, and similarities as well as differences were highlighted. The examined RFID projects took place in different industries, namely in logistics, consumer packaged goods, fashion and lifestyle, electronics, and semiconductors and were examined individually as well as in comparison to each other.

Representation of the collected data

The collected data is mainly presented in a condensed form of case studies in chapter 6 Results. This allows for a unified view of the different RFID projects yet leaves enough room to present unique features and requirements in order to dwell on the richness of the collected qualitative data. The analysis of the gathered information is presented in chapter 4 and presents the different themes and classifications discovered in the data.

Data interpretation

After the thematic analysis and presentation, the data was further examined in view of the research questions. It was interpreted and parallels as well as variations in comparison to findings from the literature were elaborated upon.

3.6 Bias

Even though careful preparations were taken in order to minimize sources for bias, some possible sources should be taken into consideration. Because the research questions look at a new technology as well as at the topic of supply chain management in which terms are not ultimately

defined and interpreted in the same way it is possible that the participants have a different understanding of certain terms than the researcher has. Also, the subjectivity of the researcher which can lead to a better interpretation of the data by including surrounding factors for instance recognizing the tone of the participant's voice during an interview can mislead the interpretation because the researcher and the interviewee do not share the same perception. Another possible source for misinterpretation is simply the different understanding of terms and definitions of the participant and the researcher. As the research was conducted in India using questionnaires in English it was possible that the participants, even though English is the corporate language in most companies operating in an international context, did not have the language capability needed to produce correct and understandable answers. This was not the case but if that had happened, the researcher would have provided the questionnaire in Hindi and translated the answers back to English, which would have represented another source for bias.

The interview and the quality of note taking during its conducting are heavily dependent on the researcher's abilities to simultaneously understand what the interviewee is saying, take notes, follow the interviewee and also ask further questions. As the researcher is used to taking notes in a lecture setting and asking questions in between, the possible influence on the correctness of the gathered data should be minimal. As the above explanations regarding the methodology of this study have shown, the chosen qualitative research approach is suitable under the given circumstances. The researcher has utilized various sources of information for the data collection bearing in mind ethical considerations. By following a structured and well documented procedure, bias is likely to be reduced to the remaining factors which are mentioned. The following chapter is the first part of the theoretical foundation for the empirical study and introduces the fundamentals of supply chain management and supply chain management systems.

CHAPTER 4: ANALYSIS

4.1 Introduction to Case

The following section introduces the examined case studies. Among them are RFID projects from a logistics service provider. The descriptions of the projects give an understanding of how the examined RFID systems work and take into consideration the particularities of each deployment.

- RFID Implementation of Supply Chain: Comparison of Three Case Studies-

1. An RFID based Supply Chain Management Solution for the Petroleum development Industry: A case study for Shell
2. An RFID Simulation for the Supply Chain Management of the UK Dental Industry
3. The use of RFID based supply chain systems in data centers for the improvement of the performance of financial institutions

This paper integrates the impact of different approaches in implementing Radio Frequency Identification (RFID) technology, namely supply chain inventory management system based on RFIDs to address the challenges encountered in the operation of the warehouses, item-level inventory tracking at retail stores, and customer order processing and distribution using RFIDs; to eventually propose RFID based supply chain management. Supply chain management (SCM) involves an effective information sharing, inventory management, transportation, sourcing and pricing strategies. This paper highlights upon how RFID can improve SCM drivers, one by one, and together that improve overall synergy. This paper extends the solutions of case studies and proposed improvements to RFID solutions in ERP applications. The paper also highlights the motivation to such implementations as these solutions offer further cost savings and performance gains. Consequently we conclude that RFID is a vital technology for the success of SCM and bridging the gaps among the existing enterprise applications.ting enterprise applications.

- RFID Pilot at a fashion and lifestyle company and its retailer

Another RFID pilot project was conducted in Germany by a global fashion and lifestyle company together with its logistics partner and a retail company. Its goal was to test current technology, examine possible applications for reasonable RFID deployment, and to identify both costs and benefits of RFID solutions in the textile trade.

