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GRADUATE SCHOOL OF SOCIAL SCIENCES
MASTER OF BUSINESS ADMINISTRATION PROGRAMME

MASTER THESIS

**SUPPLY CHAIN MANAGEMENT WITH RFID
APPLICATION: CASE STUDIES IN DIFFERENT
SECTORS**

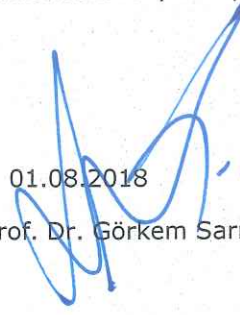
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Izmir 2018

MASTER THESIS JURY APPROVAL FORM

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ABSTRACT

SUPPLY CHAIN MANAGEMENT WITH RFID APPLICATION: CASE STUDIES IN DIFFERENT SECTORS

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Msc, Business Administration

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This research is a study of RFID (radio frequency identification) applications in supply chain processes. In the first phase of work, the focal point is entirely based on examining the supply chain processes and the management of these processes. At this stage, the historical development of the supply chain steps is also discussed. Then, the technical and historical details of RFID technology are discussed. In the later part of the study, companies were also investigated which use RFID technology during supply chain processes. It has been an important motivation for RFID technology to be able to experience its contribution to the supply chain processes in practice. It is very important for a researcher to establish an interactive link with the companies in order to create qualitative and quantitative dataset, to understand the process, to learn, to examine and to make on-site detections. The main purpose of this research can be considered as a source of motivation. Purpose of the research is to be able to determine how satisfied companies are today by applying RFID technology in practice. Therefore, by using interview method, qualitative data were obtained for this research. In addition, secondary data were obtained for the use of the statistical analysis from one volunteer company. This company's data illustrated the case study and this research. The case study includes material transitions between this company's supply chain steps (6 different production steps), during 1 month, for 3 periods per day. Transitions between steps to steps and input output material transition within steps for each periods are detected by RFID technology. Anova method was also applied in order to analyze the significance of difference of material flow between the periods of day for each production steps. Based on these analysis, conclusions were shared with the company to guide them in coming up with the basis of problems.

Keywords: SCM (Supply Chain Management), RFID (Radio Frequency Identification), Interview, Anova

ÖZ

TEDARİK ZİNCİRİ YÖNETİMİNDE RFID UYGULAMALARI: FARKLI SEKTÖRLERDEN ÖRNEK OLAY İNCELEMELERİ

Özgün Sarışın
Yüksek Lisans, İşletme
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Bu çalışma tedarik zinciri süreçlerinde RFID uygulamalarını içeren bir çalışmadır. İlk aşamada odak noktası tedarik zinciri süreçlerini ve bu süreçlerin yönetimini incelemeye dayalıdır. Bu aşamada tedarik zinciri adımlarının tarihsel gelişimi de ele alınmıştır. Ardından, RFID teknolojisinin, teknik ve tarihsel detayları incelenmiştir. Çalışmanın diğer bölümlerinde de firmaların RFID teknolojisini nasıl uygulanmakta olduğu incelenmiş, ilgili tespitler yapılmıştır. RFID teknolojisinin, firmaların tedarik zinciri süreçlerine olan katkısını pratikte deneyimleyebilmek önemli bir motivasyon kaynağı olmuştur. Nitel ve nicel veri setlerini oluşturmak adına firmalarla interaktif bir bağ kurup, süreci uygulamalı anlamak, öğrenmek, incelemek ve yerinde tespitler yapabilmek, bir araştırmacı için oldukça önemlidir. Buarştırmanın temel amacı da ayrı bir motivasyon kaynağı olarak düşünülebilir. Araştırmanın amacı, RFID teknolojisini uygulayan şirketlerin bugün ne kadar memnun olduklarını belirleyebilmektir. Bu sayede, röportaj yöntemini kullanarak, bu çalışma için niteliksel veriler elde edilmiştir. Ayrıca, bir gönüllü şirketten, istatistiksel analiz için ikincil veriler de elde edilmiştir. Bu çalışmada şirketin verileri örnek olay incelemesinde de görülmektedir. Örnek olay incelemesi, şirketin tedarik zinciri adımları (6 farklı üretim adımı) arasında, 1 ay boyunca günde 3 periyot için materyal geçişlerini kapsamaktadır. Her bir periyot için adımlar arası materyal akışı ve adımları içi materyal giriş çıkış adetleri RFID teknolojisi sayesinde tespit edilmiştir. Tüm üretim adımlarının gün içindeki periyotlar arasındaki malzeme akış adetleri farkının önemini analiz etmek amacıyla Anova yöntemi de uygulanmıştır. Bu analizlere doğrultusunda, tüm sonuçlar, firmanın sorunların temeline inebilmesi ve doğru tespit yapabilmesi için kendileriyle paylaşılmıştır.

Anahtar Kelimeler: SCM (Tedarik Zinciri Yönetimi), RFID (Radyo Frekansıyla Tanımlama), Röportaj, Anova

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 zg n SARIŞIN
 zmir, 2018

TEXT OF OATH

I declare and honestly confirm that my study, titled "Supply chain management with RFID application: Case studies in different sectors" and presented as a Master's Thesis, has been written without applying to any assistance inconsistent with scientific ethics and traditions. I declare, to the best of my knowledge and belief, that all content and ideas drawn directly or indirectly from external sources are indicated in the text and listed in the list of references.

Özgün SARIŞIN

İzmir, 2018



TABLE OF CONTENTS

ABSTRACT	iii
ÖZ	iv
ACKNOWLEDGEMENTS	v
TEXT OF OATH	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	xi
INDEX OF SYMBOLS AND ABBREVIATIONS	xii
LIST OF FIGURES	xiv
INTRODUCTION	1
CHAPTER 1	2
SUPPLY CHAIN MANAGEMENT	2
1.1. Definition Of Supply Chain Management	2
1.2. Historical Development Of Supply Chain Management.....	6
1.3. Purposes Of Supply Chain Management	8
1.4. Supply Chain Management Applications.....	9
1.4.1. Technology Use	10
1.4.2. Internal Supply Chain Management Practice.....	11
1.4.3. External Supply Chain Management Application	12
1.4.4. Product and Service Development	13
1.4.5. Forwarding	14
1.4.6. Stock Management.....	14
1.5. Supply Chain Management Components	15
1.5.1. Customer Relationship Management.....	16
1.5.2. Customer Service Management	16
1.5.3. Demand Management	16
1.5.4. Order Fulfillment.....	17
1.5.5. Manufacturing Flow Management	17

1.5.6. Procurement	17
1.5.7. Product Development and Commercialization	18
1.5.8. Returns.....	18
1.6. Superiority and Deficiency Of Supply Chain Management.....	18
CHAPTER 2	23
CONCEPT OF RFID	23
2.1. Development and History of RFID Technology	24
2.2. Automatic Identification Systems	25
2.2.1. Location of RFID System In Other Auto Identification Systems (Auto-ID)	26
2.2.2. Fundamental Differences Between RFID and Barcode	27
2.3. RFID System Components.....	28
2.3.1. RFID Labels.....	29
2.3.2. RFID LabelTypes	29
2.3.3. RFID Labels According to Functions.....	30
2.3.4. RFID Labels by Memory Type	31
2.3.5. RFID Reader	32
2.3.6. RFID Frequency Intervals	33
2.3.7. RFID Antennas	34
2.3.8. RFID Printers.....	34
2.3.9. RFID Software	35
2.4. RFID Main Suppliers	37
2.5. Standards	37
2.6. Market And Sectoral Applications.....	38
2.6.1. Retail Sector.....	38
2.6.2. Automotive Industry.....	41
2.6.3. Health and Pharmaceutical Sector	43
2.6.4. Defense And Aviation Sector	44
2.6.5. Logistics Sector.....	45
2.6.6. Other Sector Applications.....	46
2.7. Benefits and Costs Of RFID Technology	49
2.8. RFID Problems.....	52

2.8.1. Privacy.....	52
2.8.2. Software Integration Problems.....	53
2.8.3. Uncertainty of Standards.....	54
2.8.4. Cost-Related Components of RFID.....	54
CHAPTER 3	56
SUPPLY CHAIN MANAGEMENT AND RFID.....	56
3.1. The Importance of Information Sharing and Channel Setting In The Supply Chain	56
3.2. Conceptual Approaches to RFID Applications.....	57
3.2.1. Investigation of RFID Applications According to Objectives and Label Types	58
3.2.2. Interaction Concept of RFID System with CRM, SCM, ERP	58
3.2.3. RFID Delivery and Transportation Application Example.....	60
3.3. Combining RFID And Other Technologies	60
3.4. General Meaning Procurement Benefits	61
3.4.1. Human Resources and Cost Reduction.....	61
3.4.2. Tracking, Production, Sales, Marketing and Promotion Event.....	61
3.4.3. The Importance of Following the Equipment in the Supply Chain	61
3.4.4. Functionality In Reducing Whip Effect.....	62
3.5. Difficulties Encountered In RFID Application	62
3.6. Real-time Visibility	62
3.7. Preventing Thieves.....	62
3.8. Prevent Incorrect Placement and Lost Products.....	63
3.8.1. To Prevent Differences Between Stores	64
3.8.2. Preventing Stock Depletion.....	65
3.9. Acceleration of physical product flow rate	65
3.10. Lower stock level	66
3.10.1. Cost of Capital	66
3.10.2. Storage Cost.....	66
3.10.3. Cost of Inventory Risks.....	66

3.10.4. Cost of Inventory Service	67
3.11. Prevention of Fraud	67
3.12. Decrease In labor Cost	68
3.12.1. RFID Compliance Issues	69
3.12.2. Costly Costs of Hardware and Software	69
3.12.3. Integration and Education.....	70
3.12.4. Tagging Palette or Product.....	70
3.12.5. Standards	70
3.12.6. Security	71
3.13. Outsourcing In RFID Applications In Supply Chain Management Needs ...	71
CHAPTER 4	73
RESEARCH METHODOLOGY	73
4.1. Interview.....	74
4.1.1 Interview With Company A	75
4.1.2 Interview With ETI Maden Company	79
4.1.3 Interview With Company C.....	85
4.1.4 Comparative Analysis	89
4.2. Case Study.....	92
4.2.1. Flows Between Steps (In %, average).....	95
4.2.2. Input and Output Flows Within Steps (In %, average).....	97
4.2.3 Anova.....	98
CONCLUSION	104
REFERENCES.....	107

LIST OF TABLES

Table 1.1: Value Added By Supply Chain Optimization To Business.....	21
Table 2.1: Comparison of Rfid and Barcode Systems (Üstündağ, 2005b: 12).....	28
Table 2.2: Comparison of Different Labels In RFID Systems.....	31
Table 2.3: Epc Global Label Classes.....	32
Table 2.4: Rfid Main Suppliers.....	37
Table 2.5: Use Of Automative Value Chain Rfid.....	42
Table 2.6: Rfid Usage Areas.....	47
Table 3.1: RFID Costs.....	70
Table 4.1: RFID Sets and Quantities of Eti Maden Company.....	82
Table 4.2: Comparative Analysis.....	89
Table 4.3: Flows Between Steps (In %, Average).....	96
Table 4.4: Input and Output Flows Within Steps (In%, Average).....	97
Table 4.5: Loss of Items Within Steps (In %, Average).....	97
Table 4.6: ANOVA result for H_1 (TMPR).....	100
Table 4.7: ANOVA result for H_2 (CWR).....	101
Table 4.8: ANOVA result for H_3 (CPR).....	102
Table 4.9: ANOVA result for H_4 (CCR).....	103

INDEX OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS

- SCM: Supply Chain Management
- RFID: Radio Frequency Identification
- Auto-ID: Auto Identification
- QR: Quick Response
- ECR: Efficient Consumer Response
- CRP: Continuous Replenishment Planning
- PR: Public Relations
- CRM: Customer Relationship Management
- CSM: Customer Service Management
- R&D: Research And Development
- EAS: Electronic Article Surveillance
- LF: Low Frequency
- RF: Radio Frequency
- HF: High Frequency
- UHF: Ultra High Frequency
- POS: Point Of Sale
- OCR: Optical Character Recognition
- SAW: Surface Acoustic Wave
- ERP: Enterprise Resource Planning
- FDA: Food And Drug Administration
- CASPIAN: Consumers Against Supermarket Privatization Invasion and Numbering
- WMS: Warehouse Management System
- EPC: Electronic Product Code
- IT: Information Technologies
- TMPR: Thread Material Production Room
- CWR: Carpet Weaving Room

ABBREVIATIONS (continued)

- SR: Stove Room
- CPR: Carpet Printing Room
- CCR: Carpet Coating Finishing Room
- FPW: Finished Product Warehouse



LIST OF FIGURES

Figure 4.1: Steps Of Research.....74

Figure 4.2: Supply Chain Steps Of Company C.....95



INTRODUCTION

Effective management of the supply chain for today's businesses to determine the effect of applied techniques on chain performance is of vital importance. When scientific studies on supply chain management informs the most important problems that are encountered in this area, it has been found out that it is not the material flow, but information flow. Order status, stock levels and lack of accurate, real-time information on delivery times, uncertainty, and variability in the chain are all about information flow. For this reason, in supply chain management; to have access to accurate, real and timely information is important. In providing this information, Auto Identification (Auto-ID) has a great role.

In order to have a clearer idea about proceeding parts of the thesis which is based on tracing the information flow between departments of a supply chain of sample companies, testing the effectiveness and efficiency of their business intelligence, in the first chapter the supply chain management concepts are scrutinized. The Radio Frequency Identification System as a party of the Automatic Recognition Systems is studied in depth in the second chapter. It is a known fact that the prevalence of RFID is increasing day by day. Through RFID technology, by tags and readers, the Auto-Recognition is provided by the radio waves of the data system is in fact outfashioning the barcode technology. However, barcode technology despite being old is still more affordable and in-use by combination with the latter by the industry actors. The development and cost reduction of the RFID technology, covers the mass applications of this technology. Together with rapidly increasing worldwide applications, the industry and service sector in Turkey is obviously being affected too. Barcode technology used for product identification in supply chain processes, is now inadequate for today's conditions, and time consuming. Tracking and monitoring in complex processes is because of the difficulty in documentation, high labor costs, time loss and the data capacity to be stored.

The organization of this thesis at research methodology process as follows;

Interview was one of the method that the researcher used for this research. Interviews are made with three different companies working on different sectors. One is from textile sector, second one is a mining company, and third one is a carpet

manufacturer company. According to these interviews, lots of qualitative data have collected from companies. Collected dataset includes how tracking process was working before using of RFID and during RFID. The aim here is to understand the benefits of using RFID application in managing supply chains and to make a comparative analysis for different sectors.

On the other hand, after interview, there is applied on secondary data thanks to the carpet manufacturer company which has confirmed that it will be giving data from its materials flow for all steps and periods of supply chain. This company shared dataset about materials flow of its supply chain for one month. So, the dataset include 31 days of January 2017. Additionally, the company works as full time during a day. According to their working schedule, there are 3 periods and each period is 8 hours. In compliance with these quantitative dataset, statistical analyses are made by the researcher. Furthermore, these quantitative data are about flows of items within all steps of supply chain. So, it includes tracking of production and transportation process between all steps. Here, RFID works for detection. Main aim is detecting losses, errors or defected items during production and transportation between steps within periods. Another dataset includes input and output flows within steps. This set shows that how internal flows of items within each step happens. How quantity is at input of the step, and how quantity is at output of the step. So, according to inequality between input and output quantity, performance of the step can be evaluated by managers.

In addition, on this data, Anova method is applied to observe differences in performance of production steps within periods. There are some hypotheses which belong to each step of supply chain with its periods. This method evaluates flows of items within steps and between periods during supply chain. In accordance with RFID technology, differences about quantity of items between steps within periods are observed, and Anova test emphasizes detection result in statistical way. At the end of these researches, carpet manufacturing company becomes more aware of problematic steps and periods thanks to RFID. All detected data are shared with administration of carpet manufacturing company. Thus, managers of this company can focus wherever problem occurs as more carefully with less time spending, more accuracy, and fast dataflow.

This thesis, proves that RFID technology can help to improve process efficiency, accuracy and visibility levels. In this way, the chain is more tightly watched and management of inventory with fewer employees is viable. With lower labor costs and scrap rates, higher customer service quality can be gathered. It is important to know that the real-time inventory and logistics information is generated by the manufacturer, distributor and retailer at every stage of the chain to be shared for valuable and satisfactory outcome.



CHAPTER 1

SUPPLY CHAIN MANAGEMENT

1.1. Definition Of Supply Chain Management

In the USA, the term 'supply chain' as a concept employed by The Supply Chain Council, refers to any effort made on any direction from supplier to supplier, or from customer to customer, on a range of activities for the final product production and distribution. (The Supply Chain Council, 2001) According to the Logistics Management Council, Supply Chain Management can be defined as a process of managing (planning, implementing and controlling) time mannerly flow of raw materials, the stocks, the final products and the expenditures of the related activities until the point of consumption from the very beginning, to satisfy or to respond to the customer needs. (Council of Logistic Management, 2001) Supply Chain Management covers a wide range of sub-units, demanding and competing parties, in-house operations, commercial and retail customers and end beneficiaries. Other concepts used along with the supply chain are "demand chain" or "value chain". A supply chain can be also called as a 'value chain' or 'demand chain, however all these concepts are meant to put forward a value for the beneficiary or the ultimate consumer, through an integrated process management methods. (Paksoy et al., 2003: 3)

Initially, the definition of supply chain management emerged when it was argued that a new framework to manage integrated marketing lines innovatively was needed. Forrester (1958) has confirmed that business activities within marketing channels have links between themselves. The interaction between information, material, money, labor, capital flows can be illustrated as an example of these activities. (Svenson, 2002: 678)

Oliver and Webber also pointed out that in 1992, businesses in America, Japan and Western Europe were not satisfied with traditional method of managing integrated marketing lines as a result of their work. They talked about a new framework to apply. Other scientists have already begun to refer to supply chain and supply chain management concepts. (Svenson, 2002: 675)

Traditionally, supply chain management is based on an input-output model that includes equitably managed structures, practices and affiliations, and the implementation of functions that add value to each and every member of the supply chain on the basis of last-minute product and service offerings. While this is seen as a plain model in some way, it however, the traditional conceptual framework for the supply chain management. (Ritchie and Brindley, 2002: 110)

Traditionally, the concept of supply chain tries to capture the idea behind successive interconnected tasks. (Burnsand New, 1996; Saunders, 1997: 44) This ordering acts as a channel that adds value to each subsequent task as it moves from the product/service provider to the end user. (Fisher, 1997: 107) argues that sequential duties in the supply chain carry out "two interdependent but dissimilar functions, one being the physical function and while the other is the market mediation function. Physical function covers the duties of the converting the raw materials into products or semi-products. In this process, every member of the supply chain has a specific role or function that must be fulfilled in the production of the final product. This however brings the necessity of market mediation function which ensures that the product produced in the market matches the consumer needs. At large, this process works even if the supply chain operates nationally or internationally (Ritchie and Brindley, 2002: 112).

There are many definitions produced for Supply Chain Management. Some of these definitions are listed below:

Chandra and Kumar (2000) figured out that many businesses are in an effort to develop a Supply Chain Management strategy to balance the customer demand and profitable growth. These all make it necessary for companies to become flexible organizations with proper organizational relationships, over all supply chain coordination, enriched communication among themselves, outsourcing decisions, production systems, efficient inventory management and good budgeting.

Lambert et al. (1998), provide that Supply Chain Management's aim is to better off the competitiveness and profitability of the entire chain with its operation to service the demand of the end customer.

Coylev (1996) puts forward a definition that finds the SCM similar to a pipeline that carries the product to final consumption. This happens alongside the units of “supply chain, an operator's reseller and direct customers”. From the supply chain point of view, these three units are also interlayers that interact to bring the product to the market. Harrington also stresses that (1995), the supply chain management operates along with production with information flow that communicates all units, from the supplier to the end beneficiary.

Supply chain management according to Carter et al.(1996), is a coordinated approach to the successful fulfilment of the customer service prospective while minimizing the supplier's direct, most of the time indirect costs that includes flow, inventory, management and logistics.

Johannson (1994) states that; "Supply Chain Management is an operational approach to procurement". This statement means that for a good corporate management, complete and accurate information should be gathered from the operations, thus all units of the supply chain are required to be well executed. In Supply Chain Management, the link between the various units of the supply chain and the information flow is a very critical prelude to the overall performance.

According to another definition Ellram and Cooper (1993) made, Supply Chain Management is an approach to managing and analyzing the entire system, from the provider to the end customer, in order to produce a targeted level of output in terms of quantity and quality for the system.

Turner (1993) notes that Supply Chain Management is a technique that bypasses the connections from the raw material suppliers at the various levels of production, storage, distribution, and final customer.

Christopher (1992) defines the supply chain as networks of organizations with up and down trends in processes and activities that shape the services or products reaching the customer's reach.

