RFID in the Retailing Supply Chain:

A case study on a Fashion Retailing Industry

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Abstract

The implementation of RFID throughout the supply chain of a fashion retailing company may have a connection with its significant overall efficiency improvement. Therefore, the main purpose of this study is to examine which are the effects of the technology's implementation in a specific company's case. The research approach used is based on the thorough review of the relevant supply chain and RFID literature and on the empirical study of the specific company. The literature review shows that RFID implementation, even though it is very beneficial under a process oriented point of view, it is, in many cases, not a feasible solution for the companies, mainly due to its high cost of initial investment and item tagging. The case study results, on the contrary, indicate that the integration of the technology can be very successful and cost efficient when used for medium to high valued products.

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Liarostathi Charikleia,

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Abstract

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1. Introductory Chapter

This chapter deals with the presentation of the thesis topic, purpose and research questions. What is more, the limitations of the thesis research are presented, while a description of the thesis structure is also provided.

1.1 Introduction

This thesis deals with the implementation of RFID technology in the supply chain of a fashion retailing company and its relationship to the overall efficiency of the company's supply chain.

Over the last decades, there has been an enormous development in the fields of logistics and supply chain management, due to their increasing importance for the sound function of each company individually and of the market as a whole. The increasingly significant role of supply chain management for the companies is becoming evident by the fact that the majority of them are continuously investing on the improvement and optimization of logistics strategies and processes.

Therefore, the introduction of various technologies which claim that they can improve a supply chain's performance has been the natural outcome of this trend towards supply chain's function optimization. Thus, it is very interesting to examine the effects of Radio Frequency Identification Technology, one of the latest developments in this technological area, in the performance of a fashion retailing supply chain.

1.2 Purpose

The purpose of this thesis is to ***analyze the relationship*** between the application of the Radio Frequency Identification technology in a fashion retailing industry and the relative performance of this retailing supply chain.

Furthermore, the advantages and drawbacks of the application of this technology are going to be analyzed, by presenting a case study of a Greek fashion industry which has already implemented RFID throughout its logistics and transport system.

Through the presentation of the specific case study, the conclusions regarding whether the implementation of this technology is a feasible and efficient solution for a company's supply chain are going to be discussed.

1.3 Research Questions

The main research question to be answered by the thesis is:

Can the application of RFID in the logistics system of a fashion retailing company lead to a significant supply chain performance improvement within it?

If yes, under which conditions is it feasible to adopt such a technology and under which is it not?

This can be alternatively expressed as a combination of the following questions:

In which cases is it worth for a retailing company to be interested in implementing such a technology?

Which are the benefits for this company and which are the disadvantages by the implementation of RFID in logistics?

1.4 Limitations

In this thesis the technology of Radio Frequency Identification is going to be presented on a general level, in order to create an adequate understanding of the case study. Thus, the description of the technology and its components is going to be sufficient so as to serve the original purpose of the thesis, but, since it is only the basis for the analysis, it will not include a detailed description of all the different applications and technologies of RFID.

Furthermore, in the paragraphs which refer to supply chain management and retailing supply management the author has a very specific and, thus, limited scope in order to support the case study analysis. Therefore, the theory review on these particular research areas is sufficient and detailed enough for the needs of this thesis, but there is no thorough description of the different approaches towards supply chain management and the various concepts which are related to it.

It is also very important to mention that the paragraphs related to management decisions within a company are provided in order to give an overview of which is the role of management when implementing the technology of RFID. Since the management is the core of a company, it is interesting to mention its role shortly, so as to have a more complete understanding of the implementation procedure. However, the focus of this thesis is not to describe management decisions when investing on a new technology, but which are the potential benefits of it. Therefore, it must be clear that these paragraphs are only supporting the validity and coherency of the thesis content.

As already mentioned, the thesis focus is on the potential benefits and drawbacks of RFID on a fashion retailing supply chain. Thus, the relative results and effects of the technology derived by the case study can only be related to this specific industrial sector, since the research's result is based on the specific special conditions within the retailing supply chain of a specific company. For this reason, the conclusions, results and recommendations presented apply to this specific fashion retailing industry and, thus, they should not be used as examples for another company that wishes or has already implemented RFID.

1.5 Structure of the thesis

The thesis structure follows a widely accepted model for Case Study theses, which is based firstly on the presentation of a robust theoretical background that can support the case study analysis, and secondly on the description of the case study and the analysis of its relative results. Therefore, there is a methodology chapter, in which the methods applied in the thesis research are presented, a theoretical background chapter, a case study chapter and an analysis one.

It is important though to mention several specific points which require attention when reading the thesis. The potential benefits of the RFID technology are going to be firstly presented at the theoretical background chapter, while the actual benefits created to the specific company in the case study are going to be described later on. This will provide the opportunity to compare the logistical benefits of RFID on a theoretical level and in practice, according to the results of the case study. Therefore, it is very critical to distinguish between the two different benefits scopes' that are going to be presented.

The same logic applies to the description of the drawbacks of RFID, which are firstly presented in the theoretical background chapter, while the actual disadvantages or difficulties that the company came up with, are going to be discussed further in the case study and analysis chapters.

1.6 Case study

1.6.1 A short introduction - The companies involved

Before proceeding with the Theoretical Background chapter, it is important to provide some information concerning the two companies which are involved in this case study. Therefore, an essential and basic description of each company is shortly presented below in order to give a general overview of both of the companies and their role in the RFID system implementation procedure.

1.6.2 Staff Jeans

Staff Jeans began as a denim production company in 1992 in Larissa, a city in Central Greece. The focus of the company has always been on the production of high quality jeans. Nowadays, the company is one of the top European denim manufacturers, with international presence, apart from Greece, in Germany, Switzerland, Belgium, the Netherlands, Italy, Serbia, Cyprus and Russia. The company maintains factories throughout the Balkan territory, with its central logistics warehouse in central Greece, and operates numerous retail stores in various European countries.

During the 1990s, a decade that was difficult for the denim market, Staff Jeans managed to quickly become a recognizable brand because of the excellent quality of the products and its creative advertising campaigns. The company is an integrated manufacturer, distributor and retailer of garments. The main strategy of Staff Jeans is to offer excellent quality products for both boys and girls within the age target group of 18-24. The brand's goal is not only to sell high quality products, but also to promote a whole lifestyle out of them. (Staff Jeans website, 2010)

1.6.3 SENSAP S.A.

SENSAP S.A. is a private company founded in 2002 in Athens by a dynamic team of engineers and business specialists. Since then SENSAP has been developing and distributing hardware, software and consumables serving the industrial partners in the Printing and Packaging Industry and Business Logistics. The company currently manages two brands; VICOP, which includes Printing, Packaging and Logistics products and SENSAP, which includes the Application of Specific Microsystems.

SENSAP is involved in numerous Research and Development activities in national and international projects. The Department of SENSAP Microsystems, created in 2007, deals with the design and development of embedded systems with RFID, as well as the development and implementation of sophisticated software tools for Warehouse Management with RFID and integrated solutions for Process Management. The main industrial sectors from which the clients of the company come from are medicine, fashion apparel industry, packaging companies and food companies. (Sensap website, 2010)

2. Methodology Chapter

2.1 Case study general approach

Case study as a research method is one of the most challenging ones in social sciences' research. This is because a case study research illuminates a decision or a set of decisions for the specific problem presented. Before proceeding with the specific methodological tools, it is essential to build a general approach for the case study, so as to have a basis for forming the case study research. Therefore, a draft research design is the first step when deciding upon the structure and the content of the case study. (Yin, 2009)

According to Yin (2009), when forming a single-case research design, it is very important to choose a unique and representative case on this specific topic. In this thesis in particular, the case study refers to a single case, which involves two companies, the one that implements the RFID technology and the one that develops the RFID solution. What is more, Yin recommends the use of a few pilot cases, before describing the main case, in order to provide an overall view of the topic to the reader. For this reason, in the thesis, several RFID cases are presented before the Case Study chapter, based on their relevance to the topic and the proximity of their results to the expected ones from the case study.

Lastly, in the general case study approach it is of vital importance to maintain a chain of evidence and reasoning for every step of the case study presentation and description. This means that the theoretical framework has to be very well related to the analysis of the case study, in order for the research to be scientifically significant. Therefore, in the thesis there is a special emphasis on maintaining this chain of evidence and rationality throughout the case study, in order for it to be a complete piece of research work. At the same time, the results and conclusions presented are the outcome of analytic and not statistic generalization, and, thus, even the alternative perspectives are also considered. (Yin, 2009)

After having described the general approach and strategy towards the case, the different elements of this specific case study research steps and methods are presented in the paragraphs below.

2.2 Data Collection

The collection of the data which are going to be used for the case study is a time consuming process, both because of the vast quantity of data and information among various information sources, and because of the need for controlling the reliability and usefulness of each piece of information before using it for the case.

Therefore, in this particular thesis the main sources of information have been articles, websites, books and e-books, as well as the interviews, the direct observation and the relative documentation provided by the company which developed the RFID solution. (Yin, 2009)

In order for the data collected to be sufficient and appropriate to be used in the case study, there are three main principles which determine how the data collection process should be done:

➢ using multiple sources of evidence,

➢ creating a case study database,

➢ maintaining a chain of evidence.

In this case study's methodological strategy, the above principles have been followed, so as to ensure that the data collected are reliable, sufficient and scientifically significant to be used for this thesis.

2.3 Theory

Various sources have been used in order to collect the theory which is sufficient and most appropriate to support the case study analysis. Therefore, books, electronic books, websites and articles have been used so as to build a robust theoretical background, which includes adequate information concerning the RFID technology, the retailing supply chain management and their connection. This background will be lately used in order to support the analysis part of the thesis. (Yin, 2009)

2.4 Interviews

The method of interviews as a technique for collecting useful information and performing case study research is one of the most valuable research methods, thanks to the high quality and the remarkable quantity of data collected. Therefore, performing interviews with the people who are directly working to the scientific sectors or companies which are related to the case study, is a very effective way of getting an insight into the real situation or problem and its solutions. (Blumberg, 2009)

During the research for this specific case study, several interviews have been conducted with the Logistics manager of Sensap, the company which developed the RFID system for Staff Jeans. These interviews have been very valuable, since a lot of useful information and data have been collected and used for the analysis of the case study.

2.5 Observation

The method of direct observation of a workplace or a group of people is one of the most useful ones for extracting data when performing a research. There are two main types of observation: the participant's observation and the structured observation. In the first case, the researcher is observing the environment where he/she is working in. In the second case, the researcher is just focused on collecting data by observing the specific research environment, without taking part in it. (Blumberg, 2009)

For the research needs of this particular thesis, both these methods have been applied. In the first case, the author has been collaborating with the RFID development company,

Sensap, during the period between February and April. Apart from the interviews conducted, the observation of the actual work performed within the company has offered a wider picture of how a RFID project is planned and developed and which is its cost. In the second case, for the research needs of the thesis, the author has visited two Staff Jeans stores in Athens, in order to observe how the tagged garments are managed and which their additional functionalities are for the customer.

2.6 Validity of collected data

The information presented in this thesis is expected to have significantly high validity, since the data given from the theoretical background part to the analysis part are connected and highly related. The theories regarding supply chain management and retailing supply chains are based on the research of professionals and well known researchers in these fields, while all the data presented concerning the RFID technology is gathered by reliable internet sources, updated with the latest developments in this field. What is more, the analysis of the case study is conducted based on the information gathered by the people working in the specific company, which verifies the final outcome and result of the study. (Yin, 2009)

2.7 Reliability of collected data

Reliability of data is defined as the degree of accuracy of the collected information. Therefore, all the data presented in the thesis are characterized by a high degree of reliability, since the sources used are reliable and their content is acknowledged. Furthermore, the information provided in the case study analysis part is gathered through interviews with people of the company and, thus, it can be considered reliable and valid. (Yin, 2009)

3. Theoretical Background Chapter

3.1 The Supply Chain

3.1.1 Description

In order to understand how a supply chain functions, it is firstly essential to define what the term "supply chain" refers to. One of the most complete, clear and specific definitions has been given by Christopher (1998) and it goes as follows: "The supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer." The different flows within a supply chain are illustrated in Figure 1:
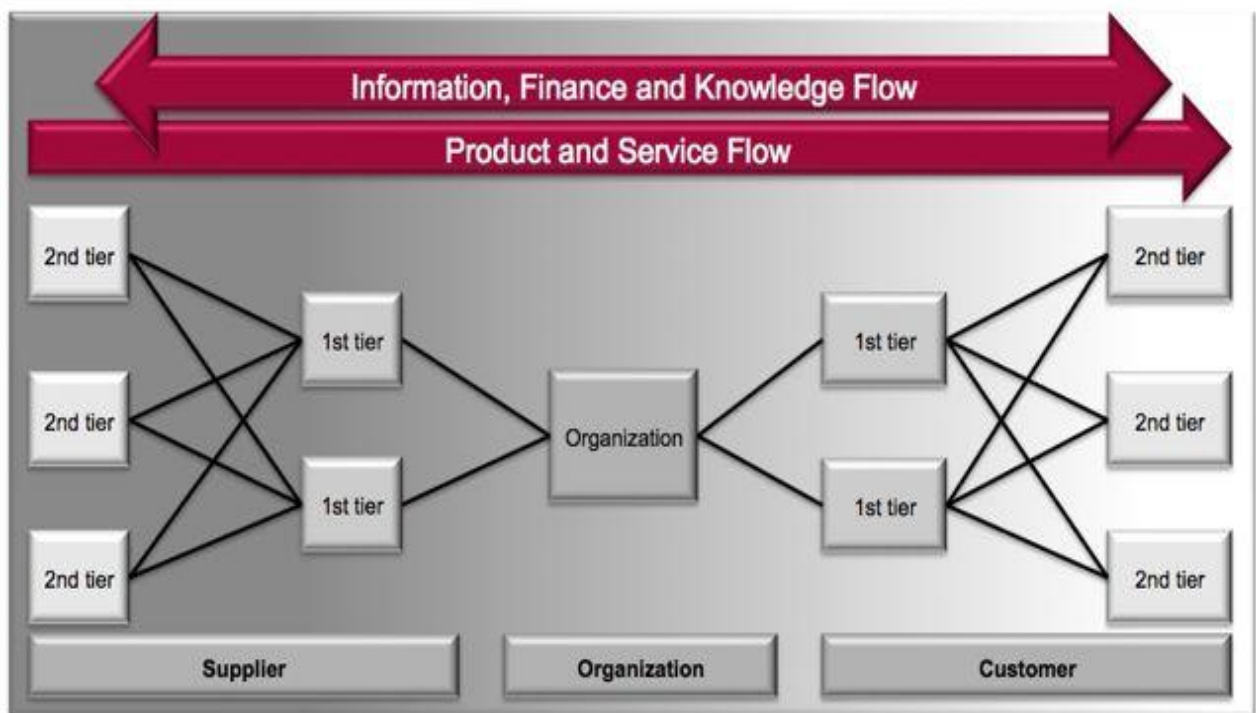
Figure 1: The different flows in the supply chain

 (Source: http://www.procise.com/upload/eng-graphics/engsupplychain.jpg)

It is, thus, interesting to describe which the different supply chain flows are, according to the figure. First, the physical flow of products and services starts from the supplier and it follows a downstream direction, passing through all the partners in between, until it reaches the consumers. Second, the monetary flow follows the opposite upstream direction, as it starts from the final customer and, step by step, it reaches the supplier. Third, the flow of information and knowledge is the one which follows both directions, upstream and downstream in the supply chain, since it is essential for the supply chain

partners to share information in order for the chain to function properly. It is interesting to mention that the information and knowledge flow can be either horizontal, by passing through all the members of the chain from supplier to consumer, or vertical, by crossing each stage of a supply chain in a vertical way; e.g. all the manufacturers share information with each other before moving on to the next step, which is information sharing with the retailers. Lastly, there is a flow which is not illustrated in the figure above, since it is not considered as part of the supply chain flows by all the researchers, but it is worth mentioning. The resources flow which starts from the initial supplier of the basic raw materials, which are later transformed into other finished or semi-finished products, and, thus, it crosses the whole chain.