- RFID solution in the semiconductor supply chain

A semiconductor company simplified its supply chain processes using an RFID solution between its manufacturing plant and a distribution centre. The main purpose of the pilot project was to present a valid business case for RFID deployment. On the one hand, the pilot serves as reference project for other company locations but also as a showcase for customers as the company produces RFID transponders. In the manufacturing plant RFID transponders are used at three levels. Every pallet, carton box and individual packaging unit is tagged with passive smart labels and scanned before shipment to the distribution centre. On arrival at the distribution centre, the receiving process is largely automated now. Before, every carton and packaging unit had to be opened to tally the shipment. Now, the shipment passes an RFID-enabled gate and information of a shipment is collected and the receipt process is shortened to a quarter of the previously needed time. The achieved costs savings also result from reduced redistribution time. One of the main efforts of the project was the process-reengineering. In order to allow for very high reading rates with products and packaging containing aluminium the location of the transponder on the packaging was critical. Also the stacking provides a source for error as transponders put too close together can block each other. The integration to the IT environment was mainly concentrated on changes in the warehouse management system.

Because of the internal business benefits, the company plans to extend the scope of the project to include customers as well. Having illustrated current uses of RFID in supply chain operations in different industries, it already became clear that the requirements as well as the results of RFID deployment vary from case to case but also have certain similarities. The goal of the next chapter is to analyze the common themes and factors.

4.2 Data Collection

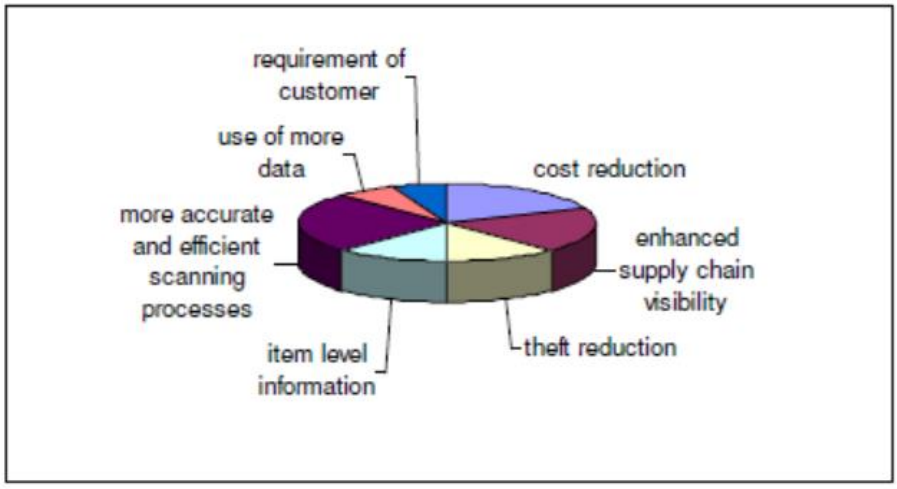
Nevertheless, these sources where mainly used for information on supply chain management systems whereas the information on RFID technology found here was rather outdated. The technological advantages and creation of standards in recent years seem to outpace the publishing processes. But still, both German and international journals could be found which contained timely articles on RFID technology. However, especially on the website of EPC Global, a standardization

body which emanated from the Auto-ID centre at the Massachusetts Institute of Technology, several publications were identified and examined. The internet was also used to locate studies, governmental publications on RFID (regulations) and to research standardization status.
The questionnaire was sent out via email and collected either by email. The questions of the survey were primarily aimed at answering the research questions but additionally, basic demographic information of the participants was collected as well.

4.3 Data Analysis

In this chapter, the underlying variables and factors of the anticipated variations are inspected in the light of the research questions. Consequently, the first part of the chapter focuses on the current use of RFID and the second part investigates the resulting impacts on supply chain management systems. To begin with, the positions of the participants in their companies were rather mixed. Though they had in common that they were responsible for the RFID projects, two of them were employed in the logistics department, two stated that they were project managers and one participant was the chief information officer (CIO) of his company. This mixture adds to the ambiguity of SCM and its function as described in the literature review. However, all of the examined RFID projects were carried out as pilot schemes. Questions were asked about the motivation and drivers of the projects as well as what the participants expected as business benefits. The prime reason to start the projects was to test the technology and to experiment with it. The main testing theme mentioned by the participants, as depicted in figure, was the improvement in scanning processes which goes along with the findings in previous research regarding the expected automation in the process in comparison to manual barcode scanning (McFarlane & Sheffi, 2003; Kambil & Brooks, 2002). Also, cost reduction is stated as a motivational factor for the use of RFID technology as well as the enhanced supply chain visibility mentioned by Joshi (2000). In two cases RFID technology was tested for theft reduction based on item-level solutions. Nevertheless, in opposition to expected and hailed RFID benefits (Sheffi 2004; McFarlane and Sheffi, 2003), the possibility to store and use more data on an RFID transponder than with a conventional barcode was only mentioned once.