Cavinato (1992) says that entities that create value added alongside the supply chain, from the raw material providers stage to the end consumer, are efficiently and

effectively administrated and operated supply and distribution channels. This more correlates to the relationship factors rather than classic operational factors.

Stevens (1990) states that Supply Chain Management controls the flow of end-user through the value-added process channel on demand. Ritchie (1990) treats the supply chain as a single unit and argues that the ultimate performance of customer satisfaction can only be as good as the weakest linked chain of the supply chain.

By going out of these definitions, a summary description of the supply chain can be made as follows: Supply chain, for the benefit of the customer; processes and methods consisting of in-house and out-of-office functions that realize the functions of procurement of materials, conversion of supplied materials into semi-finished products and products and distribution of these products to customers.(Tanyaş, 2003: 12)

Supply Chain Management is a systematic and strategic coordination that encompasses all business functions and plans of the business in question, with the aim of enhancing the long-term performance of the supply chain and all the entities in the chain. So, from the first supplier to the end user, the integration of the business processes by which the customer buys value-added products, services and information. (Council of Logistic Management, 2001)

Firms and managers have had to overcome and improve their internal processes in recent years according to rapidly changing economy, technology and market conditions. Producing new or quality products and selling them is no longer enough to grow. Providing inputs in the production process, providing services, conducting marketing, etc. all companies must be included in the management. Supply chain management is a way of integrating all these stages. This definition includes supply chain information management systems, resource and supply generation program, order process, inventory management, warehousing, customer service, and post-marketing packaging and organization. The supplier network consists of all the organizations providing input directly and indirectly to the central firm. (Willey, 2002: 28-29)

Supply Chain Management is more objectively defined as integrated management of capital and asset flows that make the end user achieve a targeted level of satisfaction with marketing mix tools for the prospective of the entire supply chain at the lowest possible expenses or a competitive budget. It is assumed that it will create an expected customer satisfaction level by putting together basic business processes strategically along the chain. (Willey, 2002: 28-29)

1.2. Historical Development Of Supply Chain Management

During 1950s and 1960s, manufacturers, in general had emphasized serial production as their operational strategy with fewer products or process flexibility and lower unit costs. New product development, therefore was slow and depended heavily only on the company's technology and capacity. Excess stocks used to prevent bottleneck operations to achieve a balanced line flow, resulting in massive investments in semi-finished stocks. Sharing technology and specialization with customers or suppliers is very risky and unacceptable, which has led to a lack of focus on business associations and strategic buyer-supplier partnerships. (Tan 2002)

As a result, cross-warehouse, storage and transport functions and customer service levels have been integrated and physical distribution management has been stepped up, which is called the first phase of supply chain management development. This period is also called as material management and physical distribution phase. (Ungan, 2011)

Since the 1970s, material requirements planning has improved and managers have realized reducing the effect of large semi-finished stocks on production costs, quality, product development and delivery times. Managers have gone to resort to new material planning ideas to increase their production performance. (Tan, 2002)

Global competition pressure in 1980s has made worldwide organizations to lower the product prices, and increase quality and flexibility with greater design and marketing success. Manufacturers have resorted to on-time production and other production management systems to prompt up efficiency in manufacturing and to reduce conversion time. They have begun to look for ways to remove the problems in production or other logistic stages with lower inventory levels and rapidly growing trend of 'Just-in-Time' production. In these areas, producers have started to realize

the potential advantages and the importance of strategic and collaborative customer-supplier relationships. The idea of supply chain management has emerged with experienced suppliers who have strategic alliances with existing suppliers. Experts in transportation and logistics have included physical distribution and transport functions, resulting in an integrated logistics idea, also known as material management ideology, supply chain management. (Tan, 2001)

After that period, in 1985, the Quick Response (QR) system, which was regarded as the first pioneer of the supply chain, was developed. The QR program was first launched in the textile industry as a supply chain pioneer and in the 1990s it followed the Efficient Consumer Response (ECR) program, an extension in the retail industry. The next development, ECR, has emerged as Continuous Replenishment Planning (CRP). (Lummus and Vokurka, 1999)

In recent days, increasing number of producers and market players have made the the idea of supply chain management to enhance their activities in the value chain popular. Today, manufacturers often use supplier strengths and technology to support new product development. Retailers integrate the physical distribution function with their transportation partners without intermediaries to control the delivery of direct office or mutual fees. In the evolution of supply chain management, a facilitating key mechanism is a customer-focused joint vision that forces firms to change their internal and external connections. (Tan, 2001)

The long-term strategic goal of procurement and supply in terms of supply chain management is to increase customer satisfaction, market share and the benefits of all the organs of the organization. The short-term goal is to increase productivity first, and to reduce the duration of the conversion. Suppliers often participate in the first phase of production design to provide cost effective design options, often guiding innovation in process and material technology to compete in the mass market. Suppliers can participate early in the design phase of the manufacturers, develop alternative solutions, choose the best technology and components and help to evaluate the design. This kind of strengthening requires more confidence in external suppliers, especially in design and engineering support. (Kocaoğlu, 2009)

The transportation and logistics perspective of supply chain management, explains it as an integrated logistics system functioning among inventory control, sales activities and PR, logistics, and warehousing activities. In all these process, as an end point where physical distribution of a product is effectively executed is a very point. Specifically, it is known that a just-in-time production system works on a function where the product must be restocked quickly and distributed to get handled in a warehouse and then to be marketed in specific location at a desired time in demand and time focused quantities. The aim is to replace the inventory with perfect knowledge. For organizational performance, effective information technology tools and effective coordination of logistics activities must be ensured. The development of the electronic data interchange systems with barcode readers and radio frequency identification technologies (RFID) has brought about the advantages of integrated logistics. (Tan 2001)

A well-functioning supply chain with advanced data informative systems involves execution the flow of material and information between suppliers, producers and end users, and involves product storage and delivery of the stored product to the customer. As the degree of integration between suppliers and customers increases in the supply chain, the competitive advantage will become even more effective. (Kocaoğlu, 2009)

1.3. Purposes Of Supply Chain Management

The main objective of Supply Chain Management is to pick up the most efficient ways (cost, time, benefit, flexibility etc.) in formation story of the product by working for the same objectives of each organization in the supply chain stages. (Sezen, 2004)

Therefore, it is impossible to supply chain partners considered independently from each other organizations. Each chain member should not only be responsible for correcting their own behavior, but also about the performances of other chain entities, otherwise when some entities of a specific chain fails to function properly, other entities too will negatively be affected too. (Sezen, 2004) In Supply Chain Management, the aim of each entity is to communicate the valuable information to its partners in the chain and to provide a better balance of supply and demand. (Çiçek and Bay, 2007: 92)

The Supply Chain Management has some objectives to be listed as follows:
(Özdemir, 2004: 89)

- To prompt up the end-user satisfaction,
- To limit the supply chain cycle time,
- To limit the costs coming from logistics and inventory levels
- To maintain a tolerable failure rate,
- To have a competitive budget for operations and management.

The aim of Supply Chain Management is to reach higher level of competitiveness and profitability over all supply chain entities and functions consisting a range of actors from the operator to end-users. (Lambert et al., 1998)
The short-term goal of the supply chain is to remove unnecessary stocks from the market and to increase the speed of responding to production and customers. The long-term strategic goal is to meet customer expectations with the right product delivered in the right place, thereby increasing market share and profits. (Çiçek and Bay, 2007: 92)

From the perspective of senior management, the most important goal of Supply Chain Management is to ensure customer satisfaction at the highest level. All the units in the chain are improving on this. Firms and Supply Chain Partners provide customized products and services tailored to individual customer needs. (Akdoğan, 2002: 157)

1.4. Supply Chain Management Applications

Supply Chain Management is very important for the simultaneous execution of product and information flow within the chain. In order to meet customer demands, it is necessary to move away from traditional limits and act in common for common denominator. The sharing of cost management systems in the chain requires that the status of stocks be determined and managed according to the student. Supply chain management goes far beyond traditional boundaries of classical material management in every way. (Karasu, 2006)

If the Supply Chain Management is to be looked at in two different ways from the viewpoint of business and engineering, In terms of business, the designs

that are interested in the business issues of the supply chain are financial aspects. From an engineering point of view, it is about the workability with quantitative and physical aspects of work. While the management view attaches more importance to customer needs and expectations, the engineering perspective tries to find optimum solutions for the design of the system to be created. Both perspectives are equally important and valid for the chain. (Yıldızöz, 2006)

It is explained by its complementary major sub-dimensions, after the implementation level of a supply chain management, from the main variables of the conceptual framework, depending on the model to be implemented in the course of the work.

1.4.1. Technology Use

Establishing an effective Supply Chain Management depends on the flow of information and the right and timely sharing of this information across the chain. In order to determine the needs of an incoming student, to enter the purchase orders, to receive and store the goods in the correct stock within the term of the fulfilled order, to the production line to be processed if the product or semi-finished product is processed, to send the customer to the sales shipment order is expressed as the elimination of the correct and possible human factor within a package program.

Bülbül et al. (2014) showed that uncertainty must be reduced in many areas, such as competition, quality, demand and delivery time, in order for Supply Chain Management to succeed in its articles, and that there is timeless, accurate, and inadequate information on the basis of uncertainties stemming from poor information flow among chain members.

For this reason, a technology-backed supply chain management eliminates the risk of making mistakes, allowing for accurate and timely shipment. The whole operation is determined according to advanced technology and needs, and thanks to a modified package program, the risk of error is reduced because it will disable the human factor which ensures complete accuracy in information flow with other units in all operations of the operator. Retrospective effective reporting can be obtained and information about future goals is available. Stocks can be monitored in real time.

With the development of technology, the package programs used in enterprises have also been developed in terms of application sector by sector. For example; it can be seen that the same program has been used in the textile and food sectors by taking into consideration the different priorities and used in the modification. It is beneficial for the users to determine the needs of the users themselves and to buy them while choosing the program to be received.

As technology is developed in the management of the supply chains, the human interface in the system is decreasing and the mistakes that may occur are reduced the most. Otherwise, it is often too late to make manual corrections for wrongly entered or incorrectly entered lines, incorrectly used codes, misconfigured pricing, and other errors, which can lead to major inefficiencies, such as commencement or incomplete orders. (Öcal, 2012)

1.4.2. Internal Supply Chain Management Practice

Intrinsic supply chain management can be said to be the whole supply chain chain that includes a company's own operations such as purchasing, logistics, customs clearance, warehousing, etc. in a technology infrastructure. Because the chain is in a company, the management of business processes is entirely self-control of the company. According to the requirement, the correctly determined technological infrastructure ensures that the information material and service flow flows in the chain accurately and quickly.

Customer needs and demands can be met and shipped on time. As the stocks are updated, purchasing demands are given according to this, and unnecessary stock formation is prevented. If you look like a positive domino effect, it is seen as much as the cost of financing.

When we look at the enterprises in our country, it seems that they are generally applied at the institutional level companies. It is managed within the organization of units such as import, export, customs, logistics warehouse under the management of supply chain management or directorship. This method should be provided with an advanced package program which is determined according to the right need as mentioned above and presented to the user.

If the firm is a multi-partner or a global company, it can be integrated into the system under different countries or legal entities so that order entry or order admission can be provided. For example, Haribo sweets that Turkey's system for the production of confectionery products in the United States Haribo shipped in Turkey, Haribo US in order to login. It is seen that our country does not share information because of our social memory such as conservative management concept, lack of information sharing, sense of insecurity, work style, and so on. For this reason, Supply Chain Management, which we can only apply within the general definition of Supply Chain Management in the country, remains as the internal supply chain management.

It is also possible to see mistakes and incorrect shipments made from the information flow of the warehouse and the shipment units or from their own internal strife, although they are managed under the same directive in some countries in our country.

1.4.3. External Supply Chain Management Application

External supply chain management; is a structure that is sourced from independent firms in the chain. Each of these firms in the chain is obliged to control their behaviour within the framework of the supply chain management approach. The issue that matters to a company within the supply chain may not be important in other parts of the chain, so it is not easy to bring independent firms, each specialized in their own field, working together. In addition, as companies can easily work in cooperation with their customers or suppliers, things become more complicated when they reach suppliers' suppliers and as they move backwards in the chain. (Tanyaş, 2011)

Although the process that is important for a company in the chain is not important to any other supplier, it is necessary to move within the chain without disturbing the harmony. In the long run, the loss of customers will affect everybody throughout the chain. Therefore, supplier choice is one of the most important problems for a company. Because, with this decision, if the right suppliers choose it, they will significantly reduce their purchasing costs, and the competitiveness of the operator will be affected in the same way.

While companies create approved supplier portfolios, suppliers must act like multi-partner, partnership-like approaches. The consciousness that a common purpose is to be served must occur. Any chain item that must be shared with a buyer or project supplier should make his own time-lapse tasks. It must be involved in the processes. Success should be the common reason and methods that everyone in the chain should succeed.

As mentioned in the previous section, information sharing and order preparation for a common denominator cannot be said to be very common except for global companies. Even companies in the cooperating supply chain are sharing a limited amount of information. This situation can be widespread in our country again. This affects the efficiency of supply chain implementation.

1.4.4. Product and Service Development

The basic purpose and function of an enterprise is to produce goods and services. It is necessary to ensure that the goods and services produced are in accordance with the current and target market requirements, are beneficial, economical and profitable. (Sabuncuoğlu and Tokol 2001) In order for this profitability to be successful and sustainable, the effectiveness of the supply chain components is important.

Supply Chain Management involves the inclusion of customers and suppliers in the product development process to reduce the time to market new products. In a highly competitive environment, the shortened life curves of the products necessitated that the companies successfully present the right products in the shortest time in order to survive. (Özdemir, 2004)

Businesses can combine new competitive advantages through joint marketing, common product development and common market monitoring with suppliers. It is also an advantage of the product development environment that a variety of manufacturers, which have different channels in a similar way, combine to address a wider and more widespread market. Thus, through merger, firms will reduce the competitive pressure on the products they have developed. (Öcal, 2012)

1.4.5. Forwarding

The ability of the suppliers to deliver has always been a competitive advantage for businesses. Suppliers must be able to deliver the exact delivery dates to the buyer's businesses to be able to express their delivery capabilities and be able to deliver the products on the given date. (Bedük, 2009)

The distribution network is a very complex system consisting of many warehouses and retailers. Due to the limited capacities of the reservoirs it is necessary to optimize the distribution. (Türköz, 2007)

The transport costs cover all the costs of transporting merchandise from one location to another with a general description. These include freight, loading and unloading expenses, and interest expenses required when the goods are in motion, and so on. The factor responsible for many goods and services not being international trade is the relative size of transportation costs. In other words, the transportation costs of these goods are big enough to exceed the pre-trade price difference between countries. (Seyidoğlu, 2013)

In this context, after the strict order is received, the shipment element must be determined in advance and the vehicle organization must be made in accordance with the type and urgency of the goods. In doing so, the cost should be considered and an expensive shipment should not be carried out while meeting customer needs. Shipment complex, air cargo, will be by road, such as options before the materials should be evaluated.

1.4.6. Stock Management

Efficient management of inventories plays a critical role in supply chain management. It's because of execution and meaningful use of related information among components of the supply chain, the unseen part of demand is been observed and efficient stock management is viable now. Thus, this making companies pay less for keeping and managing the inventory. This would in return bring more transparency and cost reduction in planning and budgeting. (Özdemir, 2004)

When each member of the chain has minimum inventory levels that are functioning on internal dynamics, market type and customer portfolio, in this process,

it is important to have an acceptable stock level for emergencies. It is because many customer requests are often unknown or unseen beforehand, businesses must have exact stock levels on prediction. Rather than this, having extra stocks more than necessary causing more cash outflows or borrowing thus bringing more operation costs. What is more operating at high stock levels as really costly as a risk for the marketing and competition factor. For instance; investments short product life cycle in food producers have the risk of expiration with limited storage flexibility when the product is not or cannot be sold. For the informatics sector, it is possible that the sales marketing department may be able to sell the products and to obtain the products which are in the upper version of the device.

In terms of high stock-level businesses in market conditions where demand cannot be detected before hand, it is always a risk to work with higher stock levels. This risk can be limited by effective information exchange and execution of it through proper routing among the chain members.

1.5. Supply Chain Management Components

The members of the Global Supply Chain Forum declared eight components of a supply chain which define the processes broadly. (Croxtan et al., 2001) These are:

- Effective CRM (Customer Relationship Management)
- Effective CSM (Customer Service Management)
- Detection of prospective demand
- Fulfilling the orders effectively
- Effective material flow in manufacturing
- Procurement and outsourcing
- R&D and Marketing
- Capital and Interest Returns

This process all makes up and effective Supplier Relationship Management (Croxtan et al., 2001), as the procurement process of supplying relates to

relationships with independent suppliers. It is also considered appropriate to call return management instead of repayment.

1.5.1. Customer Relationship Management

The Customer Relationship Management as process of SCM is structured in a way that it executes relationships with customers to be developed and maintained. The management determines the customers and customer groups to be targeted as part of the company's mission. Customer management is setting up product and service agreements that are targeted and meet the needs of other customers. (Seybold, 2001) Customer executives work with key customers to improve conditions, to detect the real demand with trends of a period and then also to limit non-value added operations and activities. Performance reports are also prepared by the department that executes this process to detect the profitability of individual customers and at the same time the financial impact of the firm on those customers.

1.5.2. Customer Service Management

Customer Service Management can be defined as a process in which the company makes interfaces with the customer. This process provides the primary information source to inform customers about issues such as having available stocks, loading time and order fulfillment. Full-time, real-time information is communicated with the customer through these interfaces like common links with processes such as manufacturing and logistics of the company. At the same time, customer service management counts for the execution of the product and after sales service agreement with customers.

1.5.3. Demand Management

It is the aim of Demand Management Process to detect the needs of the customers and open the ways for responding to it with the supply opportunities of the company. The demand management process comprises forecasting and production harmonization, enabling effective purchasing and distribution with their estimation for a range of products. This process also deals with creating alternative plans for unexpected situations where there might be excessive demand, bottleneck in production and logistics, etc.

1.5.4. Order Fulfillment

A key element of maintaining an effective supply chain is to have the ability to meet customer needs in terms of fulfilling orders. An effective order processing process also makes it necessary for the firm to integrate production, logistics and marketing and sales activities and plans. The organization should be able to develop key partnerships with each chain to satisfy customer needs and to reduce total indirect cost of logistics in the entire process. However, when all these effectiveness factors are achieved, it is time to start with efficient order processing methods within the supply chain on which the firm functions.

1.5.5. Manufacturing Flow Management

The Manufacturing Flow Management Process relates to the making of the products and establishing the manufacturing flexibility to best service the target market with high quality standards. The manufacturing flow management process includes all activities required for product flow management related to the acquisition of manufacturing activities and products, the application and management of flexibility.

1.5.6. Procurement

Supplier Relationship Management can be defined as process that concentrates on how a company can develop relationships with its suppliers. As the name suggests, this process is a reflection of CRM. Firms should also develop their relationships with suppliers, such as improving relationships with customers. In this process, the firm should enter into a close relationship with a subgroup that it considers important to its suppliers and maintain a more ordinary relationship with others. A product and service agreement must be made that defines the rules of the relationship with each supplier. Suppliers must comply with this agreement made. The supplier relationship management of this process is required to define and enforce the product and service agreement.

1.5.7. Product Development and Commercialization

The product development process maintains a critical pre-requisite for the success and competitiveness of the company. Efficiently developing new products or series, advertising and marketing them effectively is the core component of business success. This process heavily depends on exposing the critical purpose market time mannerly. The efficient supply chain involves customers and suppliers in the product development process to limit the time it takes them to market new products or designs. Because of the short life cycle time of products with the right products to help them stay competitive which is the success of the company and within a short period of time are they are required to successfully bring these to the market.

1.5.8. Returns

On the contrary, it is an important part of the Logistics process, especially in the developed countries, that the transfer and management of the goods, which are called the logistics, are coming back from the customers to the producers. On the contrary, the reasons for logistics are listed below: (Aşıcı and Tek, 1985)

- Consumers are defective, defective, disliked, corrupted, wrong, etc. goods back repayments,
- Maintenance, repair, replacement, etc. within the warranty period. return of goods with the purpose,
- Recycling of waste, Environmental Protection and Resource Saving, (Green Logistics),
- The return of the collected goods, temporarily or permanently withdrawn from the market, and the repatriation of the collected goods to the market.

1.6. Superiority and Deficiency Of Supply Chain Management

The supply chain, in which the starting point is the raw material suppliers and the last point is the consumer, is a single company that represents the whole of these businesses. While both bringing businesses' internal work in the most appropriate and simplest way, it also examines the operation of enterprises in the entire supply chain. By doing so, it also improves the work to be done by businesses against the consumer.