3.1.2 Supply Chain Management

Supply Chain Management refers to the managing of the supply chain's functions and operations. Various definitions have been introduced in order to describe what supply chain management includes. Nowadays, due to the fierce competition on a globalized environment, customer's demand is often triggering the chain more than the suppliers. For this reason, the definitions presented here are mainly customer oriented in order to provide more clearly the close relationship of supply chain management with retailing.

The two most dominant definitions with a customer focus are presented below:
"Supply Chain Management refers to the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole." (Christopher, 1998)

"Supply chain management is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders." (Enarsson, 2006)

According to these definitions, it is becoming obvious that supply chain management covers all the different factors to be considered in a chain, such as manufacturing, transportation and marketing decisions, all combined with the customer's demand and aligned with the general corporate strategy and goals.

3.1.3 Information flow in the supply chain

The most recent and modern supply chain approaches nowadays point out that "information replaces inventory", so as to stress out the significance of information sharing within a supply chain. Therefore, the main conclusion from this phrase is that in order for a supply chain to function efficiently, a continuous information flow among the different supply chain partners is indispensable. (Levi, Kaminsky, Levi, 2007)

For this reason, the majority of the new and increasingly popular logistics concepts are based on the success of the information sharing among the different supply chain partners. Concepts such as product diversification, postponement, quick response and

supply chain intelligence can only be implemented within a company with very strong relationships with its partners and a good information system.

The value of an effective information flow can only be assessed through the benefits created for the companies within the supply chain, thanks to the continuous information sharing. Thus, information sharing offers high visibility throughout all the different procedures and processes followed in the chain, which can potentially lead to better decision making. At the same time, the negative impacts of bullwhip effect are avoided and the total degree of risk when making logistical decisions decreases significantly. At this point, it is interesting to explain briefly what the bullwhip effect is, in order for the reader to understand why it is important to eliminate its impacts. According to Enarsson (2006) "As upstream behavior in supply chains is triggered by downstream decision making, the potential mistakes occurring downstream influence the upstream decision making, because they respond blindly to the information received." In other words, due to poor information sharing among the companies of the supply chain, the mistakes made as we go forward to the chain, move upwards from the retailers to the wholesalers, manufacturers and suppliers in a much augmented way, compared with the real market situation. This effect can lead to serious problems within the chain, such as excessive inventor and delays in manufacturing and delivery, which lead to decreased sales and customer dissatisfaction. Therefore, the only way to avoid the impacts of bullwhip effect is an efficient information flow, performed through a well adopted information system. (Enarsson, 2006)

Since a trend towards an increasing technology use is becoming obvious over the last decades, it is interesting to examine the possible technological solutions regarding the information sharing within a chain. There are two basic concepts which determine the way with which the information sharing is performed within a supply chain: the centralized and the decentralized concept. In the first case, there is a central information system, the database of which collects and manages all the data gathered by the different actors of the chain and distributes the information needed to each member in order to reassure that the decisions taken are in accordance with the decisions taken by the other members. Generally, the concept works quite well, but nowadays, due to the fact that the need for information sharing is increasing, the centralized database decreases the flexibility of each one of the different members of a supply chain. For this reason, the decentralized concept has been introduced, and it is based on the fact that the central database receives information by all the players, but at the same time, the supply chain partners share information in a linear way, among each other. (Levi, Kaminsky, Levi, 2007)

In conclusion, the efficient and continuous information sharing can significantly decrease the variability of demand and the degree of uncertainty for all the members of the chain, eliminating by this way the effects of bullwhip effect. It is, therefore, proved that information flow is highly connected with the supply chain performance. (Levi, Kaminsky, Levi, 2007)

3.1.4 Supply chain intelligence

Supply chain intelligence is a rather new concept in the field of supply chain management and logistics, which combines the need for information sharing within a supply chain with the introduction of new technologies towards improved decision making by the top management of all the different members of the chain. The increasing importance of the concept is becoming evident after having pointed out the significance of a sound information flow within a supply chain, and after having explained that this can be better succeeded through the implementation of advanced technological systems. It is obvious, then, that supply chain intelligence by itself would not mean anything as a supply chain concept, without the contribution and collaboration of other core supply chain ideas, such as information sharing and communication. (Supply Chain Intelligence, 2010)

Therefore, the concept is based on the idea that automated systems that can make small scale decisions at each different step of a logistics process can lead to an overall better performance of the all the different procedures by eliminating mistakes, malfunctions and delays. Consequently, the overall performance of the company's supply chain is significantly improved. The technologies which can support supply chain intelligence are Logistics Information systems, Warehousing and Order Fulfillment Information systems, as well as the implementation of Radio Frequency Identification systems.

Finally, it is becoming very obvious that the latest supply chain management trends are pointing out the increasing need for extended technology use within a chain, in order to succeed a significant degree of performance improvement. (Karimibarak, 2004)

3.2 The Retailing Supply Chain

3.2.1 Description

The retailing supply chain, as the majority of the supply chains, consists of a producer, a wholesaler, a retailer and a consumer. Since the focus of this thesis is limited to the retailing part of the supply chain, there is no direct need for this particular research to consider the supplier's role in the chain. This means that the supplier's role in this particular case is, of course, very important but the retailing and customer orientated concept of this research "moves" the chain more towards the customer than backwards.

The physical flow of goods, the cash flow and the information flow follow the traditional flow pattern as already described in the previous section. The main activities that are related to a retailing supply chain include picking, packing, warehousing and transporting.

3.2.2 Fashion Retailing Supply Chain

In order to understand the function of a fashion retailing supply chain, it is, firstly, important to describe its special characteristics and, secondly, to explain how fashion retailing companies form their supply chain management strategy based on the characteristics of the market they are focused on. Therefore, the main characteristics of fashion retailing and the main ways and concepts of managing a retailing supply chain are presented here.

3.2.3 Fashion Retailing - Characteristics

Fashion is a term that, when it comes to the economic and social sciences point of view, it characterizes a very wide range of products and services, the main characteristic of which is the short life cycle. In this way, fashion creates new markets where the styles and trends presented are changing very fast with time. These special conditions that fashion creates in the market affect radically the retailing of fashion products and, consequently, the whole fashion retailing supply chain. (Christopher; Lowson; Peck, 2004)

The most typical characteristics of fashion retailing are:

➢ Short Life Cycles. The products are designed from the very beginning with a view to capture the feeling of the consumer during a very specific period of time. This period can vary from several seasons, months or even weeks.

➢ High Volatility. The demand for fashion products is very unstable and continuously changing. This happens due to the fact that consumers' demand for these products is mainly influenced by lifestyle factors, such as the current culture, music waves, films, or even pop stars. However, this does not mean that there are no stable reference points when it comes to fashion, but it is important to point out the continuous change that characterizes it.

➤ Low Predictability. This factor is strongly connected to the previous one, the high volatility of demand for fashion products. Due to this continuously changing market environment, it is rather difficult to predict the exact demand for a specific product during a specific period of time.

➤ High Impulse Purchasing. Fashion products are usually bought by the consumers without any former planning, on the spur of the moment. This is mainly happening because they create to them the feeling of being fashionable, keeping up with the current trends and supporting a modern lifestyle.

(Christopher; Lowson; Peck, 2004)

3.2.4 Fashion Retailing Supply Chain Management

The special characteristics of fashion retailing, as mentioned above, create a very challenging situation for the logistics management of the retailing company. This means that the company's management cannot keep on applying the traditional retailing supply chain management concepts and strategies when it comes to decision making, but move one step further and take into consideration the special conditions that fashion retailing creates in the market. (Van Weele, 2004)

Apart from the special characteristics of fashion retailing, the management of a retailing company has to deal with another problem as well, which increases significantly the complexity of decision making. The most recent trend which has appeared in retailing in general and in fashion retailing even more strongly is global sourcing. This means that a fashion company chooses to source its materials and products from other countries, with significantly lower costs, but longer lead times as well. This tendency in combination with the characteristics of short products' life cycles, high volatility and low predictability create a very pressing situation for the management, which has to make strategic decisions within a very limited period of time. (Christopher; Lowson; Peck, 2004)

In order to deal with this problematic situation, retailing companies are showing an increasing interest in creating agile supply chains by implementing the relative concept of agility. The main principle of the agility concept is the elimination of every kind of waste within the supply chain, which in practice means higher flexibility in the production and distribution, shorter lead times and higher market responsiveness. It is then becoming obvious that the negative impact of volatility and low predictability within the retailing supply chain is significantly reduced, since an agile supply chain is mainly demand driven and, thus, flexible and open to changes according to the consumers' requirements. (Enarsson, 2006)

It is important to point out, though, that several changes have to be made in the company's structure in order to implement agility and enhance the principles of responsiveness and flexibility within its culture. Therefore, the management of the company must be well aware of the fact that an agile retailing supply chain is not inventory based, as in traditional supply chains, but information based. This means that

the company has to adopt new technologies which enable a continuous information flow and sharing within the whole retailing supply chain, in order to ensure the interconnectivity among all the supply chain members. (Christopher; Lowson; Peck, 2004)

Therefore, supply chain intelligence systems, as already described, can be of remarkable contribution towards a more efficient and agile management of the fashion retailing supply chain. Overall, the success and effectiveness of fashion retailing supply chain management relies on the continuous and uninterrupted information flow, which can lead to good strategic and flexible decision making by the management of the company. (Christopher; Lowson; Peck, 2004)

3.3 RFID Technology

3.3.1 Identification Technology

The introduction of identification technologies in the supply chains of various organizations has not been a very recent development. Already from the 1970's, several American companies have been using a technology very similar to the barcode one, in order to track their products. Later on, during the 1980's more and more companies incorporated the emerging at that time technology of barcode, until the 1990's when it was widely and globally adopted.

Since that time, several new developments have been introduced in this field and include the extensive use of barcodes as a basic product labeling, magnetic stripes, especially on credit cards, and RFID tags. The use of RFID as a product identification technology has been more intensified since the beginning of the 2000's, when more and more companies chose to adopt it in their supply chains.

In this chapter, the technology of RFID is going to be presented sufficiently, so as to have an overall picture of what Radio Frequency Identification is about, how it works and which are the potential benefits and drawbacks.

3.3.2 Radio Frequency Identification

Radio Frequency Identification is a technology which is based on the use of tags that emit and receive radio signals and on readers that collect the data transmitted by the tags and forward them into the company's information system for further evaluation and analysis. The implementation of RFID can support to a great extent the decision making of an organization as far as logistics and supply chain management is concerned.

Over the last few years, more and more companies are integrating the technology into their strategic planning, since it provides significant advantages over the supply chain performance. Especially after the implementation of RFID by Wal-Mart, the world's biggest retailer, the future of the technology seems very promising and challenging, since this strategic move is going to accelerate the implementation of RFID by other companies that wish to see the same results. (Levi, Kaminsky, Levi, 2007)

An overview of how the technology works is illustrated in Figure 2:

Figure 2: RFID technology functionality

(Source: http://www.12manage.com/images/picture_rfid_technology.jpg)

3.3.3 Applications

Before proceeding to the description of the technology, it is interesting to present its main applications. Table 1 below provides a more complete picture of which are the potential uses of RFID technology in the industry.

Type of industry	Example of RFID project
Manufacturing	A major tire manufacturer is going to insert RFID tags into its tires. The tags will store a unique number for each tire, which will be associated with the car's vehicle identification.
Pharmaceuticals	Pharmaceutical companies have embedded RFID chips in drug containers to track and avert the theft of highly controlled drugs, such as OxyContin.
Airlines	Continental Airlines uses RFID tags to track passenger bags, while Delta Airlines is tagging customer bags with RFID technology to reduce the number of lost bags and make it easier to route bags if customers change their flight plans.
Restaurants	A premier coffee chain is considering using RFID chips and readers to enable its suppliers to make after-hour deliveries to stores, which avoids the disruption of staff members during work hours.
Toll Roads	Many tolls roads in the United States use RFID technology to collect fees without the need for toll booth personnel.
Retail	ExxonMobil uses RFID technology for its "SpeedPass," which instantly collects payment on gas stations from a tag on a driver's keychain, while Wal-Mart is requesting that all their suppliers apply RFID tags to all cartons of goods delivered.
Seaports	Three seaport operators in the United States, which account for 70 percent of the world's port operations, agreed to deploy RFID tags to track daily arriving containers.
Government	The U.S. Department of Defense is planning to use RFID technology to trace military supply shipments.
Corporate & Municipal	Australia placed RFID tags in employee uniforms to aid in deterring theft. The same idea would work well in a corporate environment to help control desktop computers, networking equipment, and personal digital assistants or handheld computers.
Credit Card	Visa is combining smart cards and RFID chips so people can conduct transactions without having to use cash or coins.
Banks	The European Central Bank is considering embedding RFID chips in Euro notes to combat counterfeiters and money-launderers. This also would enable banks to count large amounts of cash in seconds.
People Tracking	The United Nations uses RFID technology to track the movements of its personnel.