Figure 4.1: Motivational factors for RFID projects stated by the research participants



In the interaction with the participants it became clear that the companies were mainly trying to introduce RFID technology at a small scale in order to be better prepared for possible global rollouts. The semiconductor company wanted to "showcase the benefits of RFID and generate a positive business case" for possible RFID customers. In all RFID projects, the numbering scheme of the Electronic Product Code developed by the Auto-ID Center was used. But, consistent with the stated motivation only in one case was additional information stored in the memory of the transponder. It also contained the shipment number and a return identification number only used internally. The wish for a better supply chain visibility was not only expected to be solved through the use of more check points but also by identifying entities at a lower data collection level. The extension of unique identification numbers of the Electronic Product Code compared to the barcode was used in four of the five examined cases. In these cases, the older data collection level was still used but additionally lower levels came into operation. In three cases item-level information was employed and in one project individual cases were identified. Only in one project, which was initiated because it was mandated by a customer, was the data collection level not affected.

Regarding the transponders used in the projects only passive transponders without their own power source were in operation. Because the systems were set up mainly to facilitate the shipping processes of receiving, picking and loading, distances between reading devices and transponders were rather short so that the passive transponders were sufficient. In four cases, the RFID systems were deployed in open loop systems, meaning that the transponders were disposed of and only in

the case of the fashion and lifestyle company, were the transponders removed from the clothing at the point of sale and then sent back to the manufacturer's warehouse.

This layout of the systems also determined the form of the transponders. In the closed loop system, robust plastic cases like the widespread but less sophisticated tags of the older article surveillance systems were used. Whereas in the open loop systems smart labels were in operation. The limited use of memory and the fact that the smart labels are printed and written to just once did not make it necessary to use more complex and expensive transponders. Another of the mentioned reasons why smart labels were used is the fact that the front side of the smart labels still contain the traditional barcode symbols and numbers. In the interaction with the participants it became clear that the barcode on the labels was still needed as it provided a two fold backup in case the transponder did not work. The barcode could be scanned or the numbers could be entered manually. The use of real time data which is collected via RFID technology and is one of the proposed benefits (McFarlane & Sheffi, 2003; Sheffi, 2004) was only implemented and tested in two of the five projects. In the fashion and lifestyle case the stock keeping data is permanently gathered at the retail store with RFID-enabled smart shelves and monitored by the supply chain management systems to avoid out-of stock situations. The company expects to benefit from more sales through the improved customer service.

In the transatlantic RFID deployment of the printer supplier, "RFID event information is combined with route maps which are updated immediately to reflect the time differences between plan and actual execution." Therefore, the company can provide more timely information about the location of products and the forecasts of arrival time are more accurate. Additionally, costs savings due to less express charges and contractual penalties are expected. Regarding the scope of the pilot schemes, the companies were mainly involving other supply chain members as well. Only the semiconductor company build the entire business case internally. This was necessary due to the fact that it wanted to provide the customers with reliable and uncensored data from within the company. The other projects involved all logistics service providers as well. This finding refutes the expectation of Kambil and Brooks (2002) who argued that most early RFID deployments would not be of collaborative nature. But it also indicates that the companies are aware that the greatest benefits of RFID solutions lie in a cooperative use of the technology by several supply chain members (McFarlane & Sheffi, 2003; Sheffi, 2004).