Supply Chain Management ensures that outputs such as price, quality and technology are developed and applications are compatible and high performance. As can be seen, the benefits of supply chain management arise in the entire chain of the chain, from raw material sources to the final consumer. Outputs involving supply chain management must be continually developed, strived to be in harmony with one another, and ensured that they perform well as a result of these efforts. In today's conditions, effective use of the supply chain is important so that businesses can exist in a competitive environment. Effective and efficient management of the supply chain means that businesses can partner with other market leaders, which will allow for competitive advantage.

Supply chain management creates an opportunity to reconfigure the performance criteria and objectives of the production costs of all the enterprises including the whole chain and the minimum production time. At the same time, the inclusion of customers in this chain will have many advantages. For example; The inclusion of customers in this chain will speed up the flow of information. It is important to know about customers and know exactly what customers want, since information from customers, the last member of the supply chain, contains more than just information. In this way, the information obtained; the inventory levels of the products will be planned, accordingly the supply and delivery times will be minimized and the cost will be saved. Another example is; Thanks to close relationships with customers, information will be obtained during the new product development stage and the product will be developed to the requirements of the customers of the product to be developed. Mutual benefits of supply chain management and chain member businesses can be listed as follows (Elagöz, 2006):

- Lower costs,
- More flexibility,
- Higher quality,
- Easier provision of overcapacity,
- Newer technology,
- Broader technical expertise,
- Better market intelligence,
- Focus on basic skills,

- A broader perspective,
- Simplified processes.

The benefits mentioned above include all members of the chain connected to supply chain management. When these members of the chain are mutually compatible, they will provide the product at low cost. Members must be flexible at each stage. With the advancing technology and flexibility, they will be able to exhibit the appropriate behavior. The quality of the goods or services will also appeal to the chain members who know what to expect and what to expect through communication. Of course, in this process you should definitely benefit from a wide range of people who are expert in technical sense, trained on marketing knowledge, experienced and perspectives. In addition, the baseline reduced processes that the members of the supply chain can understand will make it easier to understand these benefits.

What does an effective supply chain management bring to business? In answer to your question, it will "open up the path to steady growth with lower costs and higher profits," which will affect the operations of the enterprise in the production and marketing aspects positively, with more customer satisfaction, more efficient and efficient operation. All these gains will allow businesses to grow in all directions. As a result, strategic plans are being made in businesses that implement Supply Chain Management and strive to grow in all directions.

A study of the utility of an effective supply chain management to operation is summarized in Table 1.1 below. The data of the net contributions to the operation according to the improvement areas are handled one by one. According to this table, the most net contribution is seen in the demand forecast.

Table 1.1: Value Added by Supply Chain Optimization to Business

Improved Areas.	Final Contribution
Improving delivery performance	% 15-28
Reduction of inventory	% 25-60
Improvement of order fulfillment rate	% 20-30
Demand forecasting success	% 25-80
Abbreviation of supply cycle time	% 30-50
Reduction of logistics costs	% 25-50
Efficiency and capacity increase	% 10-20

Source:E. Şen, Supply Chain in Increasing the Competitiveness of International SMEs, Ankara, 2006, p.6

When Supply Chain Management is used correctly, it is possible to make the individual benefits to be provided to the business:

- All information, material and money flows are manageable,
- Distribution processes are shortened,
- The performance of businesses is maximized,
- Competition in the market increases,
- Stock balances are optimized,
- Product and service quality increases,
- Costs decrease and profitability increases.

The business should redirect information, material and money flow correctly. This will benefit the operation if the flow between members of the chain is correct. In this regard, extensions to be experienced in distribution will be prevented. In this way, the enterprise will be one step ahead of other enterprises. This will increase your competitive power. Enterprises with increased competition will not compromise on quality. As a result, a reduction in costs and a rise in the cost of a card will come to the fore.

It covers all the rings in the supply chain, as seen in the benefits mentioned above. It has a chained relationship to bring the business to a higher level. What is important here is that each chain acts in a coordinated and efficient manner.

It seems that supply chain management is being implemented in all enterprises. However, in some enterprises this is not fully developed or has a complex structure or is not well controlled. There are also some disadvantages

arising from the implementation of supply chain management. It is possible to list these disadvantages in terms of:

- Costs may increase due to the focus on false initiatives,
- Difficulties in establishing supply chain components correctly,
- The difficulty in ensuring communication and coordination between independent entities in the chain,
- When businesses are involved in more than one supply chain,
- The pressure that strong buyers place on the powerless suppliers and the deterioration of the chain structure of the end of this pressure,
- The excess stock that will flow in the wrong information flow in the supply chain, the increase in costs, the decrease in efficiency and efficiency.

Firstly, it is necessary for businesses to investigate the area in which the initiative is to be undertaken and to evaluate the positive and negative aspects. Wrong decisions will increase costs unnecessarily. After that, the chain members in the supply chain should be related to the operation. Communication and mutual harmony between these chain members is important. It will be easier for the operator to be in a single chain of supply chain management. Otherwise, troubles can arise because of the problems related to communication.

There is no rule that these disadvantages will be experienced in the management of every supply chain. If necessary measures are taken, these disadvantages can be reduced to the most advantageous. The important thing is, under appropriate circumstances, to follow the necessary course with appropriate strategic plans.

CHAPTER 2

CONCEPT OF RFID

RFID discloses a system that is attached to an object and that can identify by means of an electronic device that uses radio frequency or magnetic field types for communication. (Glover, Bhatt, 2006: 1)

Radio Frequency Identification is a technology that automatically identifies moving or stationary objects in a controlled environment by carrying data over radio and frequency waves.

It requires a microchip, a reader and a software that we wrap around the antenna and we call smart tag; data exchange takes place without requiring a contact between the label and the reader; is an automatic recognition system that allows recognition of products and materials using radio waves. (Ustundag, 2008, p. 4)

According to electromagnetic waves emitted by a reader meet with antennas surrounding the microchips and activate the circles on the label. The label modulates the waves and sends them back to the reader, which converts the wave into digital data. (Üstündağ, Tanyaş, 2007: 277)

It is anticipated that RFID technologies will take the place of commonly used barcode technologies with some standards such as cost reduction and system related privacy and security, because RFID technology has some advantages over barcode technology. These;

- RFID tags store high amounts of information and can be read and written in bulk and error-free, fast.
- RFID technologies can be used in a variety of environmental conditions.
- Data communication via readers can be done at distances.
- It is not necessary for the RFID reader to be in the field of vision as it is in the barcode technology.
- Labor costs are low in RFID technology compared to barcode technology.

2.1. Development and History of RFID Technology

According to scientific theories, the universe is formed as a result of a sudden and massive explosion called Bing Bang. As a result of this explosion, four basic forces have emerged along with electromagnetic energy which comprise gravity force, electromagnetic energy, and varied levels of nuclear forces. The energy that forms the basis of RFID is this electromagnetic energy. So, as the historical beginning of RFID is 14 billion years ago, that is; the beginning of time.

The first statement on the provision of data communication with radio frequency and considered as the basis of RFID technology is published by Stockman in 1948 as "Communication By Means of Reflected Power" (Ustundag, 2008: 8), but the innovations on radio waves goes back to the mids of the 1800s, and the chronology is as follows:

- 1846: Michael Faraday declared that light and radio waves carry electromagnetic energy.
- 1864: Maxwell came along with his electromagnetic theory.
- 1887: Hertz was successful to interchange the radio signals.
- 1897: The Radio was invented

Later on, the work on this area continued with the invention of the radar. The radar is an important development used as a Manhattan project in World War II. The principle of sending and receiving radio signals is used to detect surrounding objects. This reflection helps to measure the proximity and speed of the surrounding object.

Discoveries and work on radio frequency have continued. The most influential and first step was the study of "Short Range Radio Telemetry Electronic Identification Using Modulated Backscatter" using Backscatter modulation for electronic identification tags by Alfred Koelle, Steven Depp and Robert Freyman from Los Alamus in 1975. This work is a marker for passive labels at the beginning of the 1970s, the first commercial application platform called EAS, in which materials and products were electronically monitored, was the basis of today's RFID applications.

The 1980s have been the years since when all uses of RFID technology have been developed. The most important development in the USA has been in narrow areas such as transportation and personnel turnover. In Europe, it has also been in pets, short distance systems and business applications.

1990s are very important for RFID for years. The number of RFID tags used in highways has surpassed three million. The world's first autopilot highway was opened in Oklahoma in 1991. Ultra high frequency (UHF) labels were introduced at the end of the 1990s, and are now being used in supply chain applications. Due to the increased interest in RFID, many companies that have been working with barcodes have entered the market with RFID in the past decade, while others have opened many companies in this field.

By 2000, Walmart, Metro and retailers began to be used by their providers. The Auto-ID center was activated at the Massachusetts Institute of Technology for the sake of RFID, developing higher production standards, higher performances in research and better ways of information sharing. EPC Global has undertaken standard development work in RFID application areas. The International Standard Organization has set a set of standards. Started by MIT (EPC) to develop electronic product code standards; GS1, MIT, Cambridge, St. With the cooperation of Gallen, EPCGlobal has established an organization that operates for profit-free, RFID standards development. (Ustundag, 2008, 10)

At present, developments about RFID are continuing at an accelerated pace.

2.2. Automatic Identification Systems

Auto Identification Systems (Auto-ID) in the broadest sense; is a system that involves collecting all kinds of information without human intervention and entering directly into computer systems. The main purposes of Automatic Identification Systems are; standardization, synchronization, coordination and integration by providing automation and traceability (Üstündağ, 2005b: 25)

In this context, the main Auto Identification System technologies are

- Monitoring technologies,
- Biometric / Security systems,
- POS (point-of-sale) and electronic payment systems,
- Electronic access control,
- Voice recognition technologies,
- Optical character technologies,
- Card readers,
- Barcode technology,
- Smart card (chip card) technologies,
- RFID (Radio Frequency Identification) systems.

2.2.1. Location of RFID System in Other Auto Identification Systems (Auto-ID)

Auto-identification systems (Auto-ID) have different technologies in themselves. Optical Character Recognition (OCR) allows different types of writing to be read and understood by machines. However, due to the high cost of the system, the area of use remains narrow. For example; OCR technology is used when the checks are read in the banks and recorded in the system. Biometric systems are used to reveal the biological properties of human identity such as face, sound or eyes. Barcode systems are the most commonly used automatic recognition system for identification of products or materials. While these systems are cheap, their data storage capacity is inadequate and not programmable.

In the case of chip cards (smart cards), this inadequacy is accompanied by some disadvantages, such as the need for mechanical contact as well as the application of electronic ticketing between the microchip and the reader, along with the inadvertent withdrawal. Over time, wear and tear can cause problems with the reader's card. The use of chip cards in credit cards and personnel tracking systems has become widespread. RFID systems are technologically the most similar to chip cards among automatic recognition systems. (Üstündağ, 2005b: 15) However, considering the areas of use, RFID systems are mostly compared to barcode systems.

2.2.2. Fundamental Differences Between RFID and Barcode

RFID and Barcode technologies are technologies that are constantly compared to each other in terms of advantages and disadvantages. It is stated that RFID technology creates an important breakthrough compared to barcode technology. A professional magazine published in America has defined RFID and Barcode as "transition from wire to Internet". (Wyld et al., 2005: 382) Ward reports that they are continuing to discuss the benefits for the customer.

Accurate barcodes for customers and speeding up cash transactions,

The benefit of RFID is stated as guaranteeing that a desired product is present at the raft in terms of the customer. The reason is that the conditions under which the product falls below the minimum stock level can be determined.

One thing to consider when it comes to the widespread use of RFID technology is that companies have invested heavily in barcode infrastructure in the past decade. It is stated that barcode technology is not the best solution but it is tried, true and cheap technology. For example, it is stated that despite XML, which is a cheaper and more advanced technology, carriers, carriers and transporters are still using EDI. This example can also be shown as a test of how long companies will implement new technologies because of their investment in old technologies. (Reid, 2003: 36) RFID and Barcode Technologies are compared in the table.

In addition to the RFID and Barcode comparison in the table, the advantage of RFID technology versus barcodes is that they always have knowledge of certain materials and not some points, reading of the products (eg trailers, cases, pallets) can be described as recording more data from the barcode. (Sheffi, 2004: 1) Delta Airlines compared RFID and Barcode reading rates to RFID tests. In the test with 40000 suitcases, the reading rate with RFID is 96.7% in the worst case and 99.8% in the best case. The barcode reading rate was 80% in the worst case and 85% in the best case. As can be seen from the results obtained in the test, the correct label reading rate is higher in RFID technology. (Wyld et al., 2005: 386)

Table 2.1: Comparison of RFID and barcode systems (Üstündağ, 2005b: 12)

RFID System	Barcode System
The exchange of data between the label and the reader takes place without errors.	There is always a chance of error during the first reading.
The information held in the tags can be changed.	It is necessary to change the tag to change the information.
The amount of information that can be stored in RFID tags is high.	The information held on the barcode labels is much more limited.
In order for the information in RFID tags to be readable, the tag does not need to be in the reader's field of view.	For barcode systems, the label must be strictly within the reader's field of view so that the codes on the label can be read by the laser reader.
RFID microchips are not affected in dirty and humid environments.	In the barcode systems, contamination and wear are very important problems.
In RFID systems, microchip labels can be read collectively (up to 10 to 100 etiquette).	In barcode systems, it is necessary to read the labels one by one.
Reading speed of RFID tags averages 0.5 seconds / piece	In barcode systems this time is 4 seconds.
Reading distance can be up to 30 meters.	Reading distance is 50 centimeters.
It is impossible for the labels to be copied and the contents to be visually readable.	It can be easily copied and replaced.
Tag reading does not happen automatically and personnel costs do not occur.	Label reading is done manually and personnel costs are incurred.

2.3. RFID System Components

McFarlane and Warma describe the elements that make up RFID-based automatic recognition systems as follows (Üstündağ, 2008, 4):

- Unique identification information assigned to a specific product or item
- An identification label affixed to the product or material, having data storage capacity and electronically communicating with the environment
- A network structure consisting of RFID readers and data processing systems with the ability to read and correctly process the signal from a large number of labels at a high rate (100 in a row)
- One or more databases in the network that are capable of storing a large number of product information.
- RFID tag system components (tags, transponders), readers (reader), the antenna connected to the reader (antenna), are printers and system software.
- The data communication between the tag and the reader via the antenna is called coupling. The coupling takes place in two forms, electromagnetic (backscatter) and magnetic (inductive). Usually electromagnetic coupling is

used. Inductive coupling is often used in access control systems. (Ustundag, 2008, 13)

2.3.1. RFID Labels

An RFID tag consists of a microchip, a layer on which the microchip is placed, and a peripheral ligament.

The microchips are placed directly on the antenna or by using adhesive. There are also labels that do not contain microchips. They are more conveniently placed on paper documents and have lower costs. However, microchip tags do not have as high memory capacities.

RFID tag antennas are formed by a method called as ink jet printing. In this technique, the conductive elements of carbon and silver composite are drenched onto a distinct surface. Although the conductivity of such antennas is poor, it is low cost. Another method is to imprint or tingle a mold on the photopolymer exterior. A copper stratum is thus obtained. These antennas are better in terms of conductivity. However, the cost is greater than the silver-carbon mix antenna by 55-75%.

The stratum consisting of microchip and antenna combination is called inlay. This stratum achieves the RFID tagging feature with the help of tag conversion machines. (Ustundag, 2008: 16-17)

2.3.2. RFID LabelTypes

There are a wide variety of label types available. These are (Finkenzeller, 2002):

Discs: These are hollow disk shaped labels with diameters from 1-2 mm to 10 cm and widely used.

Glass tubes: They are in the form of glass tubes between 12 and 32 mm and are injected under the skin of the animals.

Plastic labels: Developed to meet high mechanical demands. For example; for electronic immobilizing systems.

Hours: Developed by the Austrian Ski-Data company in early 1990s for use in access control systems.

Contactless Smart Cards: Placed on plastic cards for use in automatic payment systems.

Smart Tags: These are labels that can be pasted onto products in supermarkets. They are also very thin labels that can also be attached to suitcases for baggage handling.

Sewing Capable Labels: Labels that are sewable for textile products.

2.3.3. RFID Labels According to Functions

RFID tags are essentially three types; active, semi-passive(semi-active), passive.

Passive tags are activated in an electromagnetic field generated by the reader, and the stored data is directed to the reader. The label is based on the principle of transmitting and receiving data on the radio waves coming from the antenna. For example, a reader in a hospital pharmacy can report every serum bottle from the door to purchasing and warehouse programs.

On active labels; an additional battery is included for the label to produce its own energy. The label on the plate is powered by power and is based on the principle of transferring data independently.

If this battery is only used for an integrated circuit, this is called semi-passive or semi-active. The pallet on the label is active with low power and is then based on the principle of transmitting and receiving the radio waves from the antenna.

Table2.2: Comparison of Different Labels in RFID Systems

Label	Active	Passive	Semi-passive
Power source	Battery	Induction by electromagnetic waves emitted from readers	Battery and induction
Reading distance	30 m.	3 m.	30 m.
Proximity information	Weak	Good	Weak
Frequency	High	Middle	High
Conflict	32k or more (read / write)	2k (read only)	32 k or more (read / write)
Amount of information stored	\$ 2- \$ 100	25cent	being developed

Source: Ömür Y. Saatçioğlu, Ege Akademik Bakış, Vol: 6 No: 1, January 2006, p.25

2.3.4. RFID Labels by Memory Type

Labels have the ability to read. However, some labels are writable at the same time. Labels that can be written once but have multiple readability are called WORM labels. The unit is used for product identification. They are used in box and pallet applications just like passive labels that can be read.

Labels also vary by memory capacities. The simplest label has 1 bit memory capacity. They are often used in stores or libraries to prevent theft. These are Electronic Article Surveillance (EAS) labels which are simple and cheap. Today, the most widely used RFID tags. With the 1 bit feature, a signal is sent to indicate whether the reader is in the domain. (Glover, Bhatt, 2006, 69-71)

SAW (Surface Acoustic Wave) tags have a memory capacity of 1 bit to 32 bits. They are readable only.

Finally, the labels in the Gen2 standard, developed under the EPC Global standards, have reached 256 bit memory capacity.

Below is the EPCGlobal label classification. (Glover, Bhatt, 2006, 72)

Table 2.3: EPC Global Label Classes

Class	Definition
Class 0	Passive, it's for reading.
Class 0+	Passive, write once. However, it is used with class 0 protocol
Class I	Passive, write once.
Class II	Passive can be written once with encryption feature.
Class III	Re-writable, semi-passive
Class IV	Rewritable, active (work with your own piano)
Class V	All of the labels in your class have reading power and processing power like class IV.

Source: Bill Glover, Himanshu Bhatt, RFID Essentials, 2006, p. 72

2.3.5. RFID Reader

In a typical RFID system, there is a need for a reader that sends digital information encoded in code and captures signals from the tag through antennas. The reader can read the existing data in the label, as well as write data on the label. The reader system includes the receiver, transmitter, memory, microprocessor, network interfaces and antennas.

Readers use three basic commands for label management. These;

Select: Determines which types of labels will respond to this command.

Inventory: In this command it is possible to sort tags in a certain group and to recognize individual number information.

Access: This command allows you to operate on a specific label. In the input command, four different operations can be performed on the label. These; Read, Write, Kill, Lock. (Üstündağ, 2008; 26)

RFID readers can be found in a wide variety of formats according to their needs. We can group them by their form, by standards and protocols, and by regional differences. (Glover, Bhatt, 2006, 113)

By Format: Readers have formats ranging from 2 centimeters to a desktop size. Some are large enough to be integrated into mobile phones. Some are in the form of a handheld device. Fixed ones can be mounted on the wall or the door. There are also those that can be mounted on transport vehicles such as forklifts.

According to standards and protocols: There are various formats according to ISO and EPC standards and protocols.

Regional Differences: Due to the use of different UHF band intervals in many different countries around the world, appropriate readers have been produced for them. The International Telecommunication Authority (ITU) has alienated the world into three parts regarding the global radio spectrum. The first part includes Europe, the Middle East, Africa, Russia, the second part is America, and the third part is Asia.

2.3.6. RFID Frequency Intervals

One of the important characteristics of RFID systems is the operating frequencies and domains. The operating frequency of an RFID system is the communication frequency of electronic tags. The reader and the electronic tag work the same frequency. However, the amount of power required for communication is several times lower for readers than for electronic labels.

The frequencies used for communication are covered in three basic bands: LF (low frequency, 30kHz-300kHz), HF (high frequency) / RF (radio frequency, 3MHz-30MHz) and UHF (ultra high frequency, 300MHz-3GHz). This category has been included in the microwave frequency (> 3 GHz) since the last 10-20 years.

RFID systems are being employed in different fields according to their frequency types. Below, different frequency ranges, their properties and application areas are presented. (Ustundag, 2008, 21)

Low Frequency (LF): It has been in application since the 1980s. There is inactive system capability. Despite its ability with low data transfer rate and very short readability distance, it performs well on metal and liquids. Bulk reading is technically possible but not practiced. Inductive coupling is used. Areas of use: animal identification and monitoring, access control, etc.