Table 1: RFID applications in the industry(Source: What Every Internal Auditor Should Know About RFID, *Knowledgeleader, June 2006)*

3.4 RFID Technology Description

3.4.1 The components

3.4.1.1Tags

The tags are devices which are attached to the products, pallets or vehicles that the Radio Frequency Identification system is planned and designed to track. Therefore, the main function of an RFID tag is to transmit data to the system's other parts and components. Tags are divided into categories depending on different categorization factors. Their first classification, which has to do with the way they are powered in order to function, includes the following tag categories:

- ➢ Active tags

- ➢ Passive tags

- ➢ Semi-passive tags
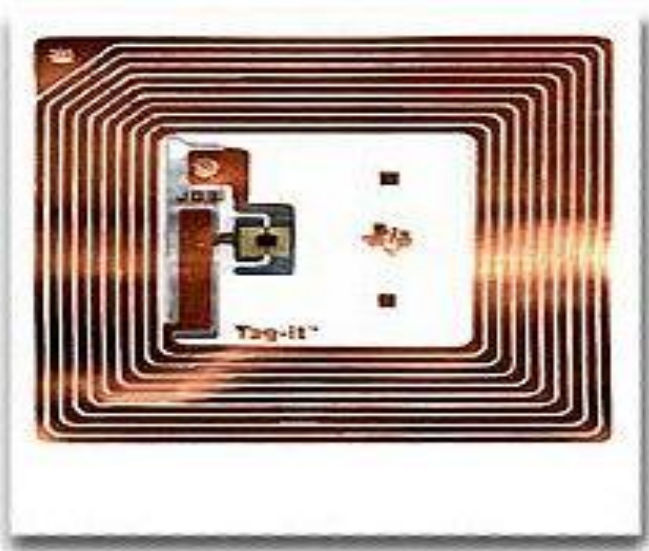
Figure 3: Common Tag

(Source: http://www.livedigitally.com/RFID.jpg)

Active tags contain a power source, usually a small battery, which helps them function independently. In order for the battery to last as long as possible, the active tags are set at a "sleep mode" when there are not within a RFID zone. In this way, the battery of an active RFID tag can power the tag up to several years. Generally, the design of the active tags is very sophisticated and complex, while their price highly depends on the type, material and size of the battery they contain. For this reason, active RFID tags are very unlikely to be used on an individual product tracking RIFD system, since they would increase significantly the total cost of the product. (Jones; Chung, 2008)

Passive tags, on the other hand, do not contain any kind of power source. Their function is based on obtaining electromagnetic power from the system's antenna. This means that their range of functioning is limited to the range of the antenna's signal. Therefore, the tag and the antenna should be in close proximity in order to reassure the sound data transmission within the system. However, it is important to mention that passive RFID tags have a simpler design and are significantly cheaper. For this reason, they are supposed to be the future of RFID technology. (Jones; Chung, 2008)

Semi-passive tags contain characteristics from both the active and the passive ones, in order to combine their advantages and eliminate their drawbacks. In particular, they have an internal battery, which is only used for the internal controlling and preservation functions of the tag, while for the data transmission function they are powered through the antenna of the RFID system. In this way, the battery life is remarkably longer and the total cost of the tag lower. (Jones; Chung, 2008)

As far as their writing capability is concerned, tags can be divided as follows:

➢ Read-only tags

➢ Write-Once-Read-Many tags

➢ Read-and-Write tags

Read-only are the tags in which the data stored have been entered by the manufacturer. Therefore, the identification data of the tags are unique and can be used and accepted by various organizations. (Jones; Chung, 2008)

Write-Once-Read-Many are tags in which the data is not initially entered by the manufacturer, but the purchaser is responsible for writing the identification data to the tag. It is important to mention, though, that once the data is written in the tag, it is not possible to re-write it. Thus, in case of wrong data entrance the tag cannot be reused. (Jones; Chung, 2008)

Read-and-Write tags are not programmed by the manufacturer either. The purchaser is again responsible for writing the identification data in the tag. However, in this case, it is possible for the purchaser to erase wrong or old data entered and write new identification data. It is obvious that this tag category is the most complex and sophisticated one, since it provides a higher degree of utility and independence to the purchaser. (Jones; Chung, 2008)

Table 2 compares the different tag categories and provides an overall view of the situation nowadays.

	Passive	*Active*	*Semi-Passive*
Power source	External Electromagnetic antenna field	On-board battery	On-board battery for internal circuitry External electromagnetic field for transmission
Range	Measured in feet	Up to thousands of feet	Measured in feet
Size	Smaller	Larger	Larger
Data storage	Less	More	More
Cost	Less	More	More

Table 2: Presentation and Comparison of RFID tags

(Source: Jones E.; Chung C., 2008)

3.4.1.2 Scanners and Readers

As already described, RFID tags receive and send data to the RFID system. In order for these functions to take place, either scanners or readers are used.

As far as scanners are concerned, they are mainly used to verify the data already written in the tags. The information gathered from the scanner is connected to other parts of the system and then evaluated according to the decisions to be taken regarding the products. In order for this verification control to take place, the employee who is responsible for controlling the tagged products, scans each item and checks whether the information provided is adequate and correct. This means that a scanner is equipment which requires the physical activity of a person, since it is not functioning automatically and from a long distance. A very good example of the RFID scanner's use is order fulfillment and warehousing. (Jones; Chung, 2008)

Figure 4: RFID Scanner

(Source: http://img.tecbuys.com/p/550/mc9000rfid%281%29.jpg)

In systems with higher complexity, the device usually used is the RFID reader. The reader is a device capable of both reading and writing data in the tags. It is important to mention that the interrogation zone, or RFID signal coverage zone, is much bigger in the case of the reader and, thus, the data transmission capabilities of this device are significantly higher. Many times the readers are also equipped with an internal antenna which provides the signal for all the tags within the RFID interrogation zone. The main types of radio frequencies used by the readers are HF and UHF. However, it is important to mention that the frequency used in every different case depends on various factors, such as the type and material of the product to be tracked, the distance within which it is traceable and, of course, the default by the manufacturer frequencies of the tags and readers in which they can function properly. (Jones; Chung, 2008)

Figure 5: RFID Reader

(Source: http://extreamtechnologies.com/images/RFID_Reader2.JPG)

3.4.1.3 Antennas, multiplexers and concentrators

An antenna is a device used to transmit the signal to the tags and dispatch it to the reader. It enables with this way the processing of the data transmitted by the RFID information system. As already mentioned, nowadays readers have an internal antenna established. The function of a typical RFID antenna depends on the type of the tag. In the case of passive RFID tags, the antenna sends a signal which provides the tag with sufficient energy supplies in order to transmit the data needed. In the case of active RFID tags on the other hand, the antenna sends a signal that only activates the tag, which will then start transmitting information to the antenna. (Jones; Chung, 2008)

However, due to the increasing complexity of RFID systems, it is very common to use more antennas, in order to create a larger interrogation zone and, consequently, to succeed better control of the whole system. Most of the times the connection of more than one antenna to one reader is a device called multiplexer or concentrator. More specifically, the multiplexer has a fixed number of communication ports and, thus, it can connect its port to different transmission frequencies, which connect with different communication channels. In this way, the multiplexer can make the most of the RFID system by reading and sending different signals at the same time. (Häkkinen; Nyberg, 2004)

3.4.1.4 Supporting Information System

In order for the Radio Frequency Identification technology to function properly and be successfully integrated in the company, specific RFID software has to be incorporated within the existing information system, based on the special requirements and needs of the relative company.

The RFID software mainly includes all the applications needed for the control and for the data transmission from the reader systems, which are installed in different areas of the company's facilities, from the manufacturing area, to the warehouse. Apart from the reader control applications, the RFID based information system also includes a database which stores all the data received from the readers and shares them with the rest of the company's departments. In this way, the different departments, such as production and logistics, obtain full visibility on the whole system and can benefit from this information sharing, since the system itself assists them in the final decision making regarding production needs, inventory levels and up to date customer demand. (Jones; Chung, 2008)

3.4.1.5 Reading Range and Communication Protocols

The reader's system communicates with the information system through various types of communication protocols. It is very interesting to examine which factors affect the choice of the most appropriate protocol.

Firstly, the choice of communication protocol depends on the distance between the readers and the computers where the information system is installed, since different protocols offer different reading ranges for the readers and communication ranges for the information system. Secondly, the quantity of the data transfer requirements both from the tags to the reader and from the reader to the host computer affect the protocol to be chosen. Thirdly, the material of the tagged products determines to a great extent the choice of communication protocol and reading range, since there are materials which facilitate the communication process while others make it difficult by affecting the signal's quality. (Jones; Chung, 2008)

Lastly, it is very important to mention that apart from these technical reasons mentioned, there is always the factor of the company's investment budget which finally determines what kind of technology is going to be used. Generally, it depends on the company's specific needs and requirements to choose the most optimal, both by means of cost and overall efficiency, reading range and communication protocol. (Jones; Chung, 2008)

3.4.2 RFID Regulation Framework – Standards

Radio Frequency Identification, as a technology that is adopted by various organizations, faces a significant problem or challenge to be solved, regarding the use of a specific standard which regulates and determines the way that different systems communicate and share information. There are various RFID systems that, unfortunately, do not have the ability of communicating with each other, due to the lack of a superior RFID standard.

Generally, the basic problem of the RFID standards is the different frequencies used for the communication. Even though the majority of countries have adopted the same frequency bands for low and high frequency communication, there is an incompatibility problem for the ultra high frequencies. For example, Europe is using 869 MHz, the United States of America are using 915MHz and Japan is using 960 MHz.

Apart from this barrier, there is also another remarkable problem; the product labeling format standard. Since there is no specific and globally adopted RFID standard, it is up to each company's decision in which way the products are going to be labeled.

It is important to mention that companies are currently dealing with these problems by acquiring hardware, meaning readers, which can work under different frequency bands and are, thus, able to identify various products. In addition, there are two major standards that regulate the use of the technology, the ISO Standard and the EPC Standard. (Jones; Chung, 2008)

3.4.2.1 The ISO Standard

As far as the ISO Standard is concerned, it is obviously developed by ISO, the biggest standardization organization in the world. However, the specific decisions concerning the RFID ISO standard are performed by two groups; the ISO and the IEC (International Electro-Technical Commission). These two organizations have formed the Joint Technical Committee number one (JTC 1) which deals with the fields of interest of both organizations. Therefore, the Committee is divided into several subcommittees in order to address specific RFID related issues to each one of them. The most basic areas of research have to do with technical communication protocols, item numbering and item coding according to different applications, such as vehicle level, pallet level or item level. (Kitsos; Zhang, 2008)

When it comes to the RFID standards at the item level, the ISO/IEC Automatic Identification and Data Capture (AIDC) Standard has been introduced. The ISO/IEC standard includes several sub-standards, such as the ISO/IEC 15961 data protocol-application interface description and the ISO/IEC 15962 data protocol-data encoding rules. Generally, the ISO/IEC 18000 series air interface standards include all the standardized working frequencies, at <135 KHz, 13.56 MHz, 433 MHz, 860–960 MHz, and 2.45 GHz. (Jones; Chung, 2008)

3.4.2.2 The EPC Standard

Apart from the ISO Standard, which has not been widely accepted and adopted, the EPC Standard has been introduced for RFID tags identification. The EPC, or Electronic Product Code Standard, has been developed by the Auto-ID Center, which has been a research center of MIT, Massachusetts Institute of Technology. The center had created a global passive RFID-based item identification system that could replace the barcodes. This system coding is called the Electronic Product Code. Nowadays, there is an official organization which is dealing with the development of the Standard, EPC global. EPC Global was formed in October 2003 and has been continuing the research on improving the standard and developing more applications within it. For this reason, the EPC Standard has been widely adopted and considered as the most important RFID standardization nowadays. (Jones; Chung, 2008)

The Global Standards Organization, which includes GS1 and GS1 US, aims at creating a common data structure for information sharing and RFID systems communication. GS1, also known as EAN International, is responsible for the European article number product identification structure, which has been used as a supply chain identifier in Europe, while GS1 US, also known as the Uniform Code Council, is responsible for the UCC identification structure mainly in the United States. The EPC Standard has successfully incorporated the identification rules and structures of both the European (GS1) and the American (GS1 US) organizations. (Jones; Chung, 2008)

The typical format of the EPC Standard is as follows:

Electronic Product Code Type 1

01-0000A89-00016F-000169DC0

Header	EPC Manager	Object Class	Serial Number
8 bits	28 bits	24 bits	36 bits

Table 3: EPC tag coding

The first 8 bits define which numbering standard is used and the next 28 bits show which company has numbered the specific product. The next 24 bits identify the article number of the specific product, while the last 36 bits show the unique serial number of the product carrying the EPC. It is obvious that the different combinations of the format presented above allow more efficient and successful global coordination. As far as Europe is concerned, GS1 has grouped all the standardization related activities into the GS1 system. The activities support the areas mentioned below:

➢ Barcodes: Numbering and bar coding

➢ eCom: EDI (electronic data interchange)

- Global Data Synchronization Network (GDSN): data synchronization

- EPC Global: RFID (radio frequency identification)

3.4.2.3 Functionality of the EPC

After having explained what the EPC Standard is, it is, now, interesting to describe shortly how the standard works. When a company is using RFID technology, the tag on each product sends its unique number to the reader system. The reader then transmits the number to the computer which manages the RFID applications, known as the Object Name Service (ONS). This service helps the computer system locate relative information on the network concerning the item carrying an EPC, such as production date. Most of the times, the Physical Markup Language (PML) is used as a common language in the EPC Global network to define data on physical objects.