Because the nature of the examined projects was experimental due to the testing purpose, the given answers also contain a certain degree of criticism which results from the testing issues discovered in the pilots. These issues represent flaws in the technology from a user perspective. Interestingly, these shortcomings were addressed by four participants but not the participant from the semiconductor company which also produces integrated circuits (IC) for RFID transponders. Among the detected weaknesses, the technical barriers for the use with products containing metal or liquids and problems with reading rates during bulk reading procedures were mentioned. Also the different standards used on different continents were brought up as a disadvantage leading to higher costs. Nevertheless, the participants revealed mainly two groups of advantages of RFID technology compared to barcodes. They often mentioned the increased efficiency in scanning, identification and receipt processes and that the time savings enabled better inventory turns. The other main group relates to the increased supply chain visibility which resulted from more checkpoints and better tracking and inventory control. Additionally, the participants appraised RFID as a more robust technology, that it can be used in counterfeit protection and that it can become a standard which has coverage of more than one industry.

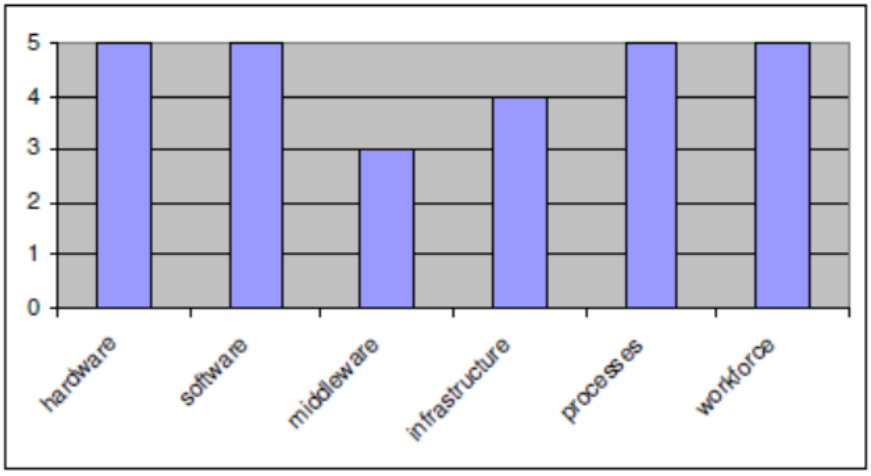
The participants expect to convert these advantages into business benefits. Better customer service with a higher supply chain transparency, less out-of-stock, increased sales, theft reduction, higher delivery reliability, increased inventory turns, and improved warehouse performance are expected to accrue in the examined industries. These findings resemble the benefits expected by McFarlane and Sheffi (2003). Interestingly, the stated benefits can be classified in two different themes. Benefits accruing to companies due to improved supply chain performance play the major role, whereas only the participant of the fashion and lifestyle company talks about improved sales performance due to less out-of-stock problems. Estimations about the future relationship of barcodes and RFID technology were rather consistent among the participants, even across the different industries. They expect a co-existence of the two for the following reasons:

- bar code has broad coverage today,
- bar code is still cheaper and more reliable,
- investments required to switch to RFID,
- RFID is only sensible for high value goods due to low prices of bar codes,
- RFID is not mature enough
- barcodes are needed in order to provide a human-readable code in case the tag is damaged

When comparing the RFID deployments in the different industries, the price of the products is associated with the data collection level. In general, it can be said that the more expensive the product, the lower the data collection level is. Whereas the item-level information of single wafer cartons justifies the price of a smart label, information about single shampoo bottles with small margins is not economic but information on pallet level serves its purpose. Currently, the mail-order and online retailer makes use of RFID labels only on high valued goods but plans to extend the use to cheaper goods as soon as the prices for transponders fall below certain price levels. With the intention of gaining a better understanding of the current supply chain integration efforts and to situate the RFID technology introduction in a superior supply chain management strategy, the researcher asked questions about the current supply chain integration efforts of the companies. The answers revealed two distinguishable themes. The participant from the logistics service provider explained the goal of becoming the market leader in the segment of lead logistics providers, which means that the company consults, plans, and controls entire supply chains of other companies with their own logistics capacities. Therefore, the company's integration focus lies in the external supply chain. Also, the participants from the fashion and lifestyle, mail order, and printer supplier companies stated that they were concentrating their efforts on external supply chain integration.