High Frequency (HF): It has been in application since 1990s. There is active or halfi-active system feature. There is a higher data transfer rate than LF and a longer read distance than LF. It performs well on metal and liquids. Provides high performance in mass reading. Inductive bonding is used and common world

standards are found. Areas of use: access control, smart cards, smart shelves, human tracking, book, luggage and clothing monitoring, anti-counterfeiting, etc.

Ultra High Frequency (UHF): It has been in application since 1990s. There is a passive and active system feature. It has fast data transfer and farther reading distance than HF. It performs poorly in metal and liquids. It has high performance and low label costs in public reading. It uses backscatter modulation. There are regional standard problems. Areas of use: Supply chain and logistics, inventory control, warehouse management, inventory monitoring and so on.

Microwave: It has been used for the last 10-20 years. It is active and semi-active system feature. There is fast data transfer and reading distance similar to UHF. It performs poorly in metal and liquids. It uses back scattering. Application areas: Access control, electronic payment, industrial automation, etc.

2.3.7. RFID Antennas

The antennas function to spread the radio signals generated by the reader. In order to accomplish this function, it can be mounted on the tank doors or on the forklift, or it can be positioned in the form of a doorway system or tunnel. If the antennas are positioned on both sides of the door, this is called the portal. (Ustundag, 2008, 28)

2.3.8. RFID Printers

RFID printers are specially designed label printers for writing information to RFID chips located in smart tags. The printer tests the chip, overwrites the chip, and then prints the barcode and label containing the other data. (Ustundag, 2008, 30)

Automated labeling automation systems can be used in RFID applications. Companies producing large RFID printers in the world include IBM, Datamax, Intermec, Avery Dennison/ Paxar, Printronix, Sato America and Zebra Technologies.

2.3.9. RFID Software

RFID software and services are another important component that is as expensive as RFID hardware. Many software and hardware companies have formed joint ventures with regard to the development of RFID applications.

One of the most important aspects of RFID software is interfaces. The interfaces determine that the tags are read correctly and process the data from the RFID readers after they are filtered. Error controls in RFID interfaces are transmitted to other critical components. The data processed by the interface is transferred to the processes and software in the enterprise. The data transferred to the software will be effective in making more efficient decisions within the enterprise. (Saatcioglu, 2006; 26)

There are main objectives behind the use of RFID interfaces. These are spanning applications from interfaces, making the process that will provide the information that the process needs to make meaningful raw observations perceived by readers.

It provides an application level for managing readers and interrogating RFID observations. (Glover, Bhatt, 2006: 137)

Today, there are companies that produce many RFID interfaces that provide these features. Some of these companies are software companies such as Sun Microsystems, ConnecTerra / BEA, GlobeRanger. (Glover, Bhatt, 2006: 162-167)

RFID software can be examined in three different categories that provide the relationship between label, reader and computer:

System software: Provides interaction between label and reader. It performs security verification operations between the reader and the label by reading / writing the label, reading a large number of labels at a specified time interval, detecting or correcting erroneous data. It is generally available in RFID hardware.

Middleware software: It bridges application software such as enterprise resource planning (ERP), warehouse and supply chain management and RFID hardware systems such as labels, readers and printers. The raw data is collected,

processed, filtered, merged and transmitted to the application software in the desired format. EPCGlobal has developed the ALE standards and ISO has developed the ISO / IEC 9126 standard for these software.

Application software: Get meaningful RFID data through middleware. Stock control, warehouse management, enterprise resource planning (ERP), etc. software is included in this category. (Ustundag, 2008, 32)



2.4. RFID Main Suppliers

Table 2.4: RFID Main Suppliers

COMPANIES	AREAS OF EXPERTISE
Accenture	Service
Alien Technologies	Equipment
Canon Fintech	Labels and Printers
Capgemini	Service
Checkpoint Software Tech.	Software
Datamaax	Labels and Printers
Deloitte	Service
DynaSys	Software
EDS	Service
HK Systems	Service
IBM	Service
ID Tech.	System Integration
ID TechEx	Service
Impinj Inc.	Equipment
Intermec Technologies Corp.	Software
Matrics	Software
Northern Apex	System Integration
ODIN Technologies	System Integration
OMRON Auto Id Systems	Equipment
Philips Semiconductor	Equipment
Printronic	Labels and Printers
Redprairie	Software
SAP	Software
Savi Technologies	Equipment
Seeburger Business Integration	System Integration
SUN Micosystems	Equipment
Symbol Technologies	Software
TAGSYS	Equipment
Texas Instruments	Equipment
Thingmagic	Equipment
Xident Technologies	Labels and Printers
Zebra Technologies	Software

Kaynak: www.rfidjournal.com/article/articleview/979/1/1

2.5. Standards

The increasing availability and proliferation of RFID technology comes at the forefront of important issues. With the development of common RFID standards, significant reductions in hardware costs will occur and new discoveries will emerge. Work on standardization in the world has been done and it is still being developed.

The most important of these studies are EPCGlobal and ISO studies. There is also the RFID Standard and Implementation Obligations standard, called the Walmart Mandate, which the Walmart supermarket chain has to comply with its suppliers, and the RFID Standard and Application Obligation standard set by the United States Department of Defence called the US-DOD Mandate.

2.6. Market And Sectoral Applications

At present, there are more than 200 major RFID companies in the world. They continue to work for the development of RFID technology, as well as providing technical and advisory services for businesses that exist in the market and in various sectors. (Www.idtechex.com/forecasts/article A)

From a literary perspective, there are many sources of references to work in industry. It is often seen to be used in sectoral applications. It is seen that in the real life, which is theoretically not used, it is used very enthusiastically, it is tried to be developed and even fairs are organized on its behalf. In the market and in various sectors, it is understood that despite their shortcomings, they found an important place for themselves.

According to IDTechEx, which sold 1.02 billion in 2005, 1.74 billion in 2006 and 1.97 billion in 2008, IDTechEx predicted to sell 2.35 billion labels for 2009. The research report, published by IDTechEx, reported that 2.4 billion RFID tags were sold by 2006 and that 600 million of these sales were made in 2005 alone. It is stated that this market, which was 2.71 billion USD in 2006, is now around 27 billion USD.

2.6.1. Retail Sector

As stated in Sheffi (2004), the adoption of such technology plays a significant role in the adoption of any technology by well-known companies. For this reason, the projects considered as important in spreading RFID technology are explained. (Saatcioglu, 2006; 30)

The retail sector is at the forefront of the sectors where RFID technology is heavily used. Wal-Mart, one of the largest chain stores in the world, has sanctioned Metro and Tesco suppliers for using RFID technology. Some of the suppliers were able to complete the transition entirely, others partially.

HORSE, Kearney said that the use of RFID technology would reduce storage costs by 10% and labor costs by 7.5%, according to a report prepared by the retail industry. (Ustundag, 2008: 61)

Tesco, UK's retail giant company, has been using this technology since April 2004, placing RFID tags in its non-food products and delivering stores from distribution centers. Tesco, who started piloting shelf management at two stores, used RFID technology at the product level, raising shelf visibility by 50%. (Roberti, 2005)

Metro Future Store project is one of the important projects related to RFID technology. The Metro Group Future Store project has provided support to nearly 40 companies including Metro Group, SAP, Intel, IBM, Gillette, Oracle, Hewlett Packard and NCR. The aim of the project was to promote important innovations in retailing both nationally and internationally at the Rheinberg store in Germany. While the project simultaneously tests many technologies, RFID technology is the basis of the test.

Materials are stacked on top of a central storage pallet before being brought to the Future Store. RFID tags on pallets and cartons have related products, barcodes for pallets and cartons. Warehouse employees read this data to the RFID commercial management system related to the Future Store. From this point on, the products are recorded in the system and their locations can be monitored throughout the entire supply chain.

When the products reach the Future Store, the pallets are lowered from the trucks and passed through the door where an RFID reader is located. The data on each pallet and carton are read and a record is made about the receipt of each product. The products are then placed on shelves where RFID tags are located and are associated with locations where portable reader products are located in the hands of employees. Information related to product and product location is transferred to the information system in the store. Thus, it is completely visible where and how much product is available. Cartons that cannot be unloaded due to lack of space are returned. The cartons are re-read by the RFID readers at the door and are reported as "backwards" in the information system. The RFID tags in the cardboards which are

required to be removed from the inside after the products are emptied are rendered inoperable.

RFID transit systems were installed at warehouse entrance, exit and payment points of the store. Shelf stocks for products are monitored by RFID technology. Suppliers can monitor product stocks in the electronic system. With handheld computers called retail shopping assistants in the store, customers can find out where their products are located more easily and get detailed information about the product. Handheld computers called mobile assistants and store salespeople can access the inventory information of the products. Shopping information is immediately visible to the customer thanks to the readers available in the shopping carts. The customer who uses the automatic check-in system for checkout transactions can make checkout transactions without cashier. With the deactivator located at the store's outlet, the customer can disable RFID tags if he wants. (Ustundag, 2008; 62)

In 2005, Metro Group reported that rapids published on their internet sites were reduced by 11-18% in in-store loss and theft, by 17% in labor costs and by 9-14% on product shelf. (Lee, Ozer, 2005)

Albert von Truchsess, spokesperson for the Metro Group, commented that "RFID technology is the most important factor in bringing the project up and that they are doing a lot of work to increase efficiency in the supply chain, and that RFID technology is the most precise technology to use in the coming years. They said they were in talks with SAP and Intel about it a year ago and they believed it was necessary to test the technology in real life. "

Although the Metro Group and its stakeholders are quite excited about technology, there are limitations to the maturity and widespread use of technology. Metro Group Spokesperson Truchsess says "RFID is only in its infancy now, but they are confident that RFID will be widely used in the future. The most important issues related to the widespread use of technology are emphasized as cost and confidentiality, emphasizing the careful consideration of privacy in particular. (Saatcioglu, 2006; 33)

In addition to inventory management, the data obtained with RFID technology is used within the scope of customer relationship management (CRM).

Marks & Spencer, the UK's largest textile retail chain, switched to RFID technology on a product basis at 78 stores in 2007. Shelf stocks of products are monitored with handheld terminals and RFID systems are used for CRM purposes.

In the research conducted by a research institute founded in 1992 under the name of Interval (Interval Research Corporation), the first five categories of customer needs were analyzed, and the processes in which RFID technology could be used and prominently benefited;

Easy and quick access to information during the shopping and more attractive and detailed suggestion services,

- Product availability at raft,
- A shorter waiting time in the cradle,
- Speed and convenience in after-sales services,
- Confidence in the authenticity of the product is revealed.

2.6.2. Automotive industry

The share of the RFID market in the automotive sector, which was published by Venture Development Company, reached 312 million dollars in 2005. With an annual growth estimate of 20%, the RFID market is expected to exceed \$ 765 million in the automotive sector in 2010. It is also estimated that RFID equipment accounts for 56% of this market.

The RFID applications on the automotive value chain are examined in three groups. These are applications related to track monitoring, inventory management and vehicle. The following tablature groups include applications:

Table 2.5: Use of Automotive Value Chain RFID

Track Tracking	Asset Management	Vehicle Related Applications
Stock management Original Track Verification Theft Control Assembly Maintenance Product Recall Recycling	Container Management Tools / Equipment Management	Vehicle Recognition Access Control Tire Pressure Monitoring

Source: Alp Üstündağ, Başar Öztayşi, Use of RFID Systems in the Automotive Sector, Istanbul University, Department of Industrial Engineering, p. 58

There are two different ways to track:

In the first method, a label is used for each piece. These parts are associated with the vehicle identification (ID) number.

In the second method, the label is used in the pallets or containers in which the pieces are moved. In this method, multiple parts are followed by labels on the container or package. Tracking can be achieved at a lower cost, especially in reusable transport systems. In terms of inventory management, the passage of material between the storage inputs and outputs and the assembly stations can be monitored. The benefits of this system can be summarized as follows:

- Lower security stocks,
- Ensuring material flow faster and more accurately,
- Decrease in high-cost emergency orders,
- Automation of material inputs and outputs.

Tracking parts with RFID tags provides real-time control of parts, prevents fraud, and theft control. Fire rate is also decreasing. (Ustundag, 2008, 75)

In the management of fixed assets, efficient monitoring of containers, pallets or other conveying units is carried out in closed loop. Within this process, we can list achievements as follows:

- Reduced route errors in containers,
- Faster handling of containers in cargo terminals,
- More efficient use of resources, faster re-use of containers,
- The fact that the place of submission can be stored,
- Higher endurance than barcode labels,
- Monitoring of the use of tools and equipment used in production,
- Identification of the tools / tools in the wrong places and checking of the deficiencies. (Ustundag, 2008, 77)

Vehicle-related applications include vehicle location, automatic switching, and tire pressure monitoring. With the RFID tag on the vehicle,

- The location of the vehicle in the field is determined,
- Theft control is provided,
- Automatic payments (bridges, parking) can be made in transit.

The RFID tag in the key provides security control. The tire pressure values are monitored with the ID number given for each tire. (Ustundag, 2008, 77)

Daimler Chrysler, one of the world's largest producers in the automotive sector, uses RFID technology in the production and logistics of its Mercedes SLK vehicles. BMW and Siemens have also begun using RFID technology in the automobile manufacturing process with a pilot launch in the München plant. (www.siemens.com/rfid) Similarly, Ford has started piloting RFID technology throughout the automobile assembly line since 2005.

2.6.3. Health and Pharmaceutical Sector

The usage areas of RFID technology in hospitals are very different. The area where the highest investment is made is inventory tracking and committee determination systems. The investment made in this area is expected to be 20.8 million dollars in 2006 and it is expected to reach 155 million dollars in 2011. In this system, it is ensured that RFID technology and other personnel are more interested in patients. In America, 600 devices are followed by Brigham Women's Hospital with RFID systems.

Another area of use is monitoring patients. It was first used to monitor the Sars virus catchers in the hospital. Following Alzheimer's patients, cardiac patients can be monitored instantly depending on the monitor, blood bags and blood stocks can be monitored. In addition, the tapes attached to the arm and the treatments applied to the disease and the operation results are more easily followed by the doctors.

In the pharmaceutical industry, Pfizer has used RFID technology in its Viagra product to prevent fraud throughout the supply chain. Likewise, Purdue Pharma, GlaxoSmithKline and Johnson & Johnson started pilot work. Fraud is the most important point in terms of this sector. Regarding this, the US Food and Drug Administration (FDA) has made binding decisions about the use of RFID in the drug supply chain and wanted to take advantage of this technology to prevent counterfeiting.

RFID investments made in hospitals and healthcare sectors can be measured much more easily than other sectors and can be returned more quickly. Studies have shown that hospitals are using RFID technology to meet their investment costs in a very short time and have achieved very high profits. Examples include Wayne Memorial Hospital, Norwegian St. Olavs Hospital, British Birmingham St. Vincent Hospital, Jacobi Hospital in New York, and Pinnacle Hospital in Pennsylvania. (Ustundag, 2008, 70-72)

2.6.4. Defense And Aviation Sector

RFID, which had begun to be used to distinguish aircraft as friendly or enemy airplanes during the Second World War, first emerged from a need in the defense sector.

The Defense Ministry of the United States (US) has been using RFID technology in warehouse management solutions since 2003 within the Defense Logistics Unit. The US Department of Defense notes that RFID facilitates and accelerates inventory management by providing hands-free trading so that even large quantities of fixtures can be easily identified by providing better resource management and transaction tracking.

From a general point of view, the benefits of RFID systems in military logistics are:

- More effective execution of operational plans,
- Directing the forces right and on time,
- Preparedness and information reliability,
- Real-time monitoring of stocks in logistics centers and operation areas,
- Working with less security stocks,
- It is the effective execution of maintenance, equipment and recall operations.

(Ustundag, 2008, 67)

In the aviation industry, Airbus and Boeing companies, one of the biggest aircraft manufacturers in the world, have begun RFID applications in production and storage processes.

Airline operators have also begun to suffer from different business processes than RFID technology. In the first part of the application, which started in Frankfurt airport, studies were carried out on the location, number of the equipment and the personnel to be used.

Airports also benefit from RFID systems in baggage management. Thanks to RFID tracking systems that match passenger and position information, it is easy to follow the system whether passengers and baggage are on the same plane. (Ustundag, 2008, 66-67)

2.6.5. Logistics Sector

In the healthcare sector, the use of RFID technology is more important in preventing fraud, while in the logistics and transportation sector it is important to monitor real-time products and materials and increase their visibility. Real-time resource allocation and route optimization for warehouse orders is made possible with the help of RFID technology.

In general, the benefits of RFID applications for businesses are to prevent stock swelling (effective inventory management), reduce labor costs for logistics

operations, control product identities (correctly) and effectively (JIT) philosophy. (Sangani, 2004)

TNT Express, a logistics company, has launched a project that uses an RFID system following a personal laptop and pallets sent from a PC factory in China to a distribution center in Germany. In the first stage, RFID technology has been proven to be used safely and in the second stage, efforts are being made to share data on the supply chain (Üstündağ, 2008; 7)

It will be followed by active RFID systems of cargoes going to Alaska by Horizon Lines. With this system, the level of supply chain appearance is also increased when transported by ship, train and truck. Horizon Lines has announced the completion of the installation of the RFID infrastructure in the highway locations at the distribution centers in terminals for the Alaska commercial strip. They are also continuing to add active RFID tags to cargo boxes. Safeway, which is a supermarket chain, continues to follow the shipments as they continue to the branches in Alaska. This system is also the result of a successful trial process with Horizon Lines.

Both Safeway and Horizon Lines plan their operations and operations using data from the RFID network in their units.

2.6.6. Other Sector Applications

Although RFID technologies are predominantly found in the above mentioned sectors, real-time data collection in garbage collection processes in municipalities, increasing process efficiency, provision of quality control etc. in construction, food, electronics, education, museum and exhibition applications, librarianship, animal husbandry, sports competitions etc. It is used for purposes. The following Table 2.6 shows the benefits provided by the places of use.

Table 2.6: RFID Usage Areas

For hung / packaged foods;	For Staff Attendance,	For Asset Tracker,	Hospitals and Health	Libraries	For parking systems,	For Vehicle Tracking Systems,	For Live Animal Tracking Systems,
Following expiration date	Real-time staff follow	Real-time fixture location and follow-up	For their institutions,	for	Real-time car park entry / exit follow-up	Vehicle security and license plate verification	Follow-up of live animals' health and vaccination
Production site and product intelligent recall capability	Input / output security	Fixed security with Smart Matching	Real-time patient follow-up	Books and archives	Parking capacity followed	Easy tax break	Live animals follow race
Product safety	Customer follow-up	Document registration and forgery follow up	Medical fixture location and follow-up	Book and archive security	Automatic billing convenience in paid parking	Easy traffic crime and accident follow-up	Easy quarantine application and follow-up during outbreak animal diseases
Medicine and Medical Devices	Automatically reach customer information	Identify the copying of valuable documents	Smart Matching and Patient Follow-up	Short time library counting and detection facility		Highway and bridge transit systems	
Following expiration date	Developing specific product recognition and sales strategies	Automatically detect the falsification of stored or presented documents	Jewelry and Antiques			Real-time money toll and bridge crossing	
Production location and content tracking	Contribution to customer continuity and remote marketing methods		Safety and follow-up of jewelry products			Automatic traffic tracking system	
Product safety						Automatic billing convenience	

Turkey is the most striking applications from laundry sector. The company named "Pak Laundry Washing and Cleaning Ltd." from Istanbul takes advantage of RFID technology in washing clothes of hotels, restaurants, hospitals and pharmaceutical factories. In search of a label that can stand on 300 washes in laundry and finding it on RFID labels, (Hurriyet Newspaper, June 30, 2009, 11), which is based on RFID technology, by developing a new invention based on the type of cloths in the baskets.

Finally, in the communications industry, Apple has given information about the new iPhone 4G, saying they are starting to use RFID technology in the new phones. NFC technology, which is called near field communication, is mainly used in mobile phones. Samsung and Nokia have already introduced NFC integrated products to the market.

Apart from sector applications, RFID applications are also being implemented in many different areas. Below are different applications according to frequency ranges.