In order for the EPC Standard to have a global identification network, a specific RFID software technology has been developed. This software is designed to transmit information globally without overloading the existing companies' or other public networks. Currently this function can be also performed by middleware software, provided by hardware retailers.

The EPC air interface protocol describes the following elements:

- Air interface (waveforms of different symbols),

- Command set,

- Operating procedure (how to use command set to identify/modify tags).

The air interface protocol determines the way the reader communicates with the tag, as well as tree traversal negotiation and command communication. The tree traversal negotiation is the process in which the tag backscatters or reflects the data and how the reader acknowledges that data and maps the path through the population. The command communication describes commands to retrieve data after confirmation that the tag has been identified. (Jones; Chung, 2008)

3.5 Enterprise Integration

In this section of the chapter, the integration of RFID technology within a firm is described. Integrating a new technology in a company is a very determining factor for the future success of the project. Therefore, it is interesting to examine which are the different steps, procedures and factors that comprise the successful enterprise RFID integration.

3.5.1 Management decisions

The role of management in the successful enterprise integration of the new RFID technology is vital, since the company's senior management is responsible for the final decision making which will lead to the effective implementation of the new system. Apart from the goal setting and strategy creation, the role of management is more practical as well, having to make decisions regarding the everyday problems that occur in the company. Therefore, the main area of interest for the company's management is to decide upon the most appropriate RFID system to be implemented. The choice of the RFID technology, as well as the adaptation process within the organization are the most crucial issues to be addressed and, thus, the decisions regarding them are the outcome of a thorough analysis of the company's internal processes. For this reason, the main areas of interest for the organization's management, when implementing a new technology, are presented in the paragraphs below and include the choice of the right RFID technology, the adaptation of the technology, the process alignment, the specific project's management and the relative human resources management. (Mpourantas; Papalexandri, 2003)

3.5.2 Choice of the right RFID technology

The choice of the RFID project to be implemented is a procedure of vital importance for the company, since the careful selection of the most appropriate RFID platform will ensure the success of the system. Therefore, choosing the right RFID technology is a time consuming process because it includes all these discussions and decisions that have to do with the definition of the specific system requirements.

Thus, there are several issues to be sorted out when a company is choosing the RFID technology to be integrated in its system. Firstly, the procedure of adapting the new technology has to be planned in an effective way, in order for it to be as smoother and more efficient as possible. Secondly, the internal business processes have to be aligned with the new technology, so as to ensure that the system will work and have positive results. Thirdly, the company's current information system's functions and capabilities have to be clearly stated, in order to define the RFID system's requirements and range of activities. (Jones; Chung, 2008) After the company has already decided on the issues mentioned above, it is important to address all these issues to the RFID technology providing company and further discuss on the choice of the most appropriate system. The additional discussions with the RFID provider will lead to the selection of the most

suitable and customized solution for the company, based on its needs and business activities. (Jones; Chung, 2008)

3.5.3 Adaptation of the technology

Even though many researchers focus on the benefits of RFID, it is very important to point out the new technology has to fit into the company's strategy in order to be beneficial in the long run. Therefore, the main operational strategy of the company has to be effectively combined with the RFID system's integration. Thus, the adaptation of the technology step refers to two basic parameters within the organization; the strategic adaptation and the technological adaptation. As far as the strategic adaptation is concerned, it means that the company needs to redefine its operational goals and processes, so as to include them in the utilization of the new technology. When it comes to the technological adaptation, apart from performing the relative adjustments and changes in the company's strategic view, it is then very important to manage the integration of the current information system with the RFID system's applications. (Jones; Chung, 2008)

3.5.4 Process Alignment

A very basic part of implementing a new technology within a company is the successful process alignment that needs to be performed as soon as possible, in order to increase the new system's potential and functionality. Therefore, the main processes that have to be adjusted and aligned according to the new system are those related to manufacturing, warehousing, packaging and transportation. By performing the relative changes in these basic parts of the supply chain function of the company, the implementation of RFID is becoming easier and faster. At this point it is very important to mention that, apart from reassuring a successful implementation, the effective process alignment also implies that the RFID project can be put into force faster and can cover a wider range of business activities. (Jones; Chung, 2008)

3.5.5 Human Resources Management

In the case of RFID integration, the management is responsible for informing the employees on the company's new situation, regarding the integration of RFID. It is crucial for the personnel to feel that the company is trying to maintain an environment of trust and communication by sharing information concerning the changes in culture and strategy. Since, the integration of a new technology alone will not bring the desirable results without the cooperation of the human factor, it is very important for the management to make the personnel aware of the new technology. What is more, it is important to mention that the management of the organization has the authority to decide upon performing effective personnel education and training, when needed, as well as supporting the efforts of the employees towards the improvement of their skills and competences, in relationship with the adoption of RFID. (Mpourantas; Papalexandri, 2003)

3.6 RFID in the supply chain of the retailing industry

In this section of the thesis, the connection of retailing supply chain management and RFID technology is presented and analyzed. Therefore, the main driving powers within a supply chain towards the implementation of RFID are presented, as well as the benefits and drawbacks or barriers that can be potentially created within a retailing company which has implemented the technology.

3.6.1 Drivers

This first section of the chapter refers to the main driving forces that incline companies towards implementing the technology of RFID. Thus, the factors mentioned here express the main reasons, rationale and motivation of a company that chooses to deploy RFID.

Need for total visibility

Nowadays, the modern supply chain management theories point out the importance of visibility through the supply chain, in order to eliminate potential products' or supplies' shortages. The visibility throughout the supply chain that RFID can offer minimizes the effects of Bullwhip Effect and increases the efficiency and safety of the supply chain. (GS1 MobileCom, 2010)

Increased information sharing

The need for information sharing is becoming more and more evident, since information is the basis of the sound collaboration among the supply chain partners. The technology of RFID not only makes it easier but also increases the total information sharing among the different departments within the company as well as among the company's business partners. (Enarsson, 2006)

Increased need for Coordination

Over the last decades, there has been an increased need for coordination among the members of the supply chain, in terms of decision making and strategy creation towards the target market, since the high competition on a global level has forced companies to compete in terms of supply chain networks and not directly with each other. This means that, lately, a new type of competition has arisen, the competing supply chains' one. Therefore, the companies who want to keep up with the current changes have adopted the concept of coordination with all the actors that belong to the same supply chain. RFID enables a successful coordination thanks to the increased visibility and information sharing which have already been mentioned. (GS1 MobileCom, 2010)

Increased Competition

The continuously increasing competition on a worldwide level, has forced the companies to adopt new methods of managing their supply chains, among which is the integration of new technologies and concepts, in order to keep up with the current market conditions. As a result, the fiercer the competition, the more urgent is the need for the companies to

adopt new ideas and invest on information systems' upgrading. Thus, new market opportunities arise for RFID, since it is considered as a good solution for the companies to improve their supply chain's efficiency and deal with their competitive environment. (Enarsson, 2006)

Increased customer awareness and demands

Nowadays, the average customer's educational level and information update are much higher than in the past and, therefore, their demands and expectations when purchasing different products are specific and individual. At the same time, their increased awareness of the products' properties are making it more difficult for a company to respond adequately to customers' needs. Thus, the need of implementing RFID is becoming more evident, since it enables the full control of the chain along with the control of each individual product's quality and current situation. (Enarsson, 2006)

Technology Trigger

Lastly, it is important to point out the trend for adopting new technologies when they are launched and appear in the market. The implementation of a new technology, which can potentially benefit the competitors is a very good reason for a company to adopt it and make it part of its strategy. This trend in the field of RFID has been always quite influencing and dominant, due to the wide advertising of the technology and the extensive research that has been and is still performed on this field of study. Especially, after having been implemented by Wal-Mart, the world's biggest retailer, the technology has been much more popular and attractive to a large number of companies. (Tajima, 2007) (GS1 MobileCom, 2010)

The continuously growing need towards cost reduction throughout the supply chain

Over the last decade, there has been an increasing interest by all companies and the researchers in minimizing costs throughout the supply chains. Various concepts towards this idea have been introduced, such as agility and lean management. Therefore, the elimination of every kind of waste and the optimization of every business process, in order to achieve lower costs and increased efficiency, are the most recent managerial trends. Since the influence of these theories has become stronger, companies are now choosing to incorporate these ideas into their strategic goals. The technology of RFID manages to reduce several cost elements throughout the supply chain, such as product losses, material handling, labor costs, and, thus, it seems as an attractive solution in order to support the newly adopted organizational concepts. (Enarsson, 2006)

3.6.2 Benefits

In the following paragraphs, the benefits realized by the utilization of RFID technology within a retailing company are presented and described. In order to provide a clear overview of the advantages which can be potentially created by the implementation of Radio Frequency Identification in a company, they are divided in two different categories; the process oriented benefits and the cost related ones. Thus, firstly, these benefits which have a direct connection with the internal business processes and procedures are described, while the ones that include any kind of cash flow, such as cost reductions or profit increases, are presented later.

3.6.2.1 Process Oriented RFID Benefits

Improved Efficiency

Efficiency can be defined as the degree of fulfillment of the initial goals set. This means that efficiency shows how well or successfully a company manages its operations and processes. The use of RFID can lead a company to improved efficiency by overall improving the existing processes under the scope of time and mistakes elimination. (Enarsson, 2006)

Improved Information Sharing

Taking for granted that the companies within a supply chain are collaborative, the use of RFID can increase the sharing of product data and general supply chain information throughout the chain. Therefore, important data such as electronic bills of landing can be transmitted more easily with the use of RFID. At the same time, the need of manual tracking of papers related to purchases or product bills will be radically reduced. (Tajima, 2007) (GS1 MobileCom, 2010)

Improved Quality Control

RFID technology can be used in order to offer supplementary and more accurate quality control within a company during production. For example, Nestle tracked product trays in order to prevent poor product quality by introducing more regular cleaning (Tajima, 2007)

Visibility

The technology of RFID offers full visibility within the supply chain, by providing the ability of total real time control of the products that are moving through the chain. The supply chain visibility is a substantial concern for companies nowadays, since the correct application of visibility within the supply chain can eliminate or completely prevent potential problems from occurring. It is well accepted that problems and accidents will definitely occur within a supply chain, no matter how good is the planning of the company. Therefore, the company must be well prepared to spot and trace any potential problematic situation in its supply chain, thanks to the full visibility that RFID offers. At

the same time, the concept of visibility can improve further opportunities within the organization, by anticipating the problems and improving the agility of the company during its strategic planning process. Thus, it can be said that in modern business the visibility concept, that RFID offers, is considered as an additional strategic weapon, as an asset for better planning and decision making. (Manhattan Associates Inc., 2003)

Traceability

Traceability refers to the tracing the current situation of a product throughout the supply chain. RFID provides this possibility by controlling the environmental and weather conditions under which the products are exposed, their location and their safety. (Häkkinen; Nyberg, 2004)

Trackability

Trackability, on the other hand, refers to the ability to spot and track a product in the chain. This function is one of the most crucial and basic for many identification technologies apart from RFID, such as GPS. Therefore, with the use of RFID the companies are able to track every item uniquely within the supply chain and improve the processes of order tracking, shipment tracking and package tracking. (Häkkinen; Nyberg, 2004)

Increased Reliability

Reliability is a key performance indicator when it comes to a supply chain's overall performance. This is why it is considered a first priority issue for all logistics provider companies. The technology of RFID increases significantly the reliability of the supply chain's basic procedures, such as picking, warehousing, packing and delivering. (Enarsson, 2006)

Reduced Material Handling

The use of RFID leads to the reduction of material handling and inspection time. Several studies have shown that the use of RFID technology decreases the inventory counting time, the products receiving time, the average loading and unloading times, as well as the average waiting time before unloading. Moreover, RFID also reduces human errors, since procedures such as product counting and manual data entry are performed automatically. Consequently, the reduced material handling decreases labor costs and increases productivity. (Manhattan Associates Inc., 2003)

Flexibility

As far as flexibility is concerned, it can be measured as the degree in which a company can successfully adjust its processes and general strategy to the continuously changing business environment. In supply chains, the main activity and purpose of which is the goods' flow from one supply chain partner to the other, flexibility is considered as a basic asset for the company, in order to be responsive to the customer demands and agile to the

environment's changes. Therefore, the deployment of RFID technology boosts flexibility within a firm and increases its responsiveness towards the customer. The successful implementation of the flexibility concept in collaboration with RFID can significantly improve the firm's performance. (Enarsson, 2006) (GS1 MobileCom, 2010)

Safety

Safety is a very crucial issue when it comes to the movement of products within a supply chain. RFID reassures to a great extent that the goods transported are safe during all the different steps of their transportation, from the manufacturer to the final customer, thanks to the continuous control of the product flow. (Manhattan Associates Inc., 2003)

Supply chain integrity

When it comes to supply chain integrity, in general, it refers to the increased reliance of the different members of a supply chain and its consequent close collaboration under the scope of succeeding an overall sound and well functioning flow of goods. Moving one step further, nowadays, in modern supply chains the term has been slightly changed in order to include technology and, thus, it is called "Software Supply chain integrity". This means that the companies involved in the supply chain are also supposed to share information through a mutual network and software, which enables this continuous cooperation. As a result, the technology of RFID enables, not only the identification of the goods in the chain, but also the information sharing among the members of it, combining with this way the principles of "Software Supply chain integrity". (Enarsson, 2006)

Inventory updates

RFID, as already mentioned, identifies the products at real time. Therefore, it is becoming much easier for the company to know at every moment how much inventory is available in the store's storage room, in the local warehouses or in the distribution center. (GS1 MobileCom, 2010)

Potential of VMI and QR

Lastly, through the use of RFID there is the potential for the companies to adopt the concepts of Vendor Managed Inventory or Quick Response. The real time information about the goods that RFID offers is a very good reason for a company to move into Quick Response, since it has all the information needed, such as average demand for a product and inventory levels at the stores, for reacting fast and efficiently to the market's changes.