Concerning the experienced and expected impacts of RFID technology on supply chain management systems in the industries, the participants' statements are aligned with the projections found in literature (McFarlane & Sheffi, 2003; Davenport & Brooks, 2004; Sheffi 2004; Angeles, 2005). From a bottom-up perspective, the mentioned impacts which are all depicted in figure start with redesigned, faster scanning processes which lead to improved stacked lead time. Because the data collection level mainly shifted to lower levels and even towards item-level in three cases, the systems are provided with a higher granularity of data. Additionally to the higher granularity, the more efficient scanning processes allow for more check points which can be integrated along the supply chain. The previous labour- and time-intensive barcode scanning processes forbid a higher number of check points. Therefore, the occurring data volume is increased by the shifted data collection level and the higher number of check points.

Figure 4.2: Affected SCM system parts in RFID technology introduction as mentioned by the research participants



The faster and higher information availability allows the supply chain management systems to conduct real time data processing. However, as already stated, only two of the participants stated that they were actually using real time data. Faster data processing in turn leads to "increased information visibility" and "better supply chain visibility" together with greater system integration. In terms of the impacts on business performance, one of the participants reported "increased inventory turns", "better delivery reliability and warehouse performance". Other participants stated they could provide better customer service because of fewer out-of-stock situations which also lead to higher sales. Therefore, RFID is seen as serving the main goal of supply chain management, namely increased customer service.

It seems that one of the most crucial aspects of external supply chain integration in RFID projects is rather not of technical nature but a question of how supply chain members are able to cooperate. But the comments also highlight the importance of a standardized data structure and a harmonized system landscape between the supply chain members. Nonetheless, the participants also stated that the integration of new hard and software, warehouse management system adaptations, and process-reengineering were among the main integration efforts. The latter required intensive testing because the location of transponders on packaging must be considered as well as the direction of the products on the pallets to allow for bulk reading. The analysis of the gathered data has shown that companies are still testing RFID technology in small scale business scenarios. Nevertheless, they do so mostly together with supply chain partners in order to leverage benefits. This testing reveals several shortcomings in the technology which most certainly will be addressed

by the RFID producers within the next years. Regarding the integration with supply chain management systems, not only technology related but also organizational and behavioral issues have been encountered in the surveyed cases.

4.4 Discussion and Findings

The examined cases of RFID deployment in supply chain operations show that companies are already using the technology. Nevertheless, the limited extent to which they deploy RFID solutions shows that they are still hesitating to use it at a full scale. Because of the lack of knowledge in companies and because of problems of technical nature, mainly pilot schemes are conducted. The participants stated that there are still technological barriers which need to be overcome. These include faultless reading processes with products and packaging containing metals and liquids. But also the performance of RFID hardware in bulk reading processes needs to be addressed by the producers of RFID systems and components. Not until these deficiencies are overcome, are widespread global and industry crossing RFID deployments likely to be seen. These are the main reasons for better performance and more efficient processes compared to barcode solutions. As long as the technology is not mature enough to deliver these promises, companies will keep on hesitating to deploy it.

Apart from the technical advantage and its availability, costs still represent a major hindrance in mass deployment. Whereas high value goods can already be tagged economically on item level, lower value goods with small margins (as can be found in the fast moving consumer goods industry) are still far from being individually identified at reasonable costs. But despite the costs for such item-level identification possibilities, the benefits must be considered. Is it sensible to individually identify for instance every yoghurt pot? From the perspective of one producer it means that out of stock situations are likely to be avoided and thus sales increased. But when every yoghurt producer makes use of such RFID solutions, is it likely that people consume more yoghurt and the total yoghurt market expands? Only the early adopters in such a scenario can leverage RFID technology and expand their market share at the expense of the (late) followers.

Often producers claim that RFID item-level identification will reduce costs for recalls. The logic in such a scenario may be clear, as affected products can be uniquely identified. But should companies not focus on preventing the sources for failures rather than curing the symptoms?

With regard to item-level identification, the end customer plays an important role even for supply chain operations. As stated by the research participants, the acceptance of item-level RFID solutions by the end-customer is ultimately needed because of privacy issues. The companies deploying item-level RFID solutions where the transponders are not deactivated during the transfer of risk are very careful not to violate privacy rights but still have to fight accusations from consumer rights groups. These groups oppose the technology in a fashion similar to those who opposed the emergence of cellular phones in fear of being monitored and eavesdropped. The advantages of item-level tagging for consumers are still far from being available. Therefore, companies have to consider privacy issues very carefully especially until there are no regulations governing the use of RFID solutions.