Short Range RFID applications are these. (Shepard, 2005, 132-143)

- Access control
- Transportation Ticket Processing
- Personnel Identification
- Definition of Blood, Tissue and Organ
- Prison Person Identification and Access Control
- Hazardous Waste Control
- Vehicle Identification
- Fleet Management
- Pigeon Race
- Production Line Control
- Car Body Manufacturing
- Passport Security

Long Range RFID applications are as follows: (Shepard, 2005, 143-153)

- Supply chain management
- Post and Transport
- Clothing Tags
- Library & Rental Companies
- Luggage Transportation
- Food Production Control

2.7. Benefits and Costs Of RFID Technology

RFID technology reshapes the business processes of firms and provides the firm with a different information technology infrastructure for collecting data. From this point of view, it is inevitable that RFID investments should be considered as a strategic decision. The steps you need to follow before issuing an RFID application decision are as follows:

- Determination of potential use areas for RFID systems
- Analysis of potential business processes
- Clarification of the gains to be made regarding RFID application
- Determination of technical and organizational requirements with test and pilot studies
- Identification of application risks
- Detailed ROI calculations for the whole system, with detailed cost and benefit analyses
- Costs in RFID applications can be examined in three basic areas: hardware, software and services.
- Hardware costs include labels, readers, antennas, computers, and networking equipment.
- Software costs can be shown as the creation or purchase of middleware and other application software.
- Service costs include installation and system integration, training, support, maintenance and process refresh (BPR). (Üstündağ, Tanyaş, 2008, 4-5)

Considering the fact that RFID applications are implemented in many different areas, and considering the obvious advantages of RFID technology over traditional information systems, it is clear that many benefits can be obtained with RFID. Benefits obtained through RFID;

- Decrease in delivery times,
- Pre-setting of delivery times,
- Reduction of repeated jobs (e.g., Product control)
- As a result of the automation of the operations realized with the labor force, the decrease of the errors and the decrease of the labor costs,

- By obtaining detailed information about the product from production to sales point, precautions can be taken against the problems that may occur in the supply chain,
- The change in supply chain can be answered immediately,
- As a result, the activation of supply chain control and management,
- Ensuring that products are deployed effectively in warehouses and distribution areas,
- Decrease in fire,
- Decrease of output / entry control times of products,
- Effective regulation of shelves due to the immediate identification of product sales,
- Reducing intransigence,
- Monitoring of expiration dates,
- Preventing the delivery of products to unauthorized channels,
- As a result of all these benefits,
- Development of customer service,
- Monitoring the purchasing behavior of the customers, the facilities provided at the end of the target customer identification,
- The customer can be described as having more time to get involved.
(Saatcioglu, 2006; 27)

Another source summarizes the benefits that retailers using and using RFID can provide to businesses and suppliers:

- Instant information about the product,
- Immediate detection of store theft, reduce fire,
- Being fast,
- Do not miss out on sales opportunities (right product, right place and right time),
- Financial income,
- Data management,
- Supply chain management,
- Inventory and product availability control,
- Downloading the most auspicious memories,

- Advanced logistics, warehousing, distribution and production control. (Orel, 2006; 2).

Many estimates and investigations are made on the numerical values to be obtained as a result of realizing the disclosed benefits. For example, in studies conducted at some textile stores in the USA, it has been determined that sales increase by 7% due to increased control of clothing in the store.

Toshiba Information Systems America Department increased productivity by RFID by 25%, reduced distribution costs by 44%, and reduced deviations from stock by less than 0.01%. (LaVie, 1998: 668)

The US production and retail sectors point out the resulting annual losses of \$ 70 billion for supply chains to be ineffective. The absence of the desired product on the shelf as the reason for the losses in the supply chain is expressed as a theft of the supply chain anywhere and misidentification of the product information. (Reid, 2003)

In addition, the positive contribution of the RFID system to the supply chain could be:

- Real-time human error free data collection
- Automatically follow the various stages of production if the labeled product is desired
- Automatic tracking of the labeled product from production to storage, storage to end user
- Real-time location of products in storage by box and pallet-based labelling
- Automatic order validation at warehouse loading doors with box and pallet-based tagging
- "Smart Shelf" labeling in FMCG supply chains followed by declining products on the rack
- When examining the faults mentioned, it would not be wrong to think that the use of RFID can be effective in preventing errors.

By integrating RFID into the system, it will save labor costs not only in warehouse but in all processes. So the mistakes that people will make will be

removed. With fewer employees, it will help you work more efficiently and reduce costs.

As the supply chain grows longer, the increase in bullwhip effect leads to weakening without anticipation, and the right information in the supply chain between producers, intermediaries and consumers is increasingly distanced. At this point, the company has the opportunity to instantly see all the processes of the supply chain with RFID, preventing both out-of-stock and swelling of stocks, in other words reducing the whip effect significantly.

2.8. RFID Problems

2.8.1. Privacy

In addition to the benefits provided above with RFID technology, there are a number of disadvantages that need to be addressed.

With RFID technology, gathering information about customers without the knowledge of customers (eg line-taking behavior) has become much easier. However, concerns about keeping personal information on the label after the sale are a major problem. If RFID tags are not removed or inactivated before the customer is out of the shop, the customer can be controlled with the radio signals that the goods they purchase recognize. (Jones et al., 2004: 46) Incorrect use of data, access by unauthorized persons, transfer of data about customers' purchasing behavior to unrelated persons, as a result, monitoring of every move of the customer can be given as an example. (Jones et al., 2005: 396) In September 2003, Britain's leading human rights and individual freedom organization, Liberty, launched a retail-oriented campaign that uses RFID technology. The reason for the start of this campaign is the withdrawal of photographs where one of the major retailers abandons the store with raffle razors and shop with the product. Gillette, the manufacturer of razor blades, vigorously opposed the pressures of this group and stated that RFID's purpose is to increase the effectiveness of its supply chains.

However, in March 2003, he announced that he would re-evaluate his policy on RFID tags used in Benetton garments, taking into account consumer privacy issues. (Jones et al., 2004: 48) Forrester Research Marks & Spencer, an independent

research firm that helps companies assess the business, customer and collective impact of technology change, praises the RFID test that has been applied to clothes at the store in Hing Wycombe. The good features that Forrester Research identifies are that the labels are visible; the customer may request that the labels be removed from the garments after purchase; RFID readers are advised to use a company that wants to keep trade secrets out of hands and trade secrets. (Jones et al., 2004: 52)

It is recommended that laws should be enacted on the basis of necessary conditions to ensure that companies do not use freedoms for violation of their privacy and that they are not related to information about individuals. According to The National Consumer Council (2004), customers may be asked whether they want their labels to be deactivated at the exit point, or incentives may be given to keep customers' labels active. According to CIVIL LIBERTIES GRUBU, the clients are required to be informed about products carrying RFID tags and to be informed clearly about passivation of post-shopping labels. In addition, CASPIAN (Consumers Against Supermarket Privatization Invasion and Numbering), which is involved in confidentiality in the United States, emphasizes the necessity of public policy development in relation to technology. The 4 issues to be avoided regarding the CASPIAN RFID project are as follows. First, firms should not force their customers to have an RFID tag on the products they buy. Second, individuals should not have restrictions on RFID tags and identification of readers and inactivation of labels. Third, RFID clothing, consumer products, or other products should not be used with people watching the channel. Finally, RFID should never be used to restrict freedom or lift. (Jones et al., 2004: 54)

2.8.2. Software Integration Problems

It is envisaged that the transition to RFID technology will take place in three stages: technological harmony, improvements within the firm and improvements outside the firm. RFID systems are another issue that needs to be taken into account as the resultant increase in yields and the need for companies to effectively use increasing data. Data from RFID systems need to be integrated with other information systems used in the organization (eg accounting records and customer relationship management). However, many retailers indicate that they use very little of their existing data. (Jones et al., 2005: 401). Integrating RFID systems with

processes and systems in operation is quite complex and costly. Zawal also notes that "real benefits will be achieved when integrated with systems running RFID technology". The investment in RFID technology is an important investment with significant return possibilities and that integration with business processes can reduce costs and increase profits. (Chau, 2004: 27)

2.8.3. Uncertainty of Standards

UHF radio spectrum used in RFID systems is one of the most important factors in the failure of the standards companies to develop in the world.

Most countries have specified 125 kHz or 134 kHz for low-frequency systems. The frequency of 13.56 MHz is used for high frequency systems all over the world. However, since UHF RFID systems are newer, there is not a single frequency range to be used by these systems yet. In the United States, 902-928 MHz is used, while for Europe, the 865.6-867.6 MHz range is specified in the Class 1 Gen 2 protocol. However, the regulations on the use of this frequency have not yet been completed in all European countries. According to the "Short Distance Accessible Radio (KET) Regulation" prepared by the Telecommunications Authority and published in the Official Gazette dated 16.03.2007 and numbered 26464, the readers of the RFID readers have maximum power of 100mW in the 865-865.6 frequency band and maximum 2W power in the frequency band 865.6-867.6 MHz and a maximum power of 500 mW in the 867.6-868 band. These frequency adjustments allow the frequency range and power specified by the EPCglobal Gen 2 standard to be used in our country (www.epcglobal.com).

2.8.4. Cost-Related Components of RFID

Costs in RFID applications can be examined in three basic areas: hardware, software, services.

Hardware costs include label, reader, antenna, computer and network equipment. Software costs can be shown as the creation or purchase of intermediate software and other application software. Service costs include installation and system integration, training, maintenance, support and process refinement.

The benefits of RFID technology can also be grouped under two main headings. The first main benefit is the reduction in costs. Process automation and productivity increase leads to a decrease in stock and personnel costs. The second main benefit is the increase in customer satisfaction, the decrease in losses and errors, and the increase in revenues.

It is also an important step in deciding what level of RFID technology can be applied in business processes. As you move from pallet level to product level, it increases in cost with visibility. The gain at the product level is higher than at the pallet or box level, but the decision of whether or not it is appropriate to bear the costs that are incurred is the one that the firm managers will give. Beginning RFID application with pallet or box and moving to product level over time can also be one of the decisions made. (Ustundag, 2005 b: 25)

CHAPTER 3

SUPPLY CHAIN MANAGEMENT AND RFID

It is expected that RFID technology will cause a new cycle after the internet technology and in the near future the enterprises will make serious changes in the operation models of the supply chain. Enterprises with RFID technology integrated with their own information systems will be able to track products automatically throughout the supply chain. This technology will add significant value to supply chain management by providing automated identification and tracking of products in production, transport, storage, distribution, sales, delivery to the end user and backtracking operations.

The main objective of supply chain management is the greater speed and cost effectiveness. (Lee, 2002) Marketing trends focus on wages, customers and products. A supply chain integrated with RFID will provide more speed and cost reduction at the same time. (Hsieh and Lin, 2004)

3.1. The Importance of Information Sharing and Channel Setting in the Supply Chain

Lee et al. (1997) have studied how information sharing can be a strategy against 'bulwip effect'. At the far end of the bad (inaccurate) information supply chain at one end of the whip effect supply chain, the demand estimates are caused by large fluctuations. Information sharing refers to the timely provision of demand information throughout the supply chain.

Thus, estimates and orders are made more accurate when pricing, transport, planning, and ownership are aligned among different actors of the supply chain. An RFID-enabled supply chain makes this more convenient by capturing and sharing retailer knowledge. (Helo and Szekeky, 2005)

Logistics and supply chain management; plays an important role in modern enterprises to respond effectively to customers. Critical questions about logistics and supply chain management; integration of inventory with distribution and sales information, in other words, making integrated logistics information transparent to other organizations in distribution and sales channels in real time. (Caputo et al., 2004)

Real-time logistics information also protects the production line from being overproduction or out of stock while allowing customers to perceive real customer requests. The key point in logistics information integration is real-time awareness and acquisition of deployment information. (Trappey et al., 2004)

In this context, the RFID and FZE achievements outlined below are becoming effective in the logistics industry day by day in practical applications.

- Real-Time Visibility
- Prevent Out-of-Stock Stay
- Faster Payment Process
- Lower Stock Levels
- Fewer Procurement Losses
- Counterfeiting Prevention
- Better Asset Usage
- Convenience in Recalling Goods
- More Effective Recycling
- Earnings from Labor Costs
- An Effective Product Tracking System in Pallet, Case and Product Size

3.2. Conceptual Approaches to RFID Applications

RFID applications are still immature and in testing phase. Therefore, it is natural to encounter many research, development and model proposals in the sectoral and academic sense. All these studies reveal the strengths and weaknesses of RFID and create opportunities for solving problems. Recalling the difficulties in the early days of transition to the Internet, it would not be wrong to say that RFID has gone through such a process.

3.2.1. Investigation of RFID Applications according to Objectives and Label Types

RFID applications can be roughly classified as follows according to their purpose (Trappey et al., 2004):

- Definition
- Verification
- Placement
- Data collection

In validation applications (such as contactless smart cards, simple automatic payments), the tag is usually very persistent from the bearer object. On the other hand, most of the supply chain applications are the object of having ethics. Supply chain applications also differ from human applications in that they are the purpose of "automatic data collection" rather than "information verification". Most of the objects of the automatic data collection applications (for example, products, shelves, pallets) are automatically monitored and the information obtained (captured) is used to activate the business applications (eg supply chain management system, customer relationship management system and enterprise resource planning system etc.).(Trappey et al., 2004)

It is also important to note that in RFID applications the label type and whether the tagged object is human or not are important for the application. The type of label varies considerably in terms of cost and effectiveness. For example, if a high frequency RFID tag is used in a container positioning application with GPS, the impact distance will increase and the cost will increase. On the other hand, identification of each product in a warehouse or market can provide a passive labeling event and cost much less.

3.2.2. Interaction Concept of RFID System with CRM, SCM, ERP

RFID technology is an evolutionary technology that will take the place of the traditional bar code for identification, tracking, and automatic scanning. With the help of RFID electronic tags, it has come to the agenda to add intelligence to the work flow by reducing the human participation in product identification. The information labels held by the electronic labels differ greatly from barcodes at the

point of remote readability and physical contact requirements. Label applications can be based on product, case, pallet, container or truck. The most effective application of RFID is the product-based approach. But today it is not possible to say that this level has been reached yet. The main reason for this is that label prices have not yet fallen to the optimum level in terms of cost. Container, pallet and case applications are intensely vital.

For readers, for example, it can be in a fixed position at the entrance of a large warehouse while it can fit in the palm of the moving spots. As a result, it will be used to mobilize the information provided by the RFID system and the wide range of applications of the enterprise (eg ERP, SCM, CRM). The interface between the RFID side and the operator's main information system will require adaptation and communication. First of all, RFID tags provided by the tags need to be caught and collected. Much of the unnecessary information will be recovered during this process. Filtering is performed with information system technologies and sorting process is performed. Subsequently, the obtained information is transmitted to the main spinal column database so that the systems to be actuated are automatically triggered.

RFID technology, on the other hand, is rapidly undergoing an integrated transformation effort with enterprise resource planning software. Using RFID technology for companies that use ERP software means that bulk goods in and out can be instantly reflected on ERP screens.(Trappey et al., 2004) The workflow is accelerated and a significant time saving is achieved. The data obtained by RFID technologies integrated into enterprise resource planning software is processed by being transferred to ERP system quickly. In order to use RFID technology, business management and decision support systems must be provided (Leach, 2004). For example, if 60 to 70 thousand pieces of merchandise are placed in the warehouse of the workplace, if they carry a label-like RFID on these goods, the RFID sensor allows these goods to be counted in front of the electronic doors at the time of passing all these goods. Otherwise, dozens of people will have to work for hours to be able to approve the entry of goods at this level. In addition, where this item is placed in a large warehouse, it will be possible to find it as if it were placed manually on the RFID tag it carries. The electronic detectors placed in the warehouse entrance and exit can report in real time how much property it has, by allowing one depot and one thousand pieces of goods to fall from the existing stock instantly.

3.2.3. RFID Delivery and Transportation Application Example

This trick is particularly directed at businesses that use the Warehouse Management System (WMS). Inventories can be updated instantaneously by automatically counting RFID tagged products as they pass from delivery-to-receiving area. RFID and Delivery and Shipment Flow operates as follows:

- Shipment of RFID tagged pallets or products
- Receiving via RFID reader
- Middleware
- RFID event processor
- Application
- Reaction
- Placement

3.3. Combining RFID And Other Technologies

Other additional benefits, such as supply chain visibility, can be gained by combining GPS and Bluetooth, which are RFID integrative technologies. DHL, a third party logistics service provider, is implementing this. DHL monitors the distribution chain of Nokia phones using existing satellite systems and RFID. (Pick, 2004) Intel is using a new supply chain management concept called 'inventory on the move' by using RFID and GPS to send products without orders. Goal; The products are produced to keep the pipeline (supply chain) full and moving by not being produced. When the order is received, the product is routed to the nearest hub. This system certainly requires knowing where the products are located in the supply chain. An RFID that works in conjunction with GPS provides this information. Intel keeps the \$ 3.5 billion inventory in its supply chain. The visibility of the supply chain, which will be developed with RFID, is estimated to cost millions of dollars to the firm while at the same time reducing the distribution cycle, which is now three weeks, to one week. (Leach, 2004)

3.4. General Meaning Procurement Benefits

3.4.1. Human Resources and Cost Reduction

The integration of RFID into the system will save not only the output of the goods but also the entire staff in addition to the whole process. Warehouse workers who are in the warehouse and who are currently counting will be saving the employees who use computers, who enter and leave the computer. So the mistakes that people will make will be removed. RFID will be the way to work more efficiently and reduce costs with fewer people.

3.4.2. Tracking, Production, Sales, Marketing and Promotion Event

The logistics director of the operator has the opportunity to monitor the product at every point. At what store or store in which store and at which spot, how often do you act, we can see what products are dated. Accordingly, the manufacturer can change the production plan even momentarily and even accelerate it in certain places in sales and marketing policies. For example, where the product is aged, it can immediately translate these products into sales by promoting it. It also gives the producer a chance to forecaster by increasing the circulation, which is the most strategic point for the RFID project itself. (Leach, 2004)

3.4.3. The Importance of Following the Equipment in the Supply Chain

Especially in food it can be observed more effectively. Soon the use of plastic pallets will become mandatory. The plastic pallet is a very expensive equipment compared to the wooden pallet. Wooden pallets are not a productive process to follow with RFID. Because, after a short time, the wooden pallet comes out from the ground. But when we go through the use of plastic pallets, these pallets will absolutely have to be RFID labelled. (Leach, 2004) The price is high and the life expectancy is very long, so we need to follow it. Permanent loss of pallets brings very serious costs. This is reflected in the unit price of the manufactured goods. In this case, we need to re-gain the palette. In doing so, the logistics director of the operating company said that the application of plastic pallets with RFID enabled them to effectively monitor valuable equipment for themselves.

3.4.4. Functionality in Reducing Whip Effect

The longer the supply chain, the weaker the bullwhip effects, and the more accurate information in the supply chain between the producer, the intermediary and the consumer is removed. At this point, the company is able to instantly see all the processes of the supply chain with RFID, preventing both out-of-stock and stock swelling, in other words reducing the whip effect significantly.

3.5. Difficulties encountered in RFID application

Despite the advantages of RFID technology, there are a number of application problems that currently exist in some technical and managerial sense, including RFID reliability, recognition distance, application costs and EPC (electronic product code) standards. When we come to supply chain practices; The RFID labeling scheme can be classified as product labeling, case labeling, and pallet labeling (labels can be added to the product, cassette or palette respectively). Because the unit cost is very high, labeling operations on product basis are still too costly to bear.

3.6. Real-time visibility

One of the most important benefits of RFID technology has been to provide visibility into the supply chain of materials. Identifying and tracking the movements of materials and their location in the supply chain without visibility. Visibility for the business is to ensure that the decision-making mechanism within the supply chain is the right decision. (Leach, 2004)

Visibility is ensured through the entrance of the goods into operation and delivery to the customer. In this way, precise and accurate stock control has been obtained from excess or missing inventory, and eventually the enterprise is saved from harm. In general, visibility has three main benefits. They prevent theft, misplacement and prevent material loss, and do not allow errors between stores.

3.7. Preventing thieves

Thanks to RFID-tagged products, product movements are seen instantly by readers. Thus, the product that is not available for the moment is detected on the raft.

There are two possibilities for non-shelf products. (Garfinkel and Rosenberg, 2005: 18) The product has been received by the customer and is at the time of payment, or the product has been mistakenly left by the customer. The product was stolen by a malicious person. Thanks to this feature of RFID technology, theft is prevented and integration with other systems ensures healthy inventory control.

3.8. Prevent incorrect placement and lost products

Another benefit of RFID tags is to prevent misplacement and loss of products in the store. At the same time, the RFID tags of the products coming from the warehouse are matched with the settlement places and it is planned which product will be placed where. The Metro Group's pilot is one of the best examples of this.

Metro Future Store project is one of the important projects related to RFID technology. Metro Group Future Store Project realization of metro Group, SAP, Intel, IBM, Gillette, Oracle, Hewlett Packard, NCR and nearly 40 companies have provided cooperation. The aim of the project, the store in Rheinberl Germany has significant innovations in retailing both nationally and internationally. The project is testing several technologies simultaneously. However, RFID technology is the basis of the test.

Materials are stacked on top of a central storage pallet before being brought to the Future Store. RFID tags on pallets and cardboards are used to code related products. Warehouse employees read this data to the RFID commercial management system related to the Future Store. From this point on, all products can be monitored throughout the supply chain.