As for the concept of VMI, its main principle is based on the idea that the suppliers are managing the replenishment of the stores, thanks to the overall visibility that they have on the market. With the use of RFID this is becoming easier and, thus, companies could potentially be inclined to combine the technology with this concept. (Enarsson, 2006)

3.6.2.2 Cost Related RFID Benefits

Inventory elimination

The benefit mentioned above, real time inventory updates, is the basis for achieving inventory optimization. RFID enables the continuous control of product availability and, therefore, makes it easier for the company's information system to find the optimal inventory level at every moment. As a result, the overall inventory is eliminated. (Tajima, 2007) (Manhattan Associates Inc., 2003)

Reduction in labor costs

The use of RFID decreases significantly the number of employees needed to perform tasks as products' control and material handling, as mentioned above. What is more, the employees can perform more added value activities within their work environment, instead of manual tasks that RFID performs instead of them. (Tajima, 2007) (Manhattan Associates Inc., 2003)

Reduction in shrinkage (product losses)

Throughout the supply chain, shrinkage occurs in many ways, from misplacement, product damages, shoplifting or even from organized retail thefts. The increased safety and real time traceability and visibility that RFID provides eliminate the amount of products that get lost or damaged. Recently, researchers estimate that RFID is able to reduce product losses and their relative shrinkage cost by two thirds. What is more, RFID is also supposed to be a very effective solution to the problem of black market sales. (Tajima, 2007)

3.6.3 Adoption Barriers – Drawbacks

In this section of the chapter, there is a description of the main adoption barriers of RFID technology. It is important to mention that the factors mentioned here are very decisive for the companies when it comes to implementing or not the technology. Therefore, they are presented after the driving forces towards RFID and its relative benefits, in order to point out that, besides the positive side of RFID implementation, there are fundamental and very serious reasons which make its integration impossible or not feasible.

High cost of implementation

The high cost of implementation is the most important and basic disadvantage of the RFID technology. It is generally accepted that the initial investment needed in order to integrate RFID is relatively high, compared with other technologies and information systems, while the costs of maintaining the use of the technology remain up to our days quite high. (GS1 MobileCom, 2010)

This means that small or medium sized companies are quite unlikely to adopt RFID as long as the cost of implementation is so high. The time of breakeven after the RFID implementation, also depends on the tagged product category, and not only on the size of the company. In other words, RFID does not seem like a feasible solution when it comes to low priced products, while it is a very good option for high valued goods.

Lack of ROI

When RFID has been firstly adopted by companies, its use was limited to the pallets' tagging before they are shipped from the central warehouses to the customers. Consequently, this very limited implementation of RFID, though easy and fast to adopt, did not offer remarkable benefits to the companies by means of Return of Investment. ROI is defined as the difference between the total gain from the investment and the cost of it, divided by this total cost (Investopedia, Dictionary). In the case where a company is not calculating the ROI for a new investment, it is not possible to assess the feasibility and potential success of it in the long term. In other words, when it comes to RFID, the advantages by the use of the technology were not capitalized in a way that would be useful to the organizations. (Tajima, 2007) (Manhattan Associates Inc., 2003)

What is more, the increased costs of full implementation of RFID, including the tags' costs, the initial investment and the relative adjustments to be made in the company after the adoption of the technology, have created the general impression to many companies that RFID implementation is not going to benefit them significantly. Therefore, according to the ARC Advisory Group survey in 2004, more than the half of the responding companies did not expect a positive Return on Investment after implementing RFID. (Tajima, 2007)

As a result, since a substantial Return on Investment is a crucial matter for a company when deciding to initiate any new activity or to fund any new technological investment,

the absence of quantified positive results after the implementation of RFID is creating a serious barrier for the companies to adopt it. (Tajima, 2007)

Technical Risks

A very important issue for the companies when it comes to the adoption of a new technology is the overall reliability of it. When it comes to RFID, there have been quite a few problems related to unreliable performance, from the beginning of using the technology till nowadays. It is interesting to mention that in several pilot projects the percentages of problematic or broken tags, false tag readings and problems in data transmission have been ranging from 20% to even 50%. These extremely high percentages are, of course, showing very low reliability of the technology and, consequently, cannot be approved by the companies. (Tajima, 2007)

Nowadays, it is worth mentioning that the majority of this kind of technical problems has been resolved successfully, due to the continuous research efforts on RFID. However, a new problem category has arisen; the increasing number of tags, readers and antennas used is causing interference problems as far as the signal's quality is concerned. At the same time, the increasing use of other types of wireless devices is very likely to cause a general confusion within the RFID system. As a result, the current needs on the technical risks part of RFID should be now focused on the elimination of total vulnerability of the system and on its successful integration and collaboration with other existing systems. (Tajima, 2007)

RFID Standards incompatibility

In order for a company to implement RFID, a basic precondition is that, apart from the fact that all the supply chain partners are also utilizing the technology, the RFID Standards used are common throughout the chain. However, there is no official common RFID Standard for the tags and readers, as already mentioned in the RFID Standards section, and, consequently, the frequencies used by each company differ from each other.

Thus, it is not always guaranteed that a tagged product would be traceable throughout the supply chain. This incompatibility also implies flexibility problems by the RFID deployment, as well as increased costs in investing on multiple standards reading equipment. (Ladas, 2008)

Materials' special demands

As already known, RFID products are electromagnetic devices. Therefore, the choice of frequency for the information to be transmitted from one device to another also depends on factors such as the materials upon which the RFID tags are attached. For example, metallic packages or packages which contain liquids are more difficult to communicate efficiently with the RFID readers. (Ladas, 2008)

High efficiency of other current technologies

Another significant disadvantage of RFID technology is the fact that the other existing technologies used are very efficient and adequate for the needs of the companies right now. The technology of barcode is still the most dominant one among the current identification technologies available. This is because it is quite cheap and easy to implement, while the current information systems support it more easily, without the need of severe changes to be made.

It is also important to point out that, especially when it comes to small or medium sized companies, which are already using an identification technology, the implementation of RFID seems like a non feasible or affordable solution. (Tajima, 2007)

Difficulties in installation and implementation

In the case of barcodes, the preparation of the technology's installation is only limited to ensuring the contact between the optical barcode reader and to adjusting the speed with which the product moves towards the barcode reader. On the contrary, RFID technology installation requires a thorough testing of the manufacturing site, the materials to be tagged, the existing equipment, and it usually also requires a pilot application. In addition, as far as the functionality is concerned, RFID tags are not so "tolerant" to potential "abuse" as barcodes, since the breaking of a RFID tag means that the information written is completely destroyed, while a barcode label remains readable. (Ladas, 2008)

Privacy Concerns

Another significant adoption barrier when it comes to RFID is the possibility of invasion of privacy by the use of the technology. Various consumer organizations, such as Consumers Against Supermarket Privacy Invasion and Numbering (CASPIAN), have declared their strong opposition against the use of RFID. Their main concerns have to do with the potential connection of the information written in the tags with the personal data of the consumer. Thus, the fear of surveillance without the consent of the consumer, not only in the supermarket but also in the house, has arisen. In order for these privacy issues to be solved, the relative legislation is, of course, a first priority but also the proper education of the public and the consumers is also of vital importance. (Tajima, 2007)

3.7 Description of several successful RFID cases

In this section of the thesis, several successful RFID projects, adopted by large global retailing companies are presented. It is, therefore, very interesting to examine how the technology of RFID has been applied in these companies and which are the current results of it. The presentation of the cases is short but sufficient, including all the main points that worth mentioning and are essential for the further understanding of how RFID works within a firm.

Thus, the cases presented below include Wal-Mart, Marks & Spencer and, of course, a fashion retailing company, American Apparel, in order to provide an example very close to the case study. The selection of these three cases has been the result of consideration of the most appropriate selection criteria. Firstly, the fact that these particular organizations are very well known globally is a basic reason for presenting them as examples in the thesis. Secondly, the implementation of RFID in these big firms paved the way for other companies to follow with its adoption. Thirdly, the implementation of RFID by these retailing firms is a very representative example for the case study presented later in the thesis, since the main research field is the application of RFID in the retailing supply chain. Thus, the first two cases, Wal-Mart and Marks & Spencer, refer to the integration of RFID by large retailing supply chains, since they are very big retailers with a huge product range and assortment. Moreover, American Apparel is even closer to the Staff Jeans case study, since it is a fashion retailing company and the adoption of RFID by this firm can stand as a very good example for the case of Staff Jeans, both under the scope of providing useful information and know-how by a global firm and under the scope of drawing a comparison between the two fashion retailing cases.

3.7.1 The phenomenon of RFID among global firms

The reason why more and more firms are choosing to use RFID is found on a theory that several economists call the network effect. According to this theory, the more people or companies are using a particular network, such as the Internet for example, the more valuable and indispensable it becomes (Roberti, 2003). Consequently, this is encouraging even more people or firms to use the same network by creating a group-think type of mentality, which is leading to the exponential growth of this network.

In the case of RFID technology this theory seems to have found its application in various companies, but with an emphasis on fashion retailing, since the cost of each product can bear the additional RFID cost more successfully.

There are also many other companies which have adopted RFID within their supply chain. Some of the most famous examples are Wal-mart, Marks & Spencer, the Metro Corporation in Germany and Tesco. As far as the fashion retailing business is concerned, the most famous examples are American Apparel, Benetton Italy, Levi Strauss and Armani Italy. More fashion retailing companies that have deployed RFID are presented in the Appendix Table. (Jones; Chung, 2008)

3.7.2 Wal-Mart

Over the last decade, Wal-Mart has been in close collaboration with the Auto-ID Center in order to develop and implement the RFID technology so as to track goods using the EPC Standard. Generally, the Wal-Mart RFID system requires that its suppliers provide pallet level RFID tagging which is scanned at ten feet distance of the dock door at all times. The RFID EPC tag is the format used. Therefore, all Wal-Mart suppliers are in close cooperation and communication with the company in order to fulfill the requirements and potential updates of the standards that Wal-Mart is using. It is interesting to mention that this Wal-Mart RFID mandate is very well organized under a complete system that runs through the whole supply chain. Wal-Mart's top one hundred suppliers not only have to put tags on their pallets, but they must also install RFID readers in their manufacturing facilities, warehouses and distribution centers. (Jones; Chung, 2008)

The long-term goal of Wal-Mart is to expand the use of RFID to the point where they will deploy smart shelves systems at the retailers to monitor how many items are on each shelf. Consequently, when the inventory level is low, the RFID software will send a signal to the retailer's storage room to fill in the shelves with more products. At the same time, the readers in the storage room will also monitor and control the inventory levels so as to alert the distribution center when more products are needed and automatically send a replenishment order. This intelligent system along with the item level tagging is a very challenging, though quite far away goal, since the company is expecting that the RFID tags will take more than a decade until they become cheap enough to allow individual labeling and control in the stores.(Wal-mart press release, 2007)

Lastly, it is important to mention that, according to Sanford C. Bernstein & Co., a New York investment research house, it is estimated that Wal-Mart can save up to $8.4 billion per year when RFID is fully deployed throughout its supply chain and in stores. (Jones; Chung, 2008)

3.7.3 Marks & Spencer

Marks & Spencer have been trying the RFID technology since 2002, as a trial project in the beginning, in selected stores in the United Kingdom. The first pilot attempt included pallet level tagging in food and clothing products, while during 2003 the company tried to expand the tagging on an item level for the man's garments produced. After a trial period of nearly two years in total, the company decided to continue the RFID deployment within their supply chain by introducing new trial projects. (Marks & Spencer press release, 2005)

The main advantage of RFID for Marks & Spencer is that the item level tagging provides the ability to control the stock levels with very high accuracy and improves the distribution and inventory planning of the firm. What is more, the increased customer satisfaction level, which is a crucial goal for the company, can be potentially improved by improving the product's availability for the customer. (RFID Journal, 2004)

Unfortunately, further information, concerning the current trial RFID projects that the company is deploying, are not yet published or available.

3.7.4 A fashion retailing success story - American Apparel

American Apparel is a vertically integrated manufacturer, distributor and retailer, based in downtown Los Angeles, California. The company currently employs approximately 10,000 people on a global level (about 5,000 in LA), and operates more than 260 retailing stores in 19 countries. The company operates the largest garment factory in the United States. (American Apparel website,2010)

The case of American Apparel, a very big fashion retailing company, which implemented RFID, is very interesting to examine, since it is a very similar case to the Staff Jeans one, which is analyzed later. By 2008, the company had already been deploying item level RFID tagging within its products, with very positive results. The project has been put in practice as a pilot to several stores in New York but, nowadays, it is still running and the company is expanding its implementation to more stores every year.

The main advantage created in American Apparel is one more time the increased inventory control accuracy, which has enabled the company to better plan the replenishment of the stores that have integrated RFID. It is impressing to mention that the level of inventory accuracy has been higher than 99% to the RFID-enabled stores of the firm. What is more, the successful inventory management had as a natural consequence the increase in sales by 15%, since the tactical replenishment of the stores was boosting the customer demand. Lastly, the company also mentions as a major advantage the improvement in their supply chain processes, such as handling and sorting the goods that were tagged.

As far as the future is concerned, American Apparel is planning to further deploy RFID in the majority of the chain's stores, since the cost of implementation is continuously decreasing, thanks to the already installed RFID systems and the experience of the personnel with working with the technology. The company's goal is to introduce RFID among the rest of the stores by achieving the lowest possible impact to the existing information systems, in order to lower the cost per store and to increase the degree of RFID integration with the older systems. (RFID Journal, 2008)

4. Case study Chapter

At this section of the thesis, the case study of Staff Jeans RFID deployment is presented. The case of Staff Jeans is a very special example of RFID implementation, since it refers to a fully integrated firm, and, thus, it is very interesting to examine how the project has been planned and integrated, and which the results have been since then. Therefore, the chapter includes a description of how the project was planned and formed, which was the technology that the company was using before RFID, the project and implementation preparation stages and, finally, the pilot and full implementation of it.

4.1 Forming the Case study

In 2008, Staff Jeans has been considering to perform a significant investment on a new technology within its supply chain, in order to improve its efficiency and customer service. Therefore, the decision was not easy. The already existing technology of barcode had a sufficiently good performance and good tracking capabilities. However, the motivation of the company was to implement a technology which could collaborate more accurately and directly with the central information system and would increase the number of automated procedures in its supply chain. Thus, Staff Jeans faced the challenge of either maintaining the barcode technology as a tracking system for its products, or implementing a new technology which, apart from the tracking capabilities, could potentially influence more radically the processes of the company's supply chain, while the actual risk of not succeeding in this attempt was always present. Thus, the company decided to consult Sensap Microsystems in order to make this strategic decision. After a series of discussions, Staff Jeans decided to take on the challenge of RFID implementation within its supply chain without the previous doubts and uncertainties.