The price issue being currently debated takes the form of the chicken and egg problem. The users of RFID transponders claim that they will deploy systems with massive numbers of transponders as soon as the prices fall. And yet at the same time, the industry leaders producing RFID devices and transponders argue that the prices will fall as soon as more RFID mass deployments are in place. As the examined cases have shown, in most cases it takes more than one company to economically deploy RFID solutions. But along a supply chain, the costs as well as the financial benefits of RFID deployments vary for each supply chain member. One way out of this problem is the emergence of solution providers which supply the RFID systems for an entire supply chain and develop innovative concepts which allow for an equitable breakdown of costs according to benefits. Due to the complexity in business and supply chain operations this is hardly achievable. Nonetheless, RFID costing concepts in which supply chain members are charged according to the accessed information are already being developed. However, the current RFID mandates by retail companies such as WalMart, Tesco, and Metro do not necessarily reflect this. The retailers' power over the end-customer is high enough that they can force their suppliers to meet their RFID requirements. However, it can be expected, that such forced mandates do not reap the benefits which accrue for RFID solutions where companies, on their free will, explore and apply the technology. This goes along with the findings of this study where the pilot project for such a mandate only used pallet-level tagging and tested automation of the previous barcode scanning processes.

The participants assess the coexistence of the barcode and RFID technology as the dominant form for automatic identification within the next five years. Because the system stability of sole RFID

solutions is not high enough for supply chain operations, a combination of barcode and RFID will be used. This solution brings the advantage that exception handling with non-working RFID transponders can be solved with barcode scanning or manually entering the human readable numbers. Because reading errors are even likely to occur with more advanced RFID technology it is questionable if a complete substitution will ever take place. However, the participants expected that the substitution will take place at some point in time, but that it will not happen within the next five years.

4.5 Limitations of Study

- There is a rapid effect on supply chain industry due to the Covid-19 and the growth rate will suffer which can't be predicted at current stage.
- The interview or the data has been gathered on previous analysis being carried out before the outbreak of Covid-19, so there can be a slight difference between the economic growth being predicted by the interviewee.
- The analysis has been carried out on the basis of data received from participants of the survey and the interviews being carried out. Many of them have been working on the RFID technology, so there are slight chances that their perception might be different from those who are still a beginner in RFID industry.
- The analysis or research has been carried out keeping in mind that the perception of the people involved in the process is based on the past and present trends.

CHAPTER 5: CONCLUSION

As an emerging technology, RFID is a currently often-discussed topic when process optimization, efficiency gains and better supply chain visibility and integration are sought after. In the aftermath of large retail companies forcing their suppliers to use RFID technology, more and more companies consider RFID technology as a way to reach long term strategic objectives.

From the series of questionnaires and the conducted interview, insight about the current use of RFID in supply chain operations and how this use impacts supply chain management systems could be gained and key findings were:

- RFID projects of the sample surveyed are overwhelmingly carried out as pilot schemes deploying passive smart labels. The costs and associated risks of large-scale roll-outs are regarded as too high because knowledge in the companies about the technology and its deployment is not sufficient yet.
- Co-existence of barcodes and RFID (in form of smart labels) can be expected at least over the next five years because backup for defect transponders is needed.
- The current use of RFID technology mainly serves as automation of previous processes whereas the promised extending advantages, for instance the possibility to store more data or to include sensors, are not exploited yet.
- RFID is used as a vehicle for tighter supply chain and systems integration between supply chain partners which theoretically could have taken place before and without the technology.
- The greatest barrier in RFID projects which include several supply chain membersis the organizational task to align and coordinate the members towards the common goal and the synchronization and standardization of the various systems along the supply chain.

As the conducted research has shown, RFID deployment in supply chain operations is not yet running routinely. Companies are mainly carrying out pilot schemes to evaluate business cases and test the technology. However, these pilot cases reveal weaknesses in the technology itself and

flaws in the initially expected possibilities and business benefits. The identification of these deficiencies helps to improve the quality of offered systems, identify best practices, and, maybe above all, clarify what the technology is actually able to deliver. The recent hype about RFID has led to exaggerated assumptions and hopes among many companies which could not (yet) be met. But as expert knowledge about RFID is still rare at most companies, a more realistic assessment of the possibilities without pilot schemes cannot be expected in the near future.