When the products arrive at the Future Store, the pallets are lowered from the trucks and passed through the door where an RFID reader is located. The data on each pallet and carton are read and a record is made about the receipt of each product. Products are then placed on shelves where RFID tags are located and are associated with locations where portable reader products are located in the hands of employees. Information related to product and product location is transferred to the information system in the store. Thus, it is completely visible where and how much product is available. Cartons that are not unloaded due to space constraints are returned. Cartons are re-read at the door by RFID readers and report "backwards" in the

information system. The RFID tags on cardboards that are required to be removed from the center after the products are emptied are rendered inoperable. On this page, both the products on the shelves are fully realized and the materials coming through the system are checked. (Reid, 2003: 38)

3.8.1. To prevent differences between stores

One of the areas where visibility is used most effectively is to remove differences between stores. With the simplest explanation, RFID tags provide control between the materials coming out of the warehouse and the materials coming into the store and preventing the introduction of the wrong materials. The best example of this is demonstrated by the Chevrolet firm:

The RFID system used by the Chevrolet Creative uses the "red light, green light" system to control 3500 cans entering and leaving the store in Michigan. There are materials used for special exhibitions in the crates. Each box has an RFID tag with a different number on it.

The doors are equipped with RFID readers and stationary antennas. When a crate crosses over the antenna as it travels towards the truck, the number on the tag is checked by the manifest in the data base. If the number in the label matches the number in the data base, a "green light" lights up indicating that the cell can be loaded. If the number in the label and the number in the database are incompatible, the "red light" is lit. The actual date and time of the event is recorded in the database.

The most important benefit of the project is to reduce errors caused by human beings due to on-paper controls, better record keeping and faster and more effective results. In the traditional system where the materials go from one point to another, pallets are stopped and barcode reading is provided for the employees to control. With RFID tags, information is read and time is saved without the need to stop pallets, the labor force used is reduced and mistakes are eliminated. Labels, on the other hand, make it easier to return to locations where errors occur.(d'Hont, 1996:22)

3.8.2. Preventing stock depletion

- Missed profitable sales opportunities due to the processed stagnant failure,
- The losses caused by the production stoppage or interruption due to raw material failure,
- Indemnity, loss and loss payments arising from non-performing orders on time,
- The loss of customer confidence,
- In addition, the lack of sufficient stocks also indicates that the firm does not benefit from the volume discounts, does not produce economic quantities, and misses advantageous buying opportunities.

Stock-keeping costs increase more rapidly than stocks, as losses and losses caused by stock shortages, or the benefits of holding stocks, grow steadily as inventory increases. The lowest level of stock holding and non-holding costs gives the optimal stock amount.

As the stock level of the firm increases, the cost of holding stocks will increase and the costs and losses will be reduced gradually. At the point where the losses caused by the stock shortage are equal to the benefits of stock keeping, the business reaches the optimum stock level. (Reid, 2003: 38)

At this point, RFID technology saves businesses from the cost of not having stock. Thanks to the instant inventory control, we are informing what the missing products are and instantly these materials are being completed. Thus, customer desires can be met in the right place at the right time.

3.9. Acceleration of physical product flow rate

Simultaneous interrogation of multiple labels within the reading area of RFID readers will significantly reduce product follow-up and control time and speed up related processes. As a result, faster product flow will come into play. For example, the time and effort required to record individual inventory of empty pallets returning to the warehouse will be significantly reduced, or payment queues in retail storehouses will be removed.

3.10. Lower stock level

The cost of holding stock is used to measure the monetary load of any kind of material that is waiting for stocks as finished, semi-finished or raw materials. It is made up of many cost elements. But they do not have to be in a particular inventory system. These cost elements are; capital cost, storage cost, inventory risk cost, and inventory service cost.

3.10.1. Cost of Capital

This cost, which can be expressed as opportunity cost, is also the most important cost of keeping cost. It can even be used alone to define the financial burden that stock keeping will bring to the business. (Gençyılmaz, 2002: 103) It is an invisible cost in accounting records. The cost of depositing the capital at any place outside the stock may be the end result. The value is equal to the biggest income that can be obtained from investments outside the stock. For example, if a firm can earn 40% of its income with the money it does not invest, it is the cost of the stake. If the firm borrows a short-term loan from the banks, the cost of the stowed money is calculated based on the interest rate used for the loan. If the company is long-term borrowed, ie, issued bonds, the interest rate paid will be used to calculate the cost of the stoking capital. (Gençyılmaz, 2002: 103)

3.10.2. Storage Cost

It covers expenses related to physical storage and transportation of stock materials. However, if these costs are the effect of the decision to reduce or duplicate inventory levels, then the account is eligible to participate. (Yenersoy, 2005: 32)

3.10.3. Cost of Inventory Risks

The risk of holding on inventory can be divided into counties. The first is the deterioration of the goods, the qualities, the physical qualities, which are in the stoct. Secondly, prices are falling. The third is that stocks lose their ability to release because of the change in consumer tastes. (Reid, 2003: 38)The first risk applies to both raw materials and finished goods stocks. The second and third risks apply only

to product stocks. However, the third type of risk may also apply to stocks of raw materials if the consumer tastes change to a product that will not be produced.

This cost may be defined as an average value by evaluating the statistical information of such cases occurring in the past in the case of the deterioration of the material in the depot.

In practice, it is very difficult to assess the risk of price declines or the risk of stocks becoming obsolete. It is better to consider such risks as a cost element rather than accepting variable costs.

Firms, especially large firms that invest heavily in stocks, can reduce the risk of price changes by making long-term sales contracts on certain prices. An industrial establishment may make a sales contract at a certain price for the raw material to be produced, as well as for the product to be produced from this raw material. In this way, it will protect itself against the risk that future price reductions may cause. However, such a policy could also deprive the firm of the additional profit that the price could provide.

3.10.4. Cost of Inventory Service

The costs required for the maintenance of goods, the cost of attitudes, fees paid to warehouse keepers, stock entry-exit records and inventory control are evaluated within these costs.

The cost of holding stock varies from firm to firm, but it can be said that it is generally 25-40% of the stock value.

RFID technology can be considered as the most important choice for companies to minimize the costs incurred without overstocking. Thanks to the inventory control provided by the RFID, the relationship between the warehouse and the elements within the supply chain is established, ensuring that the right material is available at the right time and at the right place. As a result, firms do not stock much, reducing cost.

3.11. Prevention of fraud

RFID technology allows product-based product tracking / control by allocating "Electronic Product Code" (EPC), which is stored in electronic tags to products. The ability of the RFID system to allocate product codes on a per unit basis

for each product allows tracking and control throughout the product supply chain from the design phase to the recycling stage. It is possible to get information about where and when the product is manufactured and packaged, the expiry date, where it is located and how long it remains where it is located.

3.12. Decrease in labor cost

An organization using an RFID system can be reached at the entrance of the warehouse without having to open all the information about the shipment of the products and the arm of the trolley by passing the RFID antennas through the entry point of this arm through the entrance or by taking an operator around the RFID handheld terminal and the arm for a very short time, are recorded in real time on the relevant information processing system.

Another process that allows labor costs to be reduced with the RFID system is the inventory counting process. Thanks to RFID technology, the counting process can be performed in perfect accuracy, in real time and continuously. The implementation of the RFID system in retail store shelves accelerates the payment process of the customer while reducing the possibility of the cashier's workload to make a mistake and even reducing the total number of cashiers to allow more efficient employment of redundant staff.

Taking into consideration that RFID usage takes place in many different areas, and considering the above-mentioned advantages of traditional information systems, it will not be difficult to say that many benefits can be gained with RFID. Reduction of mistakes as a result of the realization of the work done by the automation and realization of detailed information about the product from the point of production to the point of sale can be taken against the problems that may occur in the supply chain, effective control of the supply chain, effective management of the supply chain, efficient placement of the products in the warehouse and distribution areas, reduction of waste, reduced entry and exit times of the products, effective arrangement of the shelves due to the immediate determination of product sales, monitoring of the use dates, preventing the sending of products to unauthorized channels, The reduction in time spent monitoring products as a result of events, the development of customer service can be explained as the convenience provided by the determination of the target customers after the monitoring of the purchasing

behavior of the customers and the more time the customer is interested. (Ustundag, 2005: 28)

Toshiba Information Systems America Department increased RFID productivity by 25%, reduced delivery costs by 44%, and reduced deviations from stocks by less than 0.01%. (LaVie, 1998: 668) The US production and retail sectors point out the resulting annual losses of \$ 70 billion for supply chains to be ineffective. The absence of the desired product on the shelf as the reason for the losses in the supply chain is expressed as the theft and the product information being misplaced anywhere in the supply chain. (Reid, 2003: 41) When examining the faults mentioned, it would not be wrong to think that the use of RFID can be effective in preventing errors.

3.12.1. RFID Compliance Issues

RFID is not currently feasible for many businesses, financial, technical and operational aspects. Especially in the supply chain, production and logistics processes, there are points that can not be met. RFID promises to solve many problems, but at the same time it creates new potential problems and issues. Essentially, this is nothing more than a test and transition process for every new technology.

3.12.2. Costly Costs of Hardware and Software

Despite the drop in label prices, it is still a serious cost. RFID readers are sold at an average price of \$ 1000. Interface costs are quite different. Since many applications (eg RFID-backed warehouses) require customized hardware, significant additional costs arise. (Walker, 2004)

In June 2004, Walmart announced that January 2005 is the deadline for the transition to RFID for its top 100 suppliers. This means; all boxes and pallets reaching Walmart units will have to carry RFID tags on them. For many suppliers it is a serious expense to provide. After all, big suppliers have to spend \$ 9 million in the first year to keep up with this challenge. 80% of this expenditure is for electronic tags for 16 million cases and pallets.

Table 3.1: RFID Costs

Cost of sending 50 Million Cans per year in RFID	(Million dollars)
Labels and readers	5-10
System integration	3-5
Changes in existing supply chain implementations	3-5
Storage and analysis of large volumes of information	2-3

Source: Rothfeder, 2004

If there are metals blocking the RFID signals in products or pallets, or if there are carrier bands or static noise producing nylon glass or fiber present, the cost of physical infrastructure changes to combat these problems will increase. (Margulius, 2004)

3.12.3. Integration and Education

Forrester Research; operations would cost more than the cost of buying the firm's RFID technology for optimization, information analysis and training work. The passing of the RFID's life requires the integration of a system at the same time. Research shows that RFID integration service profits will surpass RFID equipment profits until 2007. Very few people have experience in RFID application (Dignan, 2004)

3.12.4. Tagging Palette or Product

The cost also depends on the level of labeling. A large number of labels will be required at the product level, and at the same time, this will lead to increased production of information. Filing of this large amount of information requires complex software layers and IT architecture. However, the tagging at the pallet level reduces the cost and the strategic benefits of the RFID are avoided.

3.12.5. Standards

Standardization, which is the prerequisite for compatibility and cost reduction, has not yet achieved a definitive result. There is no reduction in costs without widespread use of RFID. Another requirement of the widespread use of

RFID is that widespread standards have been established. In this respect, the first RFID implementers will experience time and cost loss. (Jakovljevic, 2004)

Global standards are needed for RFID solutions to enable efficient supply chain management through EPC applications and to enable many supply chain units such as manufacturers, retailers, distributors to work together. Global standards organizations with over 30 years of experience in enumeration and auto-identification standards, EPCglobal Inc. (formerly EAN International) and GS1 US (formerly UCC) they built the company. EPCglobal Inc's mission is to develop global standards for the EPCglobal network that will enable instant, automated, and accurate identification of any product or company in the supply chain. This network consists of the tags that store the EPC information on the product, the readers who read this information, the information systems to which the information is transferred, and the software that communicates all these components.

3.12.6. Security

RFID tags need to be encrypted at a sufficient level for information security. Another security issue is everything related to RFID's environment. For example; RFID tags in general are not capable of physically recognizing a real printer. For this reason it will be possible to read RFID tags without theoretically authorized physical access. (Sarma, 2002)

3.13. Outsourcing in RFID Applications in Supply Chain Management Needs

When outsourcing activities are more common, we will see more of RFID being spoken. This means that the logistics company providing outsourcing services is transformed into an equipment (a form of service that it will provide). For this reason, producers are already thinking why I should invest. Businesses also tend to wait for RFID support from vendors that are outsourcing their warehouse services. Businesses want to focus on production, which is the main business. It is accepted as a model to perform only production and other functions by receiving outsourcing services.

In this context, a logistics firm of RFID should be able to offer 3 Turkish Lira service. The biggest task of the logistics firms is to know very well what they want and the contractor is a very good choice.

In such structures, companies are in a cultural revolution. Companies will have to invest in RFID technology if they want from logistics companies. Europe is a bit ahead of us in this regard. Businesses have settled outsourcing cultures in Europe. For example; The ACR Company is able to translate all plastic pallets used by producers in Belgium. The trend in the world is no longer the producers, but the logistics companies make these technological investments.



CHAPTER 4

RESEARCH METHODOLOGY

The process of research methodology has been started by the researcher through interactive ways. The researcher uses some methods to collect data from the companies who are RFID users. Previous chapters were more about explanation of supply chain management and RFID technology. Besides these, there were also some examples of RFID using which are analyzed by other researchers. During this chapter, process of research is more interactive within companies and methods that researcher follows.

Actual feedbacks and data are received from professional business life about RFID technology and supply chain management processes. Long company list is made by the researcher. It is full of companies that experiences RFID technology during their supply chain processes. There are companies which belong to foods & beverages sector, apparel & fashion sector, chemical mining sector, aviation sector, carpet & home art sector, logistics sector, retail sector, jewelry sector, glass manufacturing sector, etc. The list was long and time was so limited. It is not easy to collect data from that much wide range company list. Therefore, the researcher had to eliminate some companies to make more efficient researches with targeted companies. During the elimination among the companies, care was taken to keep at least 1 or 2 firms from each sector.

After elimination, the list was well revised and created as volunteer company list which includes the companies those give affirmative feedback according to upcoming processes. Once volunteer company list is constituted, appointment request has been done by the researcher.

According to affirmative feedbacks about appointment requests, data collection process has been started with an interview method. Until reaching this step, 1 and half month has spent by the researcher. At the end, 3 companies from different sectors have confirmed to attend on interview as volunteer companies. Within questions of interview method, the study aims to collect some qualitative data as well as quantitative data from volunteer companies to make comparative research through datasets.

Another step of data collection process during research is case study method.

This method is applied through one of the company which is already confirmed to make interview for this study. So, secondary data is received thanks to this company which is from carpet production sector. This case study includes quantitative dataset that helps to make statistical analysis.

After data collection process, analyzing and interpreting of data constitutes data analysis process. Here, collected dataset is analyzed and interpreted through suitable methods.

In sum, the process mentioned above is shown Figure 4.1 within its titles.

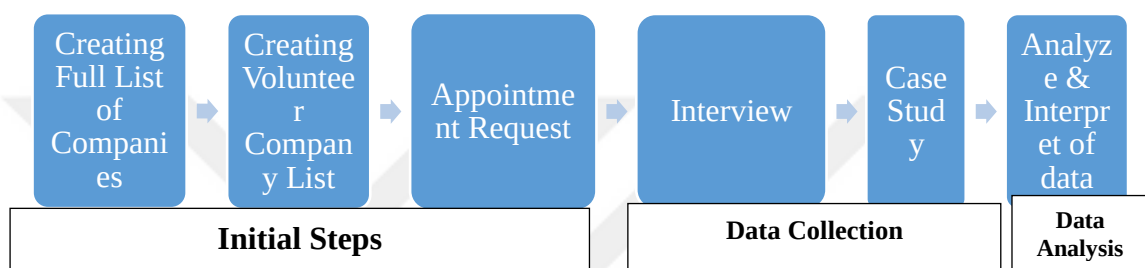


Figure 4.1: Steps of research

4.1. Interview

After appointment requests are returned with positive feedbacks, interview method is the initial data collection method of this study. In accordance with affirmative returns, there are 3 different companies who would prefer to contribute into this study. One is huge textile company, second one is a mining company, and third one is wall to wall carpet manufacturer. Before determining interview questions, these companies are investigated by white papers, some videos and some documents to understand why companies exist for.

In this section, all interview details are shown with questions and answers by companies. According to interviews, only answered questions by interviewed companies are shared in this section. Firstly, interview with textile company will be mentioned. This company did not prefer to share its name due to the privacy rights. Therefore, in this study, the company is labeled "Company A". Secondly, Eti Maden Company's interview will be shown. This company allows to share its name

after being sure that the researcher belongs to official university or institute. And lastly, interview with carpet manufacturer company will be shown. Also, sharing name of this company for this study is not allowed according to the company's privacy rights. Therefore, the company is labeled as "Company C".

4.1.1 Interview With Company A

Company A is one of the leader company at their market in Turkey. It has also really significant market share at foreign apparel markets. This company has manufacturing facilities, warehouses and distribution centers and retail stores. It produces all types of apparels such as shirts, neckties, trousers, socks, belts and some underclothes.

For this interview; Information Technology Department's Manager and his team attend on below questions. Interview is made within 2 times face to face meetings. And each meeting took approximately 1 hour. Interview questions and answers are as follows:

Before the interview, information was provided about the general contents of the questions. The manager and his team responded to the questions.

Interviewer: *In Company A's factories, raw-materials, semi-products and products are tracked in the supply chain steps (production facilities and warehouses) with which technology? (i.e. barcode, qr code, RFID)*

Manager of Company A: *All warehouse and logistics processes are monitored by RFID technology, production processes are monitored by barcode technology.*

Interviewer: *Since when has RFID technology been used?*

Manager of Company A: *RFID technology has been in use since 2014.*

Interviewer: *What kind of equipments are being purchased from the company that integrates the RFID technology into your company structure? Tag type (active, semi-active, passive RFID chip), antenna, hand-held terminal, printer, etc. what are all the hardware being used?*

Manager of Company A: *Label type received from the company is Monza R6P chip textile label. Donkey Station is purchased for tracking of hanging products. Tunnel*

Station is purchased for tracing packed products. Bluetooth handheld reader is an equipment which works as counting device for warehouse counting. Additionally, for RFID label printing, Sato RFID printers are purchased.

Interviewer: *What was the system used before RFID? How long has it been used?*

Manager of Company A: *Barcode technology was used before the RFID technology. And the use of this technology can be extended to the early 90's.*

Interviewer: *What is the quantity of products that is being produced in each facility? (Daily)*

Manager of Company A: *5000 pieces of textile products.*

Interviewer: *What is the quantity of products that comes out of a facility with label? (How many pieces products do come out without label?)*

Manager of Company A: *5000 pieces products, all is labeled. There is no unlabeled product, because at the end of production, orders are closed with barcode readings.*

Interviewer: *What is the quantity of defective / robust products coming out of all production?*

Manager of Company A: *There is 0.9% yield-deficient production. And all is being labeled as 2nd quality.*

Interviewer: *On the pallet jack, forklift, donkey, etc. In the whole production area, what is the quantity of finished products loaded on the product handling equipments?*

Manager of Company A: *3500 pieces of loads are being shipped. Most of the shipment is made with hang donkeys.*

Interviewer: *What is the quantity of the warehouse entry of finished products that*

have become ready for sale?

Manager of Company A: 3500 pieces of products from the production is being shipped. Additionally, daily of 2000 pieces of sub-production is being shipped as well.

Interviewer: What is the quantity of product/box/pallet which is transported by warehouse transportation equipment and loaded on the shipment vehicle (truck, etc.)? (daily or weekly)

Manager of Company A: 1000 boxes are transported and loaded on the shipment vehicle per week. And the number of hanged products is around 10000 pieces.

Interviewer: At the beginning of the supply chain process, what is the planned product quantity in production? And what is the actual quantity of products sent to the finished product warehouse? (daily or weekly)

Manager of Company A: It is accepted that there is 3% tolerance between planned and actual production. So the difference is maximum 3%.

Interviewer: With the previous system, to what extent could the firm reach the same actual production rate or shipment rate?

Manager of Company A: It could reach the same with the previous system, but the cost of accessing the data was higher, because it is performed the same operations with more staff for a longer time.

Interviewer: What was the actual total quantity of shipped products in the last shipment? And what was the planned quantity at last shipment?

Manager of Company A: 40000 units are shipped and planned quantity was same with actual one.

Interviewer: What is the error detection rate (%) during the quality control processes?

Manager of Company A: Error detection rate is about 0.9%.

Interviewer: How has the detection rate of errors during operation improved

compared to the previous system?

Manager of Company A:*According to new technology, detection of errors reaches 2.5 times faster than previous system. Additionally, accuracy has increased.*

Interviewer:*How many RFID chip labels are purchased annually?*

Manager of Company A:*Yearly, 8000000 pieces (Reusable labels are included.)*

Interviewer:*How is RFID chip label unit cost?*

Manager of Company A:*The price of the RFID tag is determined inversely proportional to the quantity. Currently, prices range from 0.1 USD to 0.04 USD depending on the ordered quantity.*

Interviewer:*What are RFID reader, RFID antenna, RFID handheld reader, RFID printer types that Company A uses? How are their unit costs?*

Manager of Company A:*RFID readers are about 2000 USD, printers are about 2200 USD, industrial readers are about 15000-18000 USD.*

Interviewer:*What is complementary software for RFID system integration? How is the cost of it?*

Manager of Company A:*According to the user's request, the RFID system can be integrated into the fully used ERP or the system can be used as an interface without full integration. The software cost for an average RFID project is around 80000 USD.*

According to above interview, it shows that Company A is able to track its products by RFID technology after production process. Before RFID technology, Company A was using barcode technology. Once both technologies are compared, detection of missing items is 2.5 times faster and accurate than previous system.