At this point, it is very important to mention that the case study is focused on the application of RFID among the retailing stores of Staff Jeans within Greece. This is happening because of two reasons; first, the deployment of RFID is now limited to the Greek stores and, second, the company's representatives across Europe are mainly department stores and, thus, the decision of implementing or not RFID is up to their management.

In the following paragraphs the procedure of implementing RFID by Staff Jeans in collaboration with Sensap is described. What is more, the pilot and the final RFID projects implemented are also presented.

4.2 Methodological Approach of Case study Research

Before proceeding with the further description of the case study, it is important to explain which has been the methodological approach towards the case's research. First of all, the author has been in close collaboration with the RFID project developing company, Sensap, during the whole thesis preparation period. What is more, a remarkable period of time has been spent within the company's facilities, in order to conduct interviews with the Chief Technical Officer of Sensap and at the same time perform field observation of its

RFID Microsystems Department. During this period, four interviews have been conducted, which offered the majority of the case study data. The first interview conducted was formal, structured with specific questions, while the rest three interviews, due to the fact that the author has been interacting with the company's personnel in the meantime, have been consisting of open questions that enabled a further discussion on the topic.

Apart from the observation of Sensap, the author has visited two central official Staff Jeans stores in Athens, in order to have a complete view of how RFID enables the retailing processes within the store. The combination of the data gathered from the Staff Jeans retailing stores with the information provided by Sensap have been the basis of the case study formation and analysis.

4.3 The situation before RFID

Staff Jeans has been deploying the technology of barcode as the main tracking technology within its supply chain, since the company began producing and selling its products. Therefore, all the processes related to manufacturing within the plants, transportation to the distribution center and distribution all over Greece to the local stores were aligned to the use of barcode.

The technology of barcode had been very effective till that time for Staff Jeans, since the company was able to track and sort the products in a rather fast and reliable way. However, all these activities were performed without having full visibility of the whole supply chain and flexibility to trace potential problems. Thus, the system of counting the items, managing orders and delivering to the stores was more or less "manual", since the information system of the company could not support real time information for each item.

For this reason, the company decided to take on the challenge to upgrade its current information system and change the tracking technology used till that time, from barcode to RFID. The expected outcome of this strategic decision was mainly the improvement in accuracy and speed of the main supply chain processes, warehousing, packing, transportation and picking, while at the same time the company was expecting a significant cost reduction, by means of personnel cost reduction and better warehouse management.

4.4 Preparation of RFID implementation

4.4.1 Selection and Forming of the RFID Project

The selection and forming of the RFID project to be implemented has been a quite time consuming process, since both Staff Jeans and Sensap had to make all the decisions and take all the appropriate measures that would lead to the successful implementation of the system. Thus, after a period of discussions and brainstorming of new ideas, the two sides decided upon which are the actual business needs that the new technology is going to cover and which are the expected improvements out of its implementation. Thus, the specific objectives of the Staff Jeans RFID project were set.

At this point it is essential to point out that the RFID platform that Sensap has developed is a system that covers all the basic RFID functions and communicates with a company's information system. However, this standardized platform has to be customized based on the requirements of each customer. Consequently, after Sensap has been well aware of the Staff Jeans system's requirements, could then proceed to the customization of the RFID platform.

The main issue which was taken into consideration by both sides was the alignment of manufacturing processes, warehousing, packaging and transportation with the new technology, so as to reassure the success of implementation. Apart from reassuring a successful implementation, the effective process alignment also implies that the RFID project could be put into force faster and could cover a wider range of business activities.

On a second level, Staff Jeans management also wanted to discuss several other subjects of vital importance with Sensap. Therefore, the two companies had to come in an agreement regarding the cost of the RFID's project implementation and further support. This means that apart from the main RFID application cost, other costs would also occur such as personnel education and continuous support from the part of Sensap towards Staff Jeans.

After having discussed and agreed on every different issue regarding the RFID project, the two sides had to cooperate in order to prepare the ground for the change to be made. For this reason, a set of changes and adjustments in the way that Staff Jeans had been working till that time, needed to be performed.

4.4.2 Changes performed in the company

Several improvements or adjustments have to be performed when implementing RFID, in order for the company to successfully integrate the new technology into its already running processes. As far as the changes that were performed in Staff Jeans along with the RFID implementation are concerned, it is important to point out that the firm has always been a modern and highly innovative company by means of business processes and marketing strategies. Therefore, the changes that need to be performed in an

organization which is already working successfully are obviously not referring to the change of the core procedures, but to their alignment and reassessment.

Staff Jeans was in a very close collaboration with Sensap for this very practical issue, before implementing RFID, in order to decide upon the changes to be made in advance and, thus, plan the project implementation in a more holistic and dynamic way. Therefore, the cooperation of the two sides resulted in adjustments to be made in the already well organized procedures followed within Staff Jeans. The first basic adjustment to be made was the alignment of the main manufacturing line in the company's plants, so as to fit with the RFID tagging line that had to be installed there. This step has been very crucial, because it initiated the implementation of RFID in the supply chain of Staff Jeans, by ensuring that every item is tagged in the same area where it is produced. This means that when the products are ready for shipment, they are already traceable. Thus, the company's transportation fleet had to be equipped with RFID scanners that ensure the conditions in which the products are transported and prevent potential damages and losses until the products reach the central distribution center.

Lastly, it is interesting to mention that in the cases where Sensap spotted some flaws to the logistical processes and procedures of Staff Jeans, they performed some additional consultancy in order for Staff Jeans to improve and optimize them along with the use of RFID technology.

4.4.3 The concept of AspireRFID

Before proceeding to the description of RFID implementation by Sensap to Staff Jeans, it is firstly essential to shortly describe the concept of AspireRFID, since it is the RFID platform that was finally implemented in Staff Jeans. AspireRFID is a European Union funded project for companies to introduce a low-cost alternative solution to commercial RFID suites, which would be used by enterprises in realistic RFID deployments. What is more, AspireRFID is enabling the implementation of connector interfaces with popular enterprise systems, such as ERP (Enterprise Resource Planning) and WMS (Warehouse Management System) systems. The case of Staff Jeans is one of the most characteristic success stories for AspireRFID, since it involves the use of AspireRFID middleware for the RFID project undertaken by the company. (RFID Journal, 2009)

Sensap is one of the RFID software developing companies within the European Union which is a member of the AspireRFID project and, thus, all the projects developed by the firm are deploying this platform. As a result, the choice of Staff Jeans to collaborate with Sensap has led to the implementation of the AspireRFID platform in the company, which has been one of the most pioneer European Union RFID solutions lately.

4.5 RFID implementation

The implementation of RFID in Staff Jeans involved the thorough system design planning and specification, as well as the identification and acquisition of the project's resources. Therefore, before the full RFID implementation there has been a trial period for Staff Jeans, during which both Sensap and Staff Jeans had the chance to evaluate the feasibility or not of the project. In the following paragraphs, the pilot and full RFID implementation phases are shortly described, in order to provide a short overview of the RFID system, before proceeding to the analysis of the results out of its deployment.

4.5.1 Pilot RFID implementation

The pilot RFID implementation started during 2008 and lasted for 12 months, since Staff Jeans was not yet sure whether they would fully implement the technology. Therefore, during this trial period the installation of RFID software and hardware was made, while the first basic start up RFID processes were put into practice. The pilot RFID deployment has been an extremely useful period for Staff Jeans, since the company had the chance to assess all the important RFID processes and activities, to perform quality and performance controls and to adjust the settings of the RFID system accordingly. At the same time, the company tried to motivate and educate its personnel during the trial period, in order to achieve better results with the collaboration of the existing human resources.

4.5.2 Full RFID implementation

The full RFID implementation phase started during 2009 and, thus, the project is now running for the last 8 months as a fully integrated system within Staff Jeans. Staff Jeans is utilizing radio frequency identification at its warehouse to track inventory at the pallet, carton and item levels, as well as to achieve automated handling of shipping and receiving procedures, and exploit real-time inventory data stemming from distant places.

During 2010, several additional RFID uses are going to be integrated in the supply chain of Staff. The main concern of the company is to take advantage of the marketing aspect out of the use of RFID. This means that the stores are going to be equipped with RFID enabled fitting rooms that will help the customer choose the most appropriate garments. What is more, screens inside the store, that will receive signal from the tags, are going to recommend to the customer the best potential buys for him/her individually. The company is planning to have this project completed by the end of 2010, and is also expecting to boost the sales and to increase the customers interest for shopping.

4.5.3 Functionality of RFID within the firm

After having described the RFID implementation process preparation, the pilot and, finally, the full implementation of the RFID project, it is now important to shortly present which is the functionality of RFID within the firm.

First of all, Staff Jeans is an integrated organization, as already mentioned, which means that it is the manufacturer, distributor and retailer of its own products. Therefore, it has implemented RFID throughout its supply chain, from the manufacturing plant, to the retailing store. As far as the manufacturing is concerned, Staff Jeans has adjusted its production lines within its plants by adding the RFID tagging line. This new part of the manufacturing line is placed after the core manufacturing line of the products, and before their packaging is performed. At this RFID line, each product is equipped with a passive EPC tag, before it is packed and shipped to the distribution center. Therefore, the item level tagging is performed at a very early level in the chain and it reassures the continuous control of the product's position and condition within it.

After the garments are tagged and packed, the shipment to the distribution center is performed. The company's transportation fleet is also RFID enabled, in order to control the quantity of each product category loaded and transported to the central warehouse. When the garments arrive at the distribution center in Larissa, they are unloaded, sorted and arranged within the warehouse. In order for these procedures to be accelerated and more efficient, Staff Jeans has installed big RFID scanners across the warehouse. As a result, the products are sorted more easily and, then, forwarded to the retailing stores according to the orders placed, based on the real time inventory control through the RFID enabled information system.

When the products arrive at the retailing store, they are scanned and arranged in the storage room or inside the store's selves, according to the inventory availability of each garment category. At this point, it is important to mention that the RFID tags are still active and transmit information regarding the product. However, the moment when the customer is purchasing the product, the Staff Jeans seller is responsible for deactivating the RFID tag and removing it from the garment, so as not to be active any more. This deactivation process is performed directly after the garment has been scanned at the cashier, in order for the information system to keep track of the sales and inventory levels at real time. Lastly, the deactivation process is also crucial for Staff Jeans, so as to agree with the current legislation regarding the customer's privacy.

4.5 Cost of RFID implementation

After having described the implementation of RFID, it is essential to present the costs that this project has incurred for Staff Jeans. Even though the costs of the RFID project have been made available by both Staff Jeans and Sensap, the outcome of the system's implementation has not been provided in numerical data by Staff Jeans, for reasons of confidentiality.

The different cost categories include the initial investment cost in the Distribution Center of the Staff Jeans, which consists of Hardware, Software, Planning and Installation costs, the implementation costs per store, the annual cost of support and personnel education and, finally, the major source of cost, the EPC tags purchase.

The initial investment cost for the Distribution Center in Larissa including Planning, Support, Hardware and Software equals to 60.000€. The cost of full RFID implementation for one store is equal to 10.000€. It is interesting to mention that there are five (5) official Staff Jeans stores in Greece, which means that the total cost of implementation among them is 50.000€. During 2008, the RFID implementation was only performed in two central stores, as part of the pilot project. The rest three official Staff Jeans stores adopted the technology during 2009. There are, of course, many other stores, showrooms or department stores within Greece and the rest European countries which are offering the Staff Jeans products, but the potential implementation or not of a RFID project lies completely on the management of these firms.

The annual cost of personnel education and further support from Sensap towards Staff Jeans is approximately 3.000€. Lastly, the most costly cost category, the annual cost of 1.000.000 EPC RFID tags, already containing the information needed for each product category is equal to 120.000€ .

Costs	2008	2009	2010	2011	Total
Initial Investment in DC (including planning, H/W, S/W, installation)	60000	-	-	-	
Implementation Cost per store (including planning, H/W, S/W, installation)	20000	30000	-	-	
Annual Cost of support (including education, support, service)	3000	3000	3000	3000	
Tags Purchase	120000	120000	120000	120000	
Total	203000	153000	123000	123000	602000

Table 4: RFID implementation costs

Table 4 above summarizes the costs per category and per year for Staff Jeans. The costs for the years 2010 and 2011 include only the standard cost categories of annual support and tags purchase. In case of further investment on RFID these costs are going to rise.

4.6 Effects of RFID implementation

After having provided the case study description, along with the RFID implementation costs, it is important to list the main effects that Staff Jeans has realized out of the integration of RFID. It is important to point out that the effects mentioned at this section are data reported by the company and they have been provided through the interviews within it. For this reason, their presentation here is important, since they have been the basis of the Analysis Chapter. Thus, at this part of the thesis, only a list of the different effect categories is presented. These effects can be divided into two main categories; Benefits and Drawbacks. The first effect category, the benefits, are further divided into two sub-categories, the Process Oriented Benefits and the Cost Related ones, in order for the case study results to follow the same presentation of the Theoretical background chapter. What is more, the drawbacks are listed in the same pattern as the drawbacks and adoption barriers have already been presented before. In the Analysis Chapter, though, they are going to be further analyzed and explained.

Benefits

Process Oriented Benefits

> - Improved accuracy in all logistics procedures and processes
>
> - Receiving and picking acceleration
>
> - Real-time visibility into its own supply chain processes, with particular emphasis on inventory processes.
>
> - Real time inventory management towards better delivery planning to retail stores
>
> - Automatic replenishment for room reserve stocking area
>
> - Safety stock reduction
>
> - Automatic picking and stocking routine
>
> - Real time information about the position of each separate item
>
> - Automatic order generation from current inventory availability
>
> - Better and more efficient warehouse management
>
> - Better organization of orders upon delivery, orders upon preparation and pending orders
>
> - Increased customer satisfaction

Cost Related Benefits

- ➤ Positive ROI

- ➤ Reduced labor costs

- ➤ Reduced product losses

Drawbacks

- ➤ Very High Cost of Consumables (120.000€ for tags purchase)

- ➤ No improvement of the picking procedure

- ➤ No improvement of the packing process

5. Analysis Chapter

In this chapter of the thesis, the results out of the case study are presented. Thus, there is a description of the benefits created within Staff Jeans, as well as the uncertainties incurred. What is more, the comparison between the actual benefits realized by Staff Jeans are compared with the benefits according to theory, while a cost – benefit analysis is also performed, in order to evaluate the feasibility of the RFID implementation for the company.