The deployed solutions are based on passive smart labels, a combination of RFID transponder and printed bar code. In this way, problems with defective transponders can be anticipated with exception handling routines as the barcodes can still be scanned or the corresponding numbers can be entered manually into the systems. But still, bulk reading operations where entire pallets with tagged items should be read simultaneously are not working properly with the passive smart labels. Exact placement on the packaging and correct direction on the pallets may increase reading rates but need to be figured out beforehand and strictly maintained. Such routines demand training of the staff in order to deliver the required results. Concerning the purpose of RFID technology and what it delivers, mainly an automation of previous scanning processes and operations such as picking, counting, stock keeping, loading and unloading can be seen. As budgets are small, positive business cases are strictly required which only leads to solutions on proven applications.

Also, despite the efforts of the two large standardization bodies EPC Global and ISO, differences in regional standards represent a hindering factor in global RFID supply chain applications. Nevertheless, one of the examined cases showed that the technology vendors developed devices which can deal with the different standards' requirements. But still this situation means higher than necessary costs. Especially in industries with low value items and low margins per product, the current status remains prohibitive for global roll-outs. Based on the sample taken, the development of new value-adding functionalities and services has not taken place yet. Neither the possibility to store more data on the transponders nor the combination with other technologies such as sensors is yet exploited largely. Nevertheless, it can be expected that key players in the fastmoving consumer goods and pharmaceutical industries will experiment with and examine these. Research in this field of RFID deployment needs to be conducted. As some companies are

forced by their customers to adopt RFID technology, their motivation differs from companies examining RFID which wish to use the technology to its benefits of their own free will. However, these differences should be further researched as insight can be expected to prevent suboptimal and costly RFID applications.

Concerning the role of RFID in supply chain management systems, the conducted research shows that RFID technology acts as a system enabler which delivers the needed granularity of item information and greater number of check points for higher supply chain visibility in real-time. Even though supply chain processes have been redesigned because of RFID introduction, the design of entire supply chains has not been affected yet. But RFID is used as a medium to integrate systems along the supply chain. Data structures are standardized in order to allow efficient data exchange among the supply chain members. These efforts theoretically could have been realized before, as the data collection method does not determine the data exchange. But when situating the advent of RFID technology and the development of business information and especially supply chain management systems, it becomes clear that the company internal integration of systems and data which was realized with the ERP systems in the 1990s preceded the external integration possible only since the development of APS and SCM systems. As discussed in the literature review, this order is widely regarded as superior. Therefore, RFID integration can be regarded as the logical next step in supply chain integration and supply chain management system development.

REFERENCES

- Angeles, R. (2005). RFID technologies: Supply chain applications and implementation issues. Information Systems Management, 22 (1)
- Auto-ID labs (2005). About the labs. Retrieved July 14, 2005 from: http://www.autoidlabs.org/aboutthelabs.html.
- Bowersox, D.J. (1989). Logistics in the integrated enterprise. Presented to the Annual conference of the Council of Logistics Management, St. Louis, MO.
- Bowersox, D. J. & Daugherty, P. J. (1995). Logistics paradigm: The impact of information technology. Journal of Business Logistics
- Brock, D.L., Milne, T.P., Kang, Y.Y. & Lewis, B. (2001). White paper – The physical markup language. Retrieved July 14, 2005 from: http://xml.coverpages.org/PML-MIT-AUTOID-WH-005.pdf.
- Brock, D. (2001). The electronic product code: A naming scheme for physical objects. Retrieved August 30, 2005 from: http://www.autoidlabs.com/whitepapers/MIT-AUTOID-WH-002.pdf..