On the other hand, even if Company A is already experienced about RFID technology at their supply chain processes since 2014, it still need to spend more time to integrate this technology into its other steps. During warehouse management and logistics processes, Company A is really satisfied about service of RFID technology. For the whole process, even accuracy of this tracking system is so high, cost of RFID technology integration into manufacturing processes cannot bring any

competitive advantages within today's purchasing costs as manager of Company A says. Therefore, Company A needs to wait till they find better products & services within lower costs about RFID technology.

Thanks to RFID technology, once asked to manager about total quantity of last loading during logistics process, Manager of Company A is able to make retroactive detection. Accessibility of information in any time is possible, speed of technology during operation, accuracy, security and sustainability of all these are significant services that RFID technology provides. And Company A is more satisfied than previous barcode technology thanks to these services.

On the other hand, once Company A compares operation process of production and logistics, managers think that to reach today's actual rates, quantities, they had to spend more time with more staff which is more costly for the company.

Lastly there are given RFID software and hardware costs with all specifications. According to above interview, Company A allocates budget to RFID label approximately 320000 - 800000 USD / yearly which is really significant value. The RFID label that the Company A uses is such a customized RFID label which is proper to track apparel materials. Beside monetary investments into this technology, it is obvious that Company A pays attention for creating a know-how about RFID to get better service as well.

4.1.2. Interview With ETI Maden Company

Another interview was made with Eti Maden General Directorate. This company is a mining and chemical company. It produces boron minerals and its derivatives in Turkey as owned by public.

The general outlines of the interview questions and the responses of the information technologies department's chairperson in Ankara. Interview meeting was made within one time. And it took approximately 2 hours. Details of interviewis observed at below:

Interviewer:*In Eti Maden Factories, what technology is applied for the product tracking during and after the production process? (barcode, qr code, RFID)*

Manager of Eti Maden Company:*Manual tracking is carried out in manufacturing processes. The products from the production are labeled with RFID chip labels*

during packaging. Labeled products are shipped into warehouse. The tracking process is done for correct boxing, correct shipment (which product is being handled with which vehicle), instant storage stock information. There are RFID fixed readers on the entry and exit of the warehouse and on the forklifts. It was aimed to minimize the margin of error in warehouse shipment process.

Interviewer:For how long RFID has been used? How was the integration process?

Manager of Eti Maden Company:Eti Maden has started to use it since June, 2016. RFID technology has been integrated into Eti Maden's area as a part of an Enterprise Resource Management System project by an RFID technology integration company. RFID technology has been applied in Eti Maden warehouse, logistics and product packaging processes and integration with ERP has been ensured.

Interviewer:What are label types (active, semi-active, passive RFID chip) being purchased from an RFID technology provider? What are the hardwares; as antenna, handheld reader, printer, etc.

Manager of Eti Maden Company:Passive RFID chip label, RFID fixed reader, RFID Antenna, RFID handheld terminal reader and RFID printer are all purchased from companies that provide RFID technology. They are all passive RFID chip labels.

Interviewer:What is the system used before RFID? For how long had it been used?

Manager of Eti Maden Company: In the packaging and logistics processes, manual and individual tracking was used before. Measuring systems as weighbridge etc. were the methods used in the tracking and counting processes. Ton based shipment is being done.

Interviewer:What is quantity of the product that comes out of the relevant location of a warehouse or facility? (Annual)

Manager of Eti Maden Company:Annual (2016) 1800000 tons of products were labeled in the warehouse and shipped.

Interviewer:What is the quantity of labeled product units being shipped from a

warehouse or company's facility? (Is there any unlabeled products, if so how many quantities?)

Manager of Eti Maden Company:Unlabeled product is not shipped to warehouse. All products are tagged with RFID chip labels before warehousing. Both what we call as Big Bag and 50 kgs of packages are being tagged for warehousing. Each product is labeled with one RFID chip label.

Interviewer:What is the defective / robust product rate coming out from the relevant location of a warehouse or facility? (Daily or weekly) order based?

Manager of Eti Maden Company:There is no defective product output. When the defective outputs reach the warehouse process, the quality control tests are being made to recover them from the previous process. Therefore, there is no defective product being shipped. There is also no defective product as output.

Interviewer:Pallet jack, forklift, donkey and etc. In the whole warehouse area, what is the quantity of finished products loaded on handling equipments?

Manager of Eti Maden Company:On a pallet jack, 1 ton big bag can be loaded. Details of the product specifications of the boxes is dispatched by the RFID readers or handheld terminal readers on the forklift which are displayed on the system in order to instantly check if the shipping of the correct box (order) has been carried out and to send backwards as needed.

Interviewer: What is the number of the box /big bag in the storage process that enters the daily or monthly / yearly warehouse?

Manager of Eti Maden Company:There are many warehouses in the region. It can be said that the total annual output of all the warehouses is 6700 tons per day. So, according to orders that sales team receive, can be mentioned as 6000 tons / day (6000 tons package) and 700 tons of bulk production. There is no stable performance for each month. However, an average of 168000 ton / month production input can be received monthly. On average, 150000 ton / month packed (150000 tons of packages), 18000 tons of bulk goods per day can be gathered.

Interviewer:Is the quantity of product loaded on the shipping vehicle (truck, etc.) by

a warehouse transportation equipment?

Manager of Eti Maden Company:Tracking is done through Package & box. 96% of the sales are export businesses. The average of total sales in accordance with 12 months is 180000 tons / month.

Interviewer:What are the production quantities that are planned at the beginning of the supply chain and are shipped to the finished product warehouse? (daily or weekly) With the previous system, to what extent could the firm be reached?

Manager of Eti Maden Company:Managers in the production and the warehouse did manual the tracking process before. This means that after the integration of RFID technology, there is a maximum performance increase for accuracy and retrospective detection in warehouse and logistics processes.

Interviewer:How many RFID labels are purchased annually?

Manager of Eti Maden Company:1800000 pieces per year for all the warehouses.

Interviewer:How is RFID chip label unit cost?

Manager of Eti Maden Company:Label unit cost range is between 0.10 USD - 0.20 USD. It can change according to demanded quantities. There is an inverse relationship between ordered quantities and unit price according to the content of the order.

Interviewer:What are the RFID reader, antenna, handheld terminal reader, printer types?

Manager of Eti Maden Company:

Table 4.1: RFID Sets and Quantities of Eti Maden Company

RFID SETS	NUMBERS
BARCODE READER, PLUG PRINTER, WEIGHTER INDUSTRIAL	6
BARRIER (INCLUDING ARM, BASE, SENSOR, CONTROLLER)	24
BARCODE READER, INDUSTRIAL, 25-50KG FILLING STATION	40
BARCODE READER, PLUG PRINTER (WEIGHTER)	13
BARCODE READER, PLUG PRINTER (INDUSTRIAL TYPE, WEIGHTER)	8

COMPUTER AND MONITOR (WEIGHTER STATION)	34
HAND TERMINAL GSM QUAD, GSM RFID READER AND CHARGER UNIT	15
HAND TERMINAL, RFID READER AND CHARGE UNIT	121
PRINCIPAL PRINTER (WEIGHTER STATION)	18
LED PANEL (WEIGHTER STATION)	27
PC DOCK AND ANTENNA (FORKLIFT PANEL)	11
RFID ANTENNE (SILO CONTROL)	17
RFID ANTENNA (PORT SUBWAY STATION)	2
RFID READER AND ANTENNA (4 PORTLETS) (WEIGHTER STATION)	26
RFID READER (4 PORTLETS) (WEIGHTER STATION)	6
RFID READER (SILO CONTROL SYSTEM)	17
RFID READER AND ANTENNA (FOR FORKLIFT)	9
RFID READER AND ANTENNA (FORKLIFT)	35
RFID READER, LAMP AND ANTENNA (SILO CONTROL SYSTEM)	1
RFID AND BARCODE LABEL PRINTER	51
TABLET PC (FORKLIFT TERMINAL WI-FI, BTOOTH, GSM & GPS)	8
TABLET PC, DOCK PC AND ANTENNA (FORKLIFT)	16
TABLET PC, DOCK PC AND ANTENNA (FORKLIFT TERMINAL WI-FI, BTOOTH, GSM & GPS)	9
TRAFFIC LAMPS - (2 RED / 1 GREEN)	31
TRAFFIC LAMPS - (3 RED / 1 GREEN)	1
TRAFFIC LAMPS - (3 RED / GREEN) (SILO CONTROL)	17
UPS - FOR SCALE STATION COMPUTERS	34
UPS - FOR BACKUP CONSUMERS	4
USB RFID CODING	22
TOTAL	623

Interviewer: What is the complementary software system for the integration of the RFID system? What is it cost?

Manager of Eti Maden Company: There is software developed in-house for the tracking process. There is no commercial cost, no commercial service value.

According to above interview with Eti Maden Company, some significant points must be specified.

First of all, while the company manages the product tracking process manually for many years, providing the transition to RFID technology can be regarded as a very significant and positive radical decision on technological investment.

Although the big bag sizes of the products are very large, the tracking process with RFID has given operational speed to warehousing and logistics processes.

The RFID labels used are affixed to the big bags of finished products. The use of passive RFID labels has reduced costs. However, these labels cannot be used during production process for tracking materials, because these labels are not resistant to chemical reactions.

Eti Maden is able to do retroactive inspection for warehousing and logistics processes. The company can monitor the ton-based, retroactive warehouse and shipment quantities once requested. This brings accessibility of information like Company A thanks to RFID technology.

When the purchasing price of the RFID labels is compared between Eti Maden and Company A, Eti Maden purchases RFID labels through more expensive per piece price than Company A purchase. There might be two reason of this situation; one is about ordered RFID label quantities of Eti Maden is less than Company A's ordered quantities in yearly. And the other reason might be about technical specifications of RFID labels. It is obvious that even Company A uses customized apparel passive label, purchased passive RFID label by Eti Maden must be more specific than apparel label. Because one company is tagging apparel materials and products, the other one is tagging finished chemical products. Resistance and read range of RFID label for Eti Maden must be more specific and better quality than the apparel company has.

Once technological devices are compared with both companies, Eti Maden and Company A, it is shown that Eti Maden has more devices during warehouse tracking system. This means, tracking process might be more complicated than Company A has for Eti Maden. Additionally, it is more costly for Eti Maden. However, Eti Maden is able to close the cost barrier thanks to their specific own

software that they use for monitoring RFID tracking system. Eti Maden does not have such a yearly cost like Company A has about software of RFID tracking system. Company A applies support from outsider which is RFID technology service provider but Eti Maden is able to do it through their engineers and know-how about technology.

Indeed, it is so interesting that Eti Maden manages warehouse and logistics tracking as manually by many years. However, immediately, they have applied to technological innovation to move with RFID technology at June, 2016. Moreover, Eti Maden is able to monitor this technology at their own software which brings also more security about privacy of internal operations. Additionally, they do not mark this software service with any price to apply for commercial business through this service.

4.1.3 Interview With Company C

Below are interview questions and answers that are made with a manufacturer of carpets such as wall to wall carpets. This company produces painted and unpainted carpet and some luxury furniture. The company which makes use of the latest technology that has brought the requirements of industrial revolutions into its structures. There are lots of manufacturing facilities which belong to this company in all around Turkey. They sell their products into both domestic and foreign markets.

IT manager, production department team leaders, warehouse management team and logistics department attend on this interview. This interview contains 2 times meeting. And each meeting took 45 minutes. According to the interview, details are share at below:

Interviewer: *In the factory, what technology is applied for tracking during the manufacturing and warehousing process (barcode, qr code, RFID)*

Manager of Company C:*Both barcode and RFID technology.*

Interviewer:*For how long, RFID has been used?*

Manager of Company C:*It has been two years until now.*

Interviewer:*What is the label type (active, semi-active, passive RFID chip) from an*

RFID technology provider, and what are all the hardware including antenna, handheld terminal reader, printer, etc.?

Manager of Company C:*Passive RFID chip labels, RFID antenna, handheld terminal reader (Motorola MC3190z handheld terminal reader)*

Interviewer:*What is the system used before RFID? How long has it been used?*

Manager of Company C:*Barcode label was used for 10 years, and for the last 2 years both barcode-rfid have been used.*

Interviewer:*What is the quantity of products coming from a production line or all production facilities?(daily)*

Manager of Company C: *9,264,332.33 m2 - 92835 units.*

Interviewer: *What is the quantity of labeled product from a production line / all production line? (does any unlabeled product come out?)*

Manager of Company C:*There is no product without label. Even defects are being labeled.*

Interviewer:*What is the rate of defective / robust production from a production line / entire production? (daily basis per year)*

Manager of Company C:*19,269.25 m2 - 385 units is the number of defective units, and 9,245,063.08 m2, 92450 units complete products.*

Interviewer:*What is the quantity of the finished products that are ready for sale? (daily basis per year)*

Manager of Company C:*92835 units.*

Interviewer:*What are the product quantities / box quantities / pallet quantities (according to the loading scheme) to be transported by warehouse transportation equipment and be loaded on the shipment vehicle such as truck? (daily basis per year)*

Manager of Company C:*81737 units (1 Roll: 4X25m)*

Interviewer:*What are the quantities for the planned output and finished product in*

the warehouse to be shipped? With the previous system, to what extent could the company better off?

Manager of Company C:*Automated entries are highly recognized to be traceable without human factor.*

Interviewer:*What is the most recent actual shipment rate/ planned shipment rate?*

Manager of Company C:*53 units, 5771.20 m²*

Interviewer:*What is the error detection rate (%) in the quality control processes? How were the detection rates in the previous system?*

Manager of Company C:*1.8% -3.2%*

Interviewer:*What is the annual quantity of RFID chip labels being purchased?*

Manager of Company C:*100000 pieces (most of them are non-disposable labels to be used for 1-2 years).*

Interviewer:*What is RFID chip label unit cost?*

Manager of Company C:*100000 units (0.18 USD /unit)*

Interviewer:*What are RFID reader, antenna, handheld terminal reader, printer types? How are their unit costs?*

Manager of Company C:*Handheld terminal reader (1 pcs motorola zebra mc3190z rfid, costs 1975 USD). Warehouse door readers 12 pieces (all is 60.000 USD, per piece price of these door's readers approximately 5000 USD)*

Interviewer:*What is the complementary software system for the integration of the RFID system? How is it cost?*

Manager of Company C:*Software is integrated to our own ERP system by us.*

According to above interview, Company C uses both barcode and RFID technology simultaneously. So currently, the company still at the transition process between barcode to RFID technology. It shows that even the company has been using RFID technology for 2 years, it may take more time to integrate this technology into all steps of supply chain. There might be some internal and external reasons. As an example of external reason, cost of purchasing RFID devices within

today's per piece cost might be not suitable to budget of Company C. Other than this, as an internal reason; there are many supply chain rooms, steps at Company C which makes more complicated to integrate RFID technology into whole organization chart in short time.

During supply chain steps, there are many varieties and many quantities of RFID devices that are using for tracking. One of the main reason can be about many steps at Company C's supply chain. And other reason is tracking method that they use. Company C is really strict to minimize loss of items. For example; in one step, there are fixed readers on forklifts to track what forklift driver remove from the room. To support accuracy of transportation between steps there are handheld RFID terminal readers as well. Additionally, there are RFID fixed readers at the door of rooms which tracks entrance and exit of the materials flow.

Retrospective or instant item entry and exit quantities and defected quantities can be seen in the system very easily. This means accessibility of information is fast and easy thanks to RFID technology.

Company C prefers to tag even defected items during production rooms. To make long term production process performance analysis and assessments, it is very important that even the defective items are labeled. Therefore, once the administration thinks that problem occurs, they can directly focus on the problematic part thanks to RFID.

According to type of RFID labels, Company A and Company C might be using same type of RFID labels to track items during supply chain processes. Because, raw materials of both company that uses for production is thread. Therefore, passive RFID chip labels are being used.

Lastly, there is one comparison about annual quantities and its per piece prices for Company A, Eti Maden Company and Company C.

Ordered RFID label quantities annually for Eti Maden Company and Company A is more than Company C has ordered. Additionally labels are not disposable labels for Company C. Thus they can use same labels with a few more usage.

According to capacity of annually ordered labels and technical specification of labels that Company C uses such as; type of label, reading range of RFID chip etc. Per piece price that Company C purchase by might be normal. So it is higher than others' prices. Company Eti Maden and Company A has ordered more quantities in a year might be a reason of differences between per piece prices.

4.1.4 Comparative Analysis

This step can be seen as general outline of above interviews. Table 4.2 shows general view of interviews with Company A, Eti Maden and Company C through qualitative and quantitative data.

Table 4.2: Comparative Analysis

COMPANY A	ETI MADEN COMPANY	COMPANY C
Before RFID technology, barcode was used. And both technologies are still being used.	Before RFID technology, manually tracking method was used.	Before RFID, barcode was used. And both technologies are still being used.
Earliest application between these companies to RFID technology has made in 2014 by Company A. Now it has 4 years experiences.	Only two years experience about RFID technology using. Application date is June, 2016.	3 years experiences about RFID technology using. Application date is beginning of 2015.
RFID is being used at warehouse tracking.	RFID is being used after production is finished.	RFID is being used at all steps.
Customized RFID chip label	Passive RFID chip label	Passive RFID chip label
Have support about software from outsider company.	Have own software about ERP system	Have own software about ERP system
Lowest per piece price for RFID label	2nd lowest price for RFID label	Higher per price than other 2 companies about RFID label
4 steps in supply chain; textile manufacturing facility, distribution centers, warehouses and retail stores	3 steps in supply chain; manufacturing facility, distribution center, warehouse	6 steps in supply chain; TMPR, CWR, SR, CPR, CCR, FPW
High level of accuracy for	High level of accuracy for	High level of accuracy

detection	detection	for detection
RFID label, reader, antenna, printer and software	RFID label, reader, antenna, printer and software	RFID label, reader, antenna, printer and software
Volume of labeled materials are lowest one	Volume of labeled materials are biggest one	Volume of labeled materials are middle one
Quantity volume of products are biggest ; 8M pieces yearly RFID label	Quantity volume of products are big, yearly 1.6M pieces RFID label	Quantity volume of produce products are lowest one; yearly 100.000 pcs
RFID labels are reusable	RFID labels are reusable	RFID labels are reusable
Daily production capacity is 5000 pieces textile products	Daily, 18000 tons bulk production	Daily, 92835 pieces carpet produced
Defect rate is around 0,9%	No defective products as output	Defect rate is around 0,4%.

Company A still uses both technology RFID and barcode during items tracking. Tracking process starts with barcode technology especially at the production department. Once goods become finished products; before and during packing, Company A uses RFID technology. This is the most experienced company between above companies by 3 years. According to its experiences, it has customized passive RFID label which is suitable for tracking apparel items. Yearly quantity of these labels are 8 million pieces. This quantity is largest one between above companies. Therefore, per piece price of label that they purchase is more competitive.

According to RFID project, Company A gets support from RFID technology services and products provider companies. This is an open market and competition is tough. Thanks to competition between RFID technology provider companies, Company A can receive reasonable price quotations for devices and software

supports.

Eti Maden Company is the one which does industrial revolution through applying RFID technology at its supply chain while managers were following manually tracking method before June, 2016. And Eti Maden Company even did not prefer to take barcode or qr code systems as initially. It directly moves to catch today's technology which is RFID. It uses also passive RFID label like Company A does. But quantity of labels is not that much big as yearly. Therefore, cost of these labels for Eti Maden Company is a little bit higher than Company A has. Labels are being used after production is finished. During packaging and warehousing, traceability of these products is the main aim of using this technology.

Company C uses both RFID and barcode technology. According to manager of Company C, both technologies also can be using as complementary rather than substitute. So, Company C is one of the good example of this opinion. For this company, supply chain steps are more and complicated than others. Therefore, Company C takes care of flows between steps and flows within steps. Thanks to RFID technology, Company C can detect loss items or defected items from system once it is required.

Lastly, in accordance with 3 interviewed companies' satisfied services of RFID can be mentioned as accessibility of information, traceability, detection of loss and defected materials, speed and accuracy etc. Other than these, there are also some qualifications which must be improved by technology's service providers such as more competitive prices for all devices and software, better quality RFID labels with more reasonable prices. All above companies which are customer of RFID technology actually satisfied but they demand also better quality day by day to have more accurate results during production and operation. For example, currently, semi-active or active labels are really expensive than passive RFID chip technology. And demander of this higher level technology thinks that today's prices are exaggerated. Therefore they did not apply on it. Once, today's technology will not satisfy enough to customers, RFID companies will have to become more competitive about next level of technologies to conquer market.

4.2. Case Study

In this case study, the processes about the supply chain steps of the interviewed Company C were interpreted. According to this case study, dataset includes 31 days activities of 2017 in January. This company works full time during a day. It has 3 periods according to its working schedule in a day. And each of period is 8 hours. Additionally, there are 6 different steps in Company C's production line. So, 3 periods of a daily production follows these 6 steps transition processes. In the dataset, there are lines of each days. These lines divided into 3 periods in a day. And at the top, there are supply chain steps which are 6 different steps. This dataset shows that how items flow between steps within periods. And it also shows that how items flow within steps as input and output during all periods. Thus, all data are collected through this dataset helps to researcher to make statistical analysis with its quantitative data.

All this interview and dataset creation process took a total of 45 days between the researcher and the Company C. The departments that are in contact during this period are: IT department, logistics department, production department, chief responsible for chambers and warehouses.

The company produces printed and unprinted carpets aswall to wall. They produce carpet materials themselves.

There are production departments as thread material production room (TMPR), carpet weaving room (CWR), stove room (SR),carpet printing room (CPR), carpet coating-finishing room (CCR), finished product warehouse (FPW). The goods follow their own routes during production process and all goods are labeled before leaving from its current production step.

Input-output movements of semi-finished items occur in the facilities. Forklift operators carry items with its fixed RFID readers. Additionally, there are handheld readers and door readers to support tracking process.

By these process:

- The human error factor has been reduced the most.
- Where the desired product is located can be found easily(traceability)
- Duplicate barcode formation is prevented.

- Finished and semi-finished warehouse counts are very fast and controlled.
- Automatic (INPUT-OUTPUT) current inventory tracking with door automations is obtained.
- Automatic reading of the second movement of the products read by RFID in the shipment and counting enabled the company to move efficiently.

After above brief information about Company C, there are more details about the process of supply chain management. The details between the departments are as follows:

1. Thread Material Production Room (TMPR): Here, the quantity of thread materials are to be produced weekly, daily or periodically according to the production order instructions which are determined together with their formulations. Polyamide and polypropylene materials are produced here. Relevant work order is determined after the approval of the general directorate after the work of the production manager and team, sales manager and team leaders. The required pieces for the materials are entered into the machines as formulations on the basis of the final state of the carpets to be produced as finished products in the order. Thread materials are labeled and palletized to be sent to the next department. Thanks to the RFID reader on the forklift, the thread is monitored in the production facility during shipment. Also, thanks to the fixed readers at the exit door of the thread material production room (TMPR), the system is able to record quantity of checked out from the room. Defective products can appear in this room. But, they may be recycled, and also cannot go out from thread material production room (TMPR).

2. Carpet Weaving Room (CWR): The items coming out of thread material production room as pallets enter the carpet weaving room with the forklift, and the input data in the system drops due to the readers in the entrance of the room. Here, thread materials coming out of thread material room for weaving according to the planned weaving orders. Defective material or parts with production defect can be found in the weaving room. It can be recycled within itself. After the weaving, the items that are labeled again with shift to the next step with the forklift. Some of the orders are sent directly to stove room, according to the order.

3. Stove Room (SR): Some of the weaving rolls that exit with the forklift from the carpet weaving room, enter the stove room directly, and only the cutting operation is carried out from here to the finished product warehouse. This room is for unprinted and uncoated orders and cut of woven rolls. Then, the labeled products exit with forklift and the ready-to-ship finished product is shipped to the warehouses to be shipped.

4. Carpet Printing Room (CPR): The pieces except the ones going to the stove room with the work order are shipped to the carpet printing room. Here, they go into the printing process and then get over to the coating room. This department also has defective products detections originating from printing fault. After printing, the labeled rolls are transported to the coating room with the forklift. The inputs and outputs fall into the system through RFID reader on the forklift and in the gate.

5. Carpet Coating-Finishing Room (CCR): In this step, the printed product pellets are passed through the coating process according to the work order, and after cut and coating process, they are sent to the finished product warehouse with finished product labels in rolls. The forklift is used as the transport equipment and the follow-up process is carried out with the RFID readers on the forklifts. In this departments, too, there might rarely a coating fault and cut fault.

6. Finished Product Warehouse (FPW): This warehouse is stored in the shelf system in order to wait for shipment of carpets that have been cut both in the stove and finished product operations (but not printed), as well as printed and coated operations. RFID chip labels and readers on the forklift support the process. So, the right product can be placed on the right shelf by the forklift during the warehousing process. In addition to this, in order to control the forklift element which fulfills the shipment order in the day/period, handheld terminal readers are used for accurate storage of product, and correct shipment.

The supply chain steps of Company C can be shown in figure 4.2:

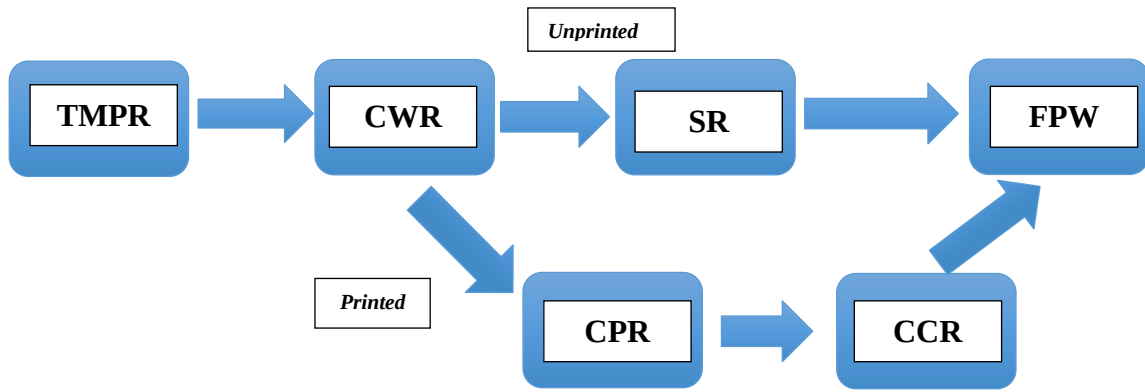


Figure 4.2: Supply Chain Steps of Company C

According to this supply chain process, it appears that materials flow between steps/rooms. And there are also input and output flows within steps. According to this route and dataset that Company C shares with the researcher, it is possible to make statistical analysis thanks to RFID technology. And also, it is possible to interpret supply chain steps according to this statistical analysis. There are 2 different analysis studied by the researcher; one is “Flows Between Steps” which analyzes flows of items per day. The other one is “Input and Output Flows Within Steps” which analyzes flows of input and outputs at production rooms within 31 days in January, 2017 and 3 periods per day.

Before observing analysis, there is one exceptional case about stove room. When CWR department send out all items to next step, unprinted items follows to catch SR, and printed items follows to catch CPR departments. Therefore, if SR has items as “a” percent, CPR will have “100-a” percent. While examining performance of steps about flows, this case must be exceptional.

4.2.1. Flows Between Steps (In %, average)

According to supply chain process of Company C and materials flow, thanks to RFID technology, flows between steps can be examined. Within this analysis, detection of defected, loss materials with quantities can be observed.

As an exceptional case, there are 2 flows, one is from CWR to SR can be calling as “a” percent, the other flow is from CWR to CPR can be calling as “100-a” percent as theoratically. Therefore, flows from SR to FPW is not such a

significant data. As it is mentioned above at the stove room, there is no specific operation about production at stove room. So, all products go to finished product warehouse with no loss. While examining performance of steps about flows between steps, this case must be exceptional.

Result of data can be seen at below Table 4.3:

Table 4.3: Flows Between Steps (in %, Average)

FLOWS BETWEEN STEPS (in %, average)						
	TMPR TO CWR	CWR TO SR	SR TO FPW	CWR TO CPR	CPR TO CCR	CCR TO FPW
1st period	100.0000	34.0160	100.0000	65.9840	99.9980	100.0000
2nd period	99.9964	35.9420	100.0000	64.0579	99.9982	99.9989
3rd period	99.9953	36.4759	100.0000	63.5240	99.9977	99.9996

According to above table, there are 2 different colored columns which are blue and yellow. Blue means significant problem appears at that column. Yellow means there is no significant problem about flows between steps.

Initially, the most problematic flows can be seen as CPR to CCR. Because, all periods at that flows between these steps have lower value than 100%. This means, there are some loss of items or defected items as detected thanks to RFID technology. Thus, administration of Company C can focus at this step to fix problems.

Secondly, there is a blue color which can be calling as signal of significant problems at 2nd period of TMPR to CWR flow. At that flow, value is lower than 100% which means that actual quantity is lower than planned one. So, there are possibly defected items or some loss items cannot reach to the next step. For this flow, same problem has appeared at the 3rd period as well. Color is blue, value is lower than 100%. Indeed, there is also possibility that at this flow, producing thread materials are doing by machines with its formulations. While giving formulation with planned output quantity, sometimes machine may have lower actual result of produced thread materials. So, it is also one of the possibility of lower actual value. If the first period would have same significant problem, it could be accepted as

exceptional case, but now there is no loss at first period. So, even if it happens just because of machine, loss is loss at the actual output. Detection of the problem can be evaluating by administration of Company C.

Thirdly, there are also blue colored columns for flows between CCR to FPW at second and 3rd periods. This means there are also losses or defected products during catching last step of supply chain. And it is detected by RFID technology. Thanks to this technology, manager can focus on the periods which have lower value than 100% for last flow of supply chain.

Lastly, at this analysis, RFID is the initial complementary to detect and solve problems through flows between steps of supply chain with it periods.

4.2.2. Input and Output Flows Within Steps (In %, average)

This analysis tracks flows of items at Company C's input and output values for all steps. On the other hand, it can be labeled as internal performance analysis of all steps. Moreover, at the dataset, input quantity and output quantity are observed. At Table 4.4, resemblance between input quantity and output quantity are shown. If there exist full of resemblance between input and output quantity of a step, the value must be written on Table 4.4 as 100%.

Here is also an exceptional case about SR. This step has no significant operation, therefore there is no defection.

According to input and output flows within steps (in%, Average) results, Table 4.4 shown at below:

Table 4.4: Input and Output Flows Within Steps (In%, Average)

INPUT AND OUTPUT FLOWS WITHIN STEPS (In %, average)					
	TMPR	CWR	SR	CPR	CCR
1st period	99.9682	99.9683	100.0000	99.9030	99.9532
2nd period	99.9672	99.9759	100.0000	99.9533	99.9850
3rd period	99.9702	99.9674	100.0000	99.9582	99.9785

Above table shows that there are flows between input and output of each steps as internal. According to result of above table, except SR, there are significant data for all steps and periods. All columns are lower than 100% which means that during input and output flows within steps, there are loss of items and defected items as detected by RFID technology. Probably, only first step of CPR and CCP must be checked by managers because, there are a little bit lower values for these steps than others. Thanks to RFID, all loss of items and defected items are detected.

Additionally, there is one more method which measures loss of items within steps in daily. The results about daily loss of items are shown at below table:

Table 4.5: Loss of Items Within Steps (In %, Average)

LOSS OF ITEMS WITHIN STEPS (In %, Average)					
	TMPR	CWR	SR	CPR	CCR
Daily	0.0939	0.0883	0.0000	0.1853	0.0832

Table 4.5 includes loss of items within steps during a day as an average. It is detected by RFID technology to collect all quantitative data about loss of items at each steps as internal. However, the most significant quantitative data is from CPR according to result. Value is the highest one between other average values. So, RFID is the key here for administration of Company C. According to above results, manager of production and other administrators need to focus at carpet printing process, because during printing, the most defection or loss appear at that step.

Additionally better all of these tables, there is an analyzing method which is calling as ANOVA (analysis of variances) will be shown at below.

4.2.3 Anova

While applying this method, quantitative dataset of Company C is used which are 31days in January, 2017, 3 periods per day with all supply chain steps. Within this method there is also one exceptional case which is SR. This step is removed from Anova method because, there is no significant data to use for analysis.

Main research question of applying Anova method is explained at below:
Are there any significant differences between any steps or any periods during input and output flows? This is the aim of doing this analyze.

According to this method, initially, the hypotheses which one required to be tested are represented as follows:

H_{1-0} : There is no significant difference between periods in input and output flows of TMPR.

H_{1-1} : There exists significant difference between periods in input and output flows of TMPR.

H_{2-0} : There is no substantial difference between all periods at input and output flows of CWR.

H_{2-1} : There is a substantial difference between all periods at input and output flows of CWR.

H_{3-0} : Here does not exist critical difference among all periods at input and output flows of CPR.

H_{3-1} : Here exists critical difference among all periods at input and output flows of CPR.

H_{4-0} : There is no meaningful difference between 3 periods at input and output flows of CCR.

H_{4-1} : There is meaningful difference between 3 periods at input and output flows of CCR.

Above hypotheses are tested by Anova analysis. Result of this analysis can be given in below tables:

Table 4.6: ANOVA result for H₁ (TMPR)

Source	DF	SS	MS	F	P
Factor	2	0.00014	0.00007	0.06	0.944
Error	90	0.11227	0.00125		
Total	92	0.11241			
S = 0.03532 R-Sq = 0.13% R-Sq(adj) = 0.00%					
Level	N	Mean	St. Dev.		
Period 1	31	99.9686	0.0365		
Period 2	31	99.9672	0.0471		
Period 3	31	99.9703	0.0139		
Pooled St. Dev. = 0.0353					

Since p-value of 0.944 is greater than 0.05, we cannot reject null hypothesis which says there is no significant difference in input and output flows of TMPR between periods. Moreover, once examining through all meanvalues of periods, values are really close to each other. Even if mean values are close to each other, we can observe that there are approximately 0.03 losses for 3 periods. Therefore, thanks to RFID technology, we can say that there is no such a significant difference during input and output flows between three periods as detected. And there are some losses for each periods. After testing by Anova Method, managers of Company C are informed about this result.

Table 4.7: ANOVA result for H₂ (CWR)

Source	DF	SS	MS	F	P
Factor	2	0.00014	0.00007	0.06	0.944
Error	90	0.11227	0.00125		
Total	92	0.11241			

S = 0.03532 R-Sq = 0.13% R-Sq(adj) = 0.00%

Level	N	Mean	St. Dev.
Period 1	31	0.03138	0.03648
Period 2	31	0.03279	0.04709
Period 3	31	0.02974	0.01391

Pooled St. Dev. = 0.03532

According to above Anova Test result, we can say that since p-value of 0.944 is greater than 0.05, we cannot reject null hypothesis. Null hypothesis says that there is no substantial difference at input and output flows of CWR between all periods. So, tracking system of items which is RFID technology proves that Company C might be good at CWR for each of the periods even if there are losses as small value. In accordance with this result, there is no significant difference at input and output flows between all periods within this step as recorded. All results about analysis are shared with administration of Company C.

Table 4.8: ANOVA result for H₃ (CPR)

Source	DF	SS	MS	F	P
Factor	2	0.05785	0.02892	7.89	0.001
Error	90	0.32994	0.00367		
Total	92	0.38779			

S = 0.06055 R-Sq = 14.92% R-Sq(adj) = 13.03%

Level	N	Mean	St. Dev.
Period 1	31	99.9031	0.0975
Period 2	31	99.9534	0.0310
Period 3	31	99.9582	0.0231

Pooled St. Dev. = 0.0605

Since p-value of 0.001 is lower than 0.05, we reject null hypothesis. The rejected null hypothesis at above Anova Test says that significant difference exists at input and output flows of CPR among all periods.

Detection by RFID technology shows that flows of items at the carpet printing step between all periods may have critical difference according to p-value result. So, there might be some significant reasons to focus and examine CPR's performance by administrative. According to summary statistics represented in Table 4.8, average of period 1 is different than others. Period 1 has lower value than other periods. This means that there is more significant difference in negative way for first period. So, managers of Company C have informed about the result. They will evaluate the reasons and find some solutions to increase performance of CPR at first period.

Table 4.9: ANOVA result for H₄ (CCR)

Source	DF	SS	MS	F	P
Factor	2	0.01749	0.00875	3.57	0.032
Error	90	0.22030	0.00245		
Total	92	0.23779			

S = 0.04947 R-Sq = 7.36% R-Sq(adj) = 5.30%

Level	N	Mean	St. Dev.
Period 1	31	99,953	0.075
Period 2	31	99,985	0.020
Period 3	31	99,979	0.035

Pooled St. Dev. = 0.049

Since p-value of 0.032 is lower than 0.05, we reject null hypothesis. Rejected hypothesis says that there is a meaningful difference at input and output flows of CCR between 3 periods. According to summary statistics shown Table 4.9, first period of CCR has significant difference once it is compared with other periods. The value of first period is lower than others which may show that period 2 and period 3 have more effective performance work than period 1. Managers of Company C have informed about the result. They will assess internal performance of first period for CCR.

In accordance with RFID technology, detection can be making when it is required and performance analyzing of CCR can be made through Anova Test here. Accessibility of information is fast. Thus, managers of Company C can apply for new methods to fix loss or defected items' problems.

CONCLUSION

In this thesis, after theoretical background with supply chain concepts and RFID technology has been established, a research has been conducted with three companies which have functioning chain models with RFID and barcode technologies.

By this research, it has once again been proven that the RFID technology helps to ensure the supply chain's process efficiency, visibility, security and accuracy levels. Incorrect placement with automation, loading and processing errors is not expected when turning a chain model into automation with RFID and barcodes. By applying RFID technology in today's businesses, the height of the difference between actual stock levels, the erroneous order decisions to keep high security stocks and errors of stock information which is causing extra costs can be limited. However, as covered at Chapter 4 in the interviews, sometimes it is a challenge to bring about full RFID system or automation to the system for companies for economic reasons and cost/benefit calculations. Managers have expressed that it is difficult to convince upper management to buy a new technology or upgrade the system because more extensive use of this technology heavily depends on getting better reader frequency, and better barcodes that are less affected by the environmental conditions, better hardware technology, and these are all costly. To expect the market to respond to this technology with more common use, prices for all these should come down to be more affordable.

Examination of first two companies (Company A and Eti Maden) by a qualitative method in this RFID project, Company A gets support from RFID technology services and products from technology provider companies. As a result of competition between RFID technology provider companies, Company A can receive reasonable price quotations for devices and software supports.

Eti Maden Company is the one which does industrial revolution through applying RFID technology at their supply chain while they were following manually tracking method before June, 2016. And they even did not prefer to take barcode or qr code systems as initially. They directly move to catch today's technology which is

RFID. They use also passive RFID label like Company A does. But quantity of labels is not that much big as yearly. Therefore, cost of these labels for Eti Maden Company is a little bit higher than Company A has. Labels are being used after production is finished. During packaging and warehousing, traceability of these products is the main aim of using this technology.

Company C uses both RFID and barcode technology. According to manager of Company C, both technologies also can be used as complementary rather than substitute. So, Company C is one of the good example of this opinion. For this company, supply chain steps are more and complicated than others. Therefore, Company C takes care of flows between steps and flows within steps. Thanks to RFID technology, Company C can detect loss items or defected items from system once it is required.

When, Company C's production facility of TMPR has been examined, the null hypothesis says that there is no significant difference in input and output flows. According to Anova method's P-value result which is greater than 0.05, we cannot reject null hypothesis. Additionally, mean values of periods are close to each other. Therefore, thanks to RFID technology, we can say that there is no such a significant difference during input and output flows between three periods as detected.

Another Anova test is made for CWR. Null hypothesis says that there is no substantial difference at input and output flows of CWR between all periods. According to Anova method's P-value result which is greater than 0.05, we cannot reject null hypothesis.

After TMPR and CWR steps, Anova test is made for CPR and CCR steps. For these both steps, we reject null hypotheses. Because their P-values are lower than 0.05. Both test results show that CPR and CCR steps might have some significant differences in material flows between periods. Other than this, It is observed that this difference might be related with 1st Period. The mean values of first periods are lower than other periods for both CPR and CCR steps. In accordance with detection results, administration of Company C has informed. Significant differences between mean values of each periods are detected through RFID technology. Determination and analysis are made by the researcher. And managers are informed. They will find specific solution for these significant differences at first periods. And then, they will

be focusing on increase of performance at CPR and CCR steps within their first periods.

According to observation of all above analyses, we can say that availability of information during tracking process is high. It is also fast and accurate through RFID technology. During supply chain process, effectively and efficiently material and product flows are tracked thanks to RFID. This process is carried out and supervised by company managers. It seems that the RFID has been the key to this process. With this technology, the company can detect all losses and defections instantly or retrospectively through the production steps and warehouse steps within periods.

This work is a pioneering work for further research on Supply Chain Management accompanied by RFID technology or smarter technology. In fact, no study is limited to just the duration and content of the research. Thus, this process will cover even more with periodical technological innovations. As the process evolves, more academic study will follow the latter. As a continuation of this process after this study, the process can be associated with industrial revolutions in more specific frameworks. Having individuals and institutions with practical experience can read the process better. In practice, it is possible to conduct academic studies that specifically delineate the finer lines of RFID and the supply chain, even with more extensive applications.

No matter what the study is done on this area, academic studies and practical sectoral technological applications will be correlated and development oriented.

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