5.1 Analysis Overview

Based on the case study's results and according to Staff Jeans' management, the implementation of RFID has had positive results for the company, since from its first pilot deployment the company achieved a positive return on investment (ROI). As a result, Staff Jeans has now fully implemented the technology and is planning to perform further extensions of its use during the years 2010 and 2011.

The positive ROI is the most decisive factor to evaluate the results of a new investment within a firm. Therefore, it is very of high importance to point out that the integration of RFID has brought such results for Staff Jeans, which, along the years, is benefiting more and more from the technology's use. According to the firm's management, the positive ROI has been increasing over the years of RFID use and this is further encouraging the company into exploiting more uses of the technology. Since these data are confidential for the company, Staff Jeans is not able to provide the exact ROI that has realized over the years after RFID implementation. However, it is sufficient to know, as a general and fundamental positive result of the technology, that the Return on Investment has been positive in this particular case.

Apart from the first and easy to measure benefit of a positive ROI, Staff Jeans has realized various improvements among its internal processes and supply chain procedures. The specific benefits created out of the RFID use are presented thoroughly later on the Analysis chapter. As a general impression though, the management of both Staff Jeans and Sensap are considering the overall result achieved as very positive and promising for the future.

However, there have been also several comments and objections that occurred after the RFID implementation, mainly within Staff Jeans. On the downside of RFID deployment, it has been revealed that RFID is not a panacea for improving all business processes. For example, even though the warehouse and inventory management have been improved, Staff Jeans did not see any real benefit over the picking and packing processes, in which RFID deployment has offered no tangible improvement over the previously existing barcode system.

Apart from this realization, Staff Jeans management also declares that the item-level tagging that the company is performing is increasing to a great extent the firm's consumables budget, which consists of the already written passive EPC tags. As a result,

the purchasing of approximately 1.000.000 tags per year is raising to quite high levels this particular cost category, the consumable products, for the company's balance sheet. This is, of course, happening because the company accounts for the total cost of the tags instead of their relative cost, which is calculated as tag per item.

The calculation of the relative cost is the result of the division of the total cost of the tags, 120.000 euros, with the number of tags, 1.000.000 items. Consequently, the additional cost per garment is only 0,12 euros, which is relatively low, considering two basic factors; that the technology is still rather new within the firm and that each item's price is medium to high.

These two factors are very decisive for Staff Jeans so as to continue deploying RFID. The first one, the fact that the technology is still new generally but also specifically, within the firm, means that there is a lot of potential for improvement and even better integration of all the supply chain related processes. As a result, the company can even realize much more benefits, to a greater extent than already, in the near future. As far as the product's price is concerned, it is one of the most significant reasons why the item level tagging has been successful and, consequently, all the benefits related to this kind of tagging have been created for Staff Jeans. The item's price is a major barrier for other business sectors, since it prevents the companies from adopting the item level tagging RFID and they are mainly limited to pallet level tagging for their products. Therefore, it is very important to point out that the fact that if the price range of a firm's products is from medium to high levels, it is much easier, feasible and reasonable to adopt an item level tagging.

As a result, it can be said that the RFID implementation is causing high cost increases within the company's balance sheet, but it creates a rather low cost per item, that can be easily absorbed by the garment's price, without seriously influencing the profit per garment that the company is realizing. This is also the main reason why Staff Jeans is having positive ROI results, despite the high costs of implementing the technology and maintaining of its use.

5.2 Benefits

After having presented the general overview of the results realized within the company, it is now very important to present the benefits that Staff Jeans realized after the deployment of RFID. In order to maintain the logic applied in the Theoretical Background chapter, the benefits are also divided here into two main categories: process oriented benefits and cost / revenue related benefits.

5.2.1 Process Oriented Benefits

Improved accuracy in all logistics procedures and processes

Staff Jeans realized a very increased accuracy when performing the supply chain related processes of packing, warehousing and transporting the products. This means that the potential delays and bottlenecks have been eliminated, while all the time wasting problems due to human errors have been also minimized.

Receiving and picking acceleration

Staff Jeans has also radically improved two very basic supply chain processes after RFID integration, receiving and picking. These two processes were significantly accelerated, given that RFID obviated the need for manual item-level processing. This means that the company has been able to save time and prevent delays occuring during receiving and picking the products to and from the central distribution center. What is more, the fact that these two procedures are now being performed much faster is increasing the reliability and flexibility of order processing and shipping to the retail stores.

Real-time visibility into its own supply chain processes, with particular emphasis on inventory processes.

Staff Jeans, thanks to the RFID deployment, achieved complete visibility to all its processes, from manufacturing, packing, order preparation, shipping and warehousing. However, it is very interesting to point out that the greatest improvement has been realized in the inventory handling processes. The visibility that RFID is offering enables the better management of inventory levels, and, thus, is helping the company towards inventory elimination.

Real time inventory management towards better delivery planning to retail stores

The ability to manage inventory in real time is of the uttermost importance in the apparel industry, since there is very little room for returns. At the same time, the apparel company must have a very high degree of responsiveness and this can only be achieved through an efficient inventory management strategy. Staff Jeans has been able to plan deliveries to the stores much more successfully and effectively than before, and respond to potential increased demand from several retail stores very fast.

Automatic replenishment for room reserve stocking area

RFID implementation has helped Staff Jeans perform automatic replenishment for its room reserve stocking area, since the software of the technology is connected with the central information system and is sending alerts when the inventory level is too low. Thus, the product replenishment is managed automatically by the RFID system and the company avoids potential stock-out situations. At the same time, the personnel is able to perform more adding value tasks instead of being busy with managing the replenishment of the room reserve stocking areas.

Safety stock reduction

The deployment of RFID technology has already changed to a great extent the inventory strategy of Staff Jeans, as described in the paragraphs above, but it has also helped in the reduction of the company's safety stock within the central distribution center. This happens because the ability to control and plan the desirable inventory levels in each store through RFID, is also affecting the safety stock level for reassuring that the demand in each store can be satisfied at any time. Therefore, better inventory planning reduces safety stock levels as well.

Automatic picking and stocking routine

Another very useful outcome of the use of RFID in Staff Jeans has been the automation of many supply chain and logistics processes, as already mentioned. In particular, the picking and stocking routines within the central distribution center have been automated through the new technology, which enables the faster and more convenient handling of the products.

Automatic order generation from current inventory availability

The general inventory handling improvement thanks to RFID has helped Staff Jeans to automatically organize and manage the orders to the retailing stores, since the system is well aware of the inventory levels in each store's storage room. Therefore, when the inventory levels are low, the RFID system informs the distribution center's system to generate a new order for replenishing the relative store with the products needed.

Real time information about the position of each separate item

Staff Jeans has performed item-level tagging with RFID, which means that each individual garment is equipped with a RFID tag. This enables the company to track the position, as well as the conditions to which the product is exposed. As a result, Staff Jeans has been able to minimize the products losses and damages, and, thus, increase the reliability of manufacturing, warehousing and transportation functions.

Better and more efficient warehouse management

The deployment of RFID has generally created a remarkably improved warehouse management strategy. This happens because several time consuming processes such as stocking and picking have been automated, while, at the same time, the personnel responsible for these tasks can take advantage of this automation and improve its working conditions by eliminating mistakes and errors.

Better organization of orders upon delivery, orders upon preparation and pending orders

Managing the different kinds of orders within the central warehouse is a task of responsibility, due to the high complexity of each type of order. There are three basic kinds of orders to be managed: the orders upon delivery to the retail stores, the orders upon preparation for shipment and the pending orders, which are the orders that have not yet been prepared and forwarded. Apart from the type of order, another important issue to be considered is the composition of each different order; how many products of every kind are requested from each retail store. Thanks to the RFID system, which is able to manage each garment individually, the order management within the distribution center is performed more easily, faster and more conveniently.

Increased customer satisfaction

As a final, general benefit created by the implementation of RFID in Staff Jeans, is the achievement of a high customer service level. This is happening because the company has increased its reliability towards the customer, by avoiding stock out situations, by improving the service in the stores and by providing a lot of information about the product to each customer individually.

5.2.2 Cost Related Benefits

Positive ROI

As already mentioned in the general results section, Staff Jeans has realized a positive Return on Investment out of the RFID deployment. This means that the company has had such benefits out of this implementation, since the money invested have brought an even higher profit.

Reduced labor costs in such procedures as receiving and packing

The implementation of RFID in Staff Jeans has had an influence on the labor costs of the company. As a result, the number of employees working in the distribution center has been reduced, since several activities have been automated. What is more, when it comes to the processes of receiving, picking and packing, the use of the RFID system has accelerated them to a great extent and reduced the degree of the human interference in performing them. Consequently, the company realized that it did not need the excessive personnel that has been working in the central warehouse and decided to use the same human resources in more adding value working positions within the company's network.

Reduced product losses

The ability to control in real time the position of every single product within the supply chain eliminates the number of products that are lost at every different part of the chain, from manufacturing to shipping. Therefore, Staff Jeans has realized a significant reduction in product losses thanks to RFID, which has helped in saving money which are already considered invested capital for the company.

5.3 Comparison of actual benefits with the benefits according to theory

Drawing a comparison between the benefits of RFID, as a result of the theory review, and the benefits realized in Staff Jeans after the RFID implementation is a very interesting way of understanding which are the benefits, that are generally met in all the companies that integrate the technology, and which are the particular benefits created in the particular case of Staff Jeans. At the same time, the comparison can show whether the benefits presented in the theory review are correct or overrated, and which their actual deviation from reality is.

As far as the process oriented benefits are concerned, the first and very obvious comment to be made is that, generally, RFID is improving to a great extent various business processes and activities. The research results are very similar to the results that Staff Jeans has realized after the RFID deployment. Therefore, in both cases there has been a significant inventory and warehousing strategies change and improvement, while, at the same time, in both cases there has been an emphasis on improved flexibility and accuracy within the supply chain processes.

However, it is becoming obvious that the benefits presented in the Theoretical Background chapter are mainly based on the general improvements realized by implementing RFID, while the benefits presented in the Analysis are directly reflecting the specific process or procedure improvement that has been created. In other words, the benefits that Staff Jeans has realized are much more specific, while the benefits according to theory are more general and abstract.

When it comes to the cost related benefits, it is interesting to point out that even though Staff Jeans has realized several very important cost reductions, the cost category of ROI, mentioned in the Analysis, has not been covered in the theoretical review as a benefit but as an adoption barrier. This remarkable difference lies on the fact that Staff Jeans has been considering the measurement of ROI since the beginning of RFID implementation, while the majority of the companies, according to the theory review, do not take this factor into consideration.

The table below illustrates the process oriented and cost related benefits realized by RFID both according to theory and in Staff Jeans. The table's logic is based on the effort to match the different benefit categories from theory with the closest ones from Staff Jeans, so as to point out the similarities and differences in these two cases. In the case where one benefit category does not match with another one from the other column, it is presented individually.

Benefits		Theory	Staff Jeans
Process Oriented	*Mutual Benefits*		
		Flexibility-reliability-efficiency	Improved accuracy
		Improved quality control	
		Inventory updates	Better inventory management
		Reduced material handling	Automatic replenishment
			Automatic picking and stocking
			Automatic orders
			Receiving and picking acceleration
		Trackability-traceability-visibility	Real time information
		Improved information sharing	
	Differences		
		Potential of VMI and QR	
		Safety	
		Supply chain integrity	
			Safety stock reduction
			Better warehouse management
			Better order management
			Increased Customer Satisfaction
Cost Based	*Mutual Benefits*		
		Reduction in shrinkage	Reduced product losses
		Reduction in labor costs	Reduced labor costs
	Differences		
		Inventory elimination	
			Positive ROI

Table 5: Comparison of RFID Benefits

From Table 5, it is now becoming more obvious that the benefits according to the theoretical review are more general, while the ones created in Staff Jeans are directly referring to specific processes within the company. This can be explained by the fact that the theoretical review is only providing the framework and the overall picture of the potential benefits that RFID can create, while the case study is showing which the actual result in each process or activity is after implementing RFID.

However, there are several benefits where there is no match between the theory and the case study. Some of these benefits are only mentioned in the theory review, while some others are only met in the specific company. It is natural to come across this kind of deviations when performing a research in a firm, since there is a very specific and unique environment and way of conducting business within it, which can potentially bring different results than the ones mentioned in the theory. At the same time, several benefits mentioned in the theoretical review, such as the potential of VMI and QR, are not always included in the goals of a company that wishes to implement RFID.

5.4 Economical Analysis

After having presented the benefits that Staff Jeans has realized through the RFID technology deployment and the costs occurred out of this implementation, it is very interesting to perform an Economical Analysis as an additional means of examining whether this project has been a successful strategic decision. What is more, this analysis will evaluate whether this RFID project can be a feasible solution for the company in the future.

Generally, when performing an Economical Analysis, it is crucial to compare the benefits and the costs occurring out of a business decision, so as to come up with a result that is valid and reliable in terms that it reflects the reality. In the case of Staff Jeans, there is a basic restriction before performing the analysis; even though the RFID costs data are provided by Sensap, the data concerning the positive results or profits out of RFID implementation are not provided by Staff Jeans. This is happening because the company is not allowed to publish this particular information, since they are considered confidential. Thus, this means that despite the fact that the all the different cost categories are quantified, the different benefit categories for Staff Jeans are not quantified either individually or in a total positive result.

However, since the two data sources, costs and benefits, are available, it is possible to perform the Analysis, on an analytical, explanatory and exploratory level only, without mentioning the specific numerical data.

Both the companies involved in this RFID project, Sensap and Staff Jeans, have declared that the integration of RFID has had a positive Return on Investment. Based on the ROI formula, the outcome of the difference between the total gain from the RFID investment and the cost of it, divided by this total cost has given a positive result. This positive result is proving that the investment made on RFID by Staff Jeans has been not only a feasible, but also a very correct strategic decision. Therefore, the potential of profitability for Staff Jeans can be further exploited through the use of RFID.

Apart from the positive ROI, both the involved companies have provided information, not in quantified numerical data, that the quantification of the benefits created after the implementation of RFID have, at this point, not only covered the costs occurred, but also created significant profits, mainly due to the cost reductions realized in various supply chain activities. More specifically, Staff Jeans has declared that "there would be no tangible reason to keep on investing on this particular project, unless it was actually beneficial for our company, in terms of cost reductions, sales and, of course, marketing."

The picture below is providing and summarizing the outcome of this explanatory economical analysis.

Costs		Benefits
Initial Investment in DC *(including planning, H/W, S/W, installation)*		Improved accuracy
		Real time information
		Better inventory management
		Automatic replenishment
Implementation Cost per store *(including planning, H/W, S/W, installation)*		Automatic picking and stocking
		Automatic orders
	<	Receiving and picking acceleration
		Safety stock reduction
Annual Cost of support *(including education, support, service)*		Better warehouse management
		Better order management
		Increased Customer Satisfaction
		Reduced product losses
Tags Purchase		Reduced labor costs
		Positive ROI

Figure 6: Economical Analysis summary

As a result, it is obvious that the undertaking of this particular investment on RFID for Staff Jeans has been very positive for the company till now and will, potentially, continue to be beneficial in the long run.

5.5 Key Factors for the Case's success

The analysis has conducted a clear and robust examination on the application of RFID in the retailing supply chain of Staff Jeans. The assessment of this particular case study has proven that the company has realized significant benefits out of the use of RFID, both under a process improvement and a cost reduction scope.

The benefits that Staff Jeans has realized by implementing RFID technology can be explained after taking into consideration two determining factors: first, the company is a vertically integrated manufacturer, distributor and retailer and second, the price range of its products is medium to high. As far as the first factor is concerned, it is obvious that the implementation of RFID in the distribution center and the stores has been easier and more successful, since there has always been an increased degree of integration and collaboration among the different supply chain steps. Therefore, it is important to point out that RFID implementation can be very successful in the cases of integrated organizations, as the other cases presented also proved, including Wal-mart, Marks & Spencer and American Apparel.

As far as the second factor is concerned, the price of the products affected to a great extent the choice of Staff Jeans to implement RFID, since the added cost per item would be quite low and yet the company would be able to continue on having high profits and, at the same time, investing on a new technology. Thus, it can be said that the medium to high valued products are another crucial factor for reassuring the successful RFID implementation.

What is more, even if the specific numerical data concerning profits and sales after the RFID implementation in the company are not provided, the fact that Staff Jeans has realized a positive ROI is proving that the capital invested has been covered by the company's results till now. Therefore, the full implementation of the project has been a beneficial and profitable strategic decision.

Concerning the RFID project developing company, it is crucial to mention that the two sides have had and are still having a very close relationship and collaboration, in order to solve all the problems and reassure the sound function of the RFID system. Thus, it is obvious that cooperation and continuous communication between the two partners is one more success factor, when performing an investment in a new field.

Summing up, the determining factors of the Staff Jeans success case have not only been internal but also external. Therefore, apart from the company's vertical integration, its pricing policy and its innovation strategy, the cooperation on an external level, with Sensap, has been of primary importance for the success of the RFID project.

6. Conclusions

6.1 Conclusions from the case study

This paper has investigated the application of RFID technology within the supply chain of a fashion retailing company, Staff Jeans. The main purpose of the investigation has been to evaluate which is the relationship between the RFID implementation in the supply chain processes of an apparel company and the overall performance of this fashion retailing supply chain.

It is, therefore, essential at this point to remember which have been the research questions of the thesis and whether they have been answered. Thus, the main research questions to be answered from this thesis have been whether the application of RFID in the logistics system of a fashion retailing company is able to lead to a supply chain performance improvement and, if yes, under which conditions can this happen.

After having performed a robust theoretical review, which is covering all the areas related to the topic thoroughly, there has been an analysis of the Staff Jeans case study, in order to come up with the final results. The results have shown that an integrated company with medium to high valued products and with a very good planning and cooperation with the RFID development company can have positive results out of RFID implementation.

The above conclusion is providing the answer to the research question of this thesis, since it is finally explained which are the most determining factors and preconditions for this retailing company that contributed to its successful RFID implementation. In other words, the conclusion out of the case study can be summarized as following:

An integrated fashion retailing firm, from suppliers to retailers, selling medium to high valued products and maintaining a close cooperation with the RFID project developing company, can realize a significant supply chain performance improvement out of implementing RFID technology. Thus, it is proved that the application of RFID is able to improve the performance of a fashion retailing supply chain, when these crucial preconditions are met.

6.2 General Conclusions

The conclusions drawn from the Staff Jeans case study are very useful for understanding the conditions under which a firm can potentially be successful with implementing RFID. It is, though, crucial to point out that the results that came up from this specific case study, even if there has been an overall and objective approach by the author, they still correspond to the specific case's special conditions and, consequently, many other factors can be decisive and determining for other fashion retailing companies.

However, the Staff Jeans case study can be an interesting and useful example for other companies within this field, which can potentially lead to better organized and planned decisions when it comes to RFID implementation in the future. The case's results indicate that a fashion company which is vertically integrated and offers medium to high valued products can benefit to a great extent by the implementation of RFID.

6.3 Future Reflections

The implementation of RFID by more and more retailing companies is becoming a global trend, since the benefits created by the RFID solutions can overcome their costs. However, the majority of the running RFID projects are limited to pallet level tagging and only few firms have adopted the item level tagging, mainly due to the technology's rather high cost.

However, the future use of the technology seems to be very promising, since there is continuous interest and research performed on this particular field. Therefore, there is still a lot of potential for improvement of the RFID's functionality and for decreasing its total cost. At this point, it is important to mention that the big, global retailing organizations are more likely to pave the way for the rest companies to adopt the technology.

The main challenge, nowadays, for RFID technology is the minimization of the implementation and maintenance costs of the technology since this improvement will directly overcome the main adoption barrier of the technology for the majority of the companies. What is more, the agreement on a global standardization process is a major concern, because it will make it easier for companies to integrate the technology and communicate under the same RFID standards. Lastly, it is very crucial to point out the role of the legislation when it comes to RFID implementation, which is currently not completely clear and specific for every business sector or activity. Thus, a revision and improvement of the current legislation will also be a determining factor for the future use of the technology.

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Appendix

European Union Recommendations concerning the use of RFID

Brussels, 12 May 2009

Small chips with big potential: New EU recommendations make sure 21st century bar codes respect privacy

Europeans should be able to have control over smart chips, a worldwide market set to grow five times over in the next decade, while still being able to easily use them to make everyday life simpler. There are already over 6 billion smart chips, microelectronic devices that can be integrated into a variety of everyday objects from fridges to bus passes. With Radio Frequency Identification (RFID) technology, they can process data automatically when brought close to 'readers' that activate them, pick up their radio signal and exchange data with them. They are in the passes you use to enter your office and the smart cards that pay highway tolls. Today, the European Commission adopted a set of recommendations to make sure that everyone involved in the design or operation of technology using smart chips respects the individual's fundamental right to privacy and data protection, contained in the Charter of Fundamental Rights of the European Union *proclaimed on 14 December 2007.*

"A promising technology for the future, smart chips can make life simpler in all sorts of ways. We are talking about everyday objects suddenly becoming smart by connecting to a network and exchanging information. Think of smart-fridges that inform you your milk is past its use-by date or smart-food packaging warning parents about possible allergies," said Viviane Reding, EU Commissioner for Information Society and Media. *"There is clear economic potential in using small, smart chips to allow communication between objects. But Europeans must never be taken unawares by the new technology. This is why the Commission issued strong recommendations to the industry today. European consumers must be confident that if and when their personal data is involved, their privacy will be impregnable also in a changing technological environment. The Commission therefore wants RFID technology to empower consumers to control their data security, which is the best way to make sure it is an economic success. After all, the European share of the global smart chips market will reach 35% in the next eight years."*

Smart chips, or radio tags, can, and already do, have a huge impact on business tasks, public services and consumer products, from more efficient recycling and healthcare to less time spent at toll booths and waiting for luggage at the airport. To make sure Europe is ready for these changes, the Commission today laid out the following principles for protecting privacy and data protection in their use:

> ➢ Consumers should be in control whether products they buy in shops use smart chips or not. When consumers buy products with smart chips, these should be deactivated automatically, immediately and free-of-charge at the point of sale,

unless the consumer explicitly opts-in by asking to keep the chip operational. Exceptions can be granted to avoid unnecessary burden on retailers, for example, but only after an assessment of the chip's impact on privacy.

➢ Companies or public authorities using smart chips should give consumers clear and simple information so that they understand if their personal data will be used, the type of collected data (such as name, address or date of birth) and for what purpose. They should also provide clear labeling to identify the devices that 'read' the information stored in smart chips, and provide a contact point for citizens to obtain more information.

➢ Retail associations and organizations should promote consumer awareness on products containing smart chips through a common European sign to indicate whenever a smart chip is used by a product.

➢ Companies and public authorities should conduct privacy and data protection impact assessments before using smart chips. These assessments, reviewed by national data protection authorities, should ensure that personal data is secure and well protected.

2.2 billion RFID tags, such as the ones used at toll booths or to identify shipping containers, were sold worldwide in 2008, roughly a third of these in Europe. The worldwide market value for RFID tags is estimated to be of €4 billion in 2008 and to grow to about €20 billion by 2018.

Background: In 2006, the European Commission launched a public consultation (IP/06/289) on the development and use of smart chips (or Radio Frequency Identification technologies). Based on this, it then adopted a Communication in March 2007 (IP/07/332) showing that further action was expected by the public in terms of privacy and data protection. Today's Recommendation, which was elaborated by consulting all stakeholders from both the supplying and using industries, standardization bodies, consumers' organizations, civil society groups, and trade unions, responds to these expectations and seeks to create a level-playing field for the European industry while respecting individual's privacy. Member States now have two years to inform the Commission on the steps they intend to take to make sure that the objectives of the Recommendation are met. Within three years, the Commission will report on the Recommendation's implementation, including an analysis of its impact on companies and public authorities using smart chips as well as its impact on citizens.

http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/740&format=HTML&aged=0&language=EN&guiLanguage=en

Examples of RFID implementation in fashion - apparel companies

It is interesting to have an overall picture of the companies which have already implemented the technology within their retailing supply chain. The table below provides information about fashion companies all over the world which are currently using RFID as a pilot or standard system.

RFID projects around the world	
Adler USA	LC Waikiki Turkey
American Apparel USA	Le Coq Sportif France
Aokang Group China	Lemmi Fashion Germany
Aoyama Trading Japan	Levi Strauss Mexico/ USA
Armani Italy	LSCA USA
Atelier Sab Japan	LIPS Netherlands
Bailian Group China	Long Deed Taiwan
Benetton Italy	Marks and Spencer UK
Boboli Spain	Marui Japan
Bültel International Fashion Group Germany	Max Mara Italy
C&A Germany	Mikuni Japan
Canadian Linen and Uniform Service Canada	Mitsukoshi Japan
Cannes Hospital Laundry France	Mi Tu Hong Kong China
Charles Vögele Switzerland	Moku Moku Japan
DHL Fashion Belgium	Mustang Germany
Dillards USA	New Balance USA
Dolce and Gabbana Italy	NP Collection/ Naisten Pukutehdas Finland
El Corte Inglés Spain	Onward Kashiyama Japan
Falabella Chile	Otto Versand Germany
Fashion Group RFID Germany	Pantaloon India
Fenland Laundry UK	Prada USA

Figleaves UK	Reno Germany
Flandre Japan	Russell Activewear USA
Frandol Japan	St Olavs Hospital Norway
Fruit of the Loom USA	Sanyo Shokai Japan
Galeries Lafayette/ Echangeur France	SRI Surgical Express USA
Gardeur Germany	Star City Casino Australia
Gerry Weber Germany	Sumikin Bussan Japan
Goldwin Sportswear Italy	Sumitex International Japan
Griva Italy	Sumitomo Bussan Japan
Hankyu Japan	Sungod Enterprise Group China
Hellmann Meyer and Meyer Germany	Takashimaya Department Stores Japan
Hennes &Mauritz H&M Sweden	Target USA
Hong Kong Knitwear China	The Gap USA
Initial Hokatex Netherlands	Throttleman Portugal
Isetan Shinjuku Japan	Tokyo Shirt Japan
Jacadi/ Véronique Delachaux France	Tomorrow's Mother USA/Canada
J Crew USA	Trussardi Italy
Jones Apparel Group USA	Ueyama Orinomo Japan
Karstadt Germany	VF Corporation USA
Kaufhof/Metro Germany	Wal-Mart/ Sam's Club USA
Kids Headquarters USA	Wave n'Wash USA
Lauren Scott USA	

Source:
http://www.idtechex.com/research/reports/apparel_rfid_2009_2019_000207.asp

Questionnaire for Sensap

What is the organization of the company?

What is the main field of specialization of the company?

What kind of RFID solutions do you provide?

What is AspireRFID?

What a RFID solution consists of? Which are the parts you provide? What about Hardware, Software, Support, Education?

Are your solutions unique for every customer or standardized?

What RFID standards do you provide? (ISO, EPC)

From which industrial sector do your clients come from?

What is the total cost of implementing the RFID solution in Staff Jeans?

What is the biggest part of the total cost?

What is the average estimated time of implementation of such a solution?

Which are the main drivers nowadays for implementing RFID?

Which do you consider the greatest problems or obstacles for a company to implement RFID? What about the case of Staff Jeans?

Which is the role of your company during:

- Choosing the right project?

- Forming the project?

- Planning the implementation?

- Forming the strategy of the company?

- The pilot program?

- The full implementation?

- And the personnel education period?

What kind of RFID tagging has Staff Jeans implemented: item labeling, pallet or case labeling?

The tagging is performed at Larissa warehouse and continues till the items arrive at each store? Is RFID used for warehousing and better transportation tracking? Which other purposes?

What are the specific improvements Staff Jeans has seen as a company?

What do you think about the future of RFID in the fashion retailing industry? Name the advantages and drawbacks.

What are the most important benefits a company can get out of RFID implementation? What should they expect?

How do you think the management strategy alignment should be made?

What recommendations do you make to your customers when selling them a solution, in order to have the best possible results?

What about EU regulation? Which are the future trends?