- Bundesamt für Sicherheit in der Informationstechnik (2004). Risiken und Chancen des Einsatzes von RFID-Systemen.
- Busch, A., Dangelmaier, W., Pape, U., & Rüther, M. (2003). Marktspiegel Supply Chain Management Systeme – Potenziale, Konzepte, Anbieter im Vergleich
- Wiesbaden: Gabler.Buxmann, P., König, W., Fricke, M., Hollich, F., Diaz, L.M. & Weber, S. (2004).
- Byrne, P.M. & Markham, W.J. (1991). Improving quality and productivity in the logistics processes: Achieving customer satisfaction breakthroughs.
- Chang, Y., McFarlane, D., Koh, R., Floerkmeier, C. & Putta, L. (2002).
- Methodologies for integrating Auto-ID data with existing manufacturing business information systems. Retrieved June 12, 2005 from: http://www.autoidlabs.com/whitepapers/cam-autoid-wh009.pdf.
- Chung, S. & Snyder, C. (1999). ERP initiation: A historical perspective. Americas Conference on Information Systems AMCIS, Milwaukee: Association for Information System

- Coard, P. (2004): A comparative study of the use of the internet by manufacturing businesses in the small rural town of Levin, Horowhenua, MComp Dissertation, Unitec New Zealand.
- Cooper, M. C., Lambert, D. M. & Pagh, J. D. (1997). Supply chain management: more than a new name for logistics. The International Journal of Logistics Management
- Creswell, J. W. (2003). Research design – qualitative, quantitative and mixed methods approaches. (2nd ed.) Thousand Oaks, Cal.: Sage.
- Currie, K.W. (1993). An empirical study of logistics organizations, electronic linkage, and performance. Working Paper, Texas A&M University.
- Datta, S. (2005). Radio frequency made easy. Retrieved August 31, 2005 from http://supplychain.mit.edu/innovation/docs/RFID%20Made%20Easy.pdf.
- Davenport, T.H., & Brooks, J.D. (2004). Enterprise systems and the supply chain. Journal of Enterprise Information Management
- Die Deutsche Bibliothek (2001). Die Deutsche Bibliothek in brief. Retrieved August 11, 2005 from: http://ddb.de/wir/ddb_im_ueberblick_e.htm.
- Edmonson, R.G. (2005. Dueling technologies. Journal of Commerce, 6 (11), 18-19. Edwards, P. Peters, M., & Sharman, G. (2001). The effectiveness of information systems in supporting the extended supply chain. Journal of Business Logistics
- EPCGlobal (2005b). The EPCglobal architecture framework version 1.0. Retrieved July 14, 2005 from: http://www.epcglobalinc.org/standards_technology/Final-epcglobal-arch-20050701.pdf.
- Schlegel, G. & Smith, R. (2005). The next stage of supply chain excellence. Supply Chain Management Review
- Sheffi, Y. (2004). RFID and the innovation cycle. The International Journal of Logistics Management
- Yin, R.K. (2003). Case study research Design and methods. London: Sage.

ANNEXURE

Annexure 1: Questions and Answers of the questionnaire:

1. What is your name?
2. What is the company name?
3. What is your designation in the company?
4. Are you currently working on any project?
    - Yes
    - No
5. Does your project has implementation of RFID?
    - Yes
    - No
6. Where do you see the main focus in the current supply chain integration efforts of your company (i.e., internal or external) and what is the reason?
7. Please list some main impacts of RFID technology on SCM systems in industry.
8. Where do you see the major business benefits of RFID in the industry?
9. How do you see the future relation of Bar Codes to RFID in the industry?
10. What are the disadvantages of RFID in the industry?
11. What was the motivation for the RFID technology introduction?
12. What kind of data do you collect with RFID?
13. If the data collection level was affected, how?
14. What is your opinion on RFID technology trending in industries?
15. If you collect and effectively make use of real time data through RFID technology, how?
16. Which parts of the existing SCM system are or were affected by the RFID technology introduction?
17. Where are the main integration efforts to align the existing SCM system?
18. What are the expected business benefits?
19. What do you see as the barriers to introduction of RFID technology to SCM systems?
20. What impacts do these barriers have on introduction of RFID technology?
21. Why is RFID used in your industry?

22. What are the impacts of RFID technology on SCM systems in your industry?
23. Where do you see the major business benefits of RFID in your industry?
24. Why do you expect or experience benefits from the more detailed level of information with item-level identification?
25. Which parts of the existing SCM system are or were affected by the RFID technology introduction and how are or were they affected? (e.g. Hardware, Software, Infrastructure (e.g. Warehouse design), Architecture, Processes, Work force)
26. Will use of RFID technology in various operational processes would reduce the overall cost to organization?
27. Will use of RFID in tracking of projects and logistics would increase the efficiency rate?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree