

RFID: Benefits & disadvantages with focus on supply chain efficiency

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Abstract

The present master thesis deals with the radio-frequency identification technology (RFID) and discusses several ongoing projects and implementation barriers for the use in local and global logistics management. RFID technology and its components as well as functionality are explained and implemented RFID systems from different areas are introduced. Current standards as well as functional restrictions of RFID will be shown before the enormous optimising potential of logistics processes within the supply chain will be presented by the help of simulations on the basis of modelled examples. The benefits of using RFID for different companies like Siemens or C&A will be discussed and analysed with the aim of gaining a deeper insight into their motives for using RFID as well as its fields of application.

Also the last member of the supply chain will be taken into account. Customers may benefit by RFID. The quality of the customer service increases by using RFID in the supply chain. Out-of-stock situations can be avoided, or additional information can be provided to the customer. This thesis also tries to figure out whether RFID tagged products are acceptable to consumers or even influence their shopping behaviour.

General problems and dangers of the application of RFID systems are pointed out. There are still many obstacles for the application of RFFID. Missing data protection and technical standards build the biggest source of danger for a successful diffusion of this technology.

Finally, the role of the internet is discussed before a forecast for the future development of this technology and its acceptance is given.

1.	Introduction	P.1
1.1	Research objectives, motives and structure	P. 1
1.2	History of origins	P. 2
1.3	Automatic identification	P. 3
1.4	Compared to the barcode	P. 5
2.	Technology and Standards	P. 8
2.1	Technology	P. 8
2.1.1	<i>Design and operation</i>	
2.1.2	<i>Frequency ranges</i>	
2.1.3	<i>Reading and writing ranges</i>	
2.1.4	<i>Data transmission</i>	
2.1.5	<i>Transponder forms</i>	
2.1.6	<i>Middleware</i>	
2.2	Standards	P.14
2.2.1	<i>The Electronic Product Code (EPC)</i>	
2.2.2	<i>National and international RFID frequency regulations</i>	
2.2.3	<i>RFID in the stage of development</i>	
3.	Research Methodology	P. 16
3.1	Research philosophy and paradigm	P. 18
3.2	Research Purpose	P.20
3.3	Research Approach	P.20
3.4	Research Method and Strategy	P.21
3.5	Research Ethics	P.22

4. RFID in the Logistic Management P. 23

- 4.1 Priorities of a logistics manager _____ P. 25
- 4.2 Key areas _____ P. 26
 - 4.2.1 *Optimal utilisation of operating resources*
 - 4.2.2 *Operative use*
 - 4.2.3 *Security*
 - 4.2.4 *Control*
- 4.3 RFID in the individual enterprise _____ P. 29
- 4.4 Process innovation _____ P. 29
- 4.5 RFID impacts on economic models _____ P. 30
 - 4.5.1 *Requirement planning*
 - 4.5.2 *Warehousing*
 - 4.5.3 *Bullwhip Effect*

5. Use of RFID for specific companies P. 45

- 5.1 Metro Group _____ P. 45
- 5.2 Media-Saturn-Holding _____ P. 47
- 5.3 C & A _____ P. 47
- 5.4 Siemens _____ P. 49

6. Problems and dangers of RFID P. 50

- 6.1 Data protection _____ P. 50
- 6.2 Marketing exploitation _____ P. 51
- 6.3 Globalisation as a source of danger _____ P. 51

7. Influenced consumer behaviour? P.52

List of tables

<u>Table 1</u> : Research questions and research motives	P.2
<u>Table 2</u> : Research Outline	P.2
<u>Table 3</u> : Comparison of the barcode and RFID system	P.7
<u>Table 4</u> : Communication ranges	P.11
<u>Table 5</u> : RFID transponder classes	P.13
<u>Table 6</u> : EPC explanation	P.15
<u>Table 7</u> : Customer demand and orders of the companies for periods T1 to T24	P.31
<u>Table 8</u> : Demand forecast by exponential smoothing without RFID	P.32
<u>Table 9</u> : Demand forecast by exponential smoothing with the use of RFID	P.33
<u>Table 10</u> : Daily demand of company X and company Z	P.36
<u>Table 11</u> : Conditions of the example 3.5.2	P.37
<u>Table 12</u> : Order quantity, change of the inventory and ordering time point of company X (without using RFID and a fix reorder point)	P.38
<u>Table 13</u> : Order quantity, change of the inventory and ordering time point of company Z (with RFID and a reorder point as soon the inventory falls below 240 items)	P.39

List of Graphics

<u>Graphic 1</u> : Auto-ID Technologies	P.4
<u>Graphic 2</u> : Barcode	P.5
<u>Graphic 3</u> : A typical RFID System Architecture	P.9
<u>Graphic 4</u> : Example of a 94 bit EPC	P.15
<u>Graphic 5</u> : The 'onion' research process	P.17
<u>Graphic 6</u> : The research labyrinth	P.18
<u>Graphic 7</u> : Fuelling Innovation: Deductive vs Inductive Thinking	P.21
<u>Graphic 8</u> : RFID technologies in logistics management	P.26
<u>Graphic 9</u> : Demand of the companies for periods T1 to T24	P.31
<u>Graphic 10</u> : Demand forecast by exponential smoothing without RFID	P.33
<u>Graphic 11</u> : Demand forecast by exponential smoothing with the use of RFID	P.34
<u>Graphic 12</u> : Supply chain	P.41
<u>Graphic 13</u> : The Bullwhip Effect	P.42
<u>Graphic 14</u> : Supply chain	P.43

List of Appendices

1. RFID Questionnaire Consumers
2. RFID Questionnaire Companies
3. RFID Tags used at Saturn
4. Ethics Form

List of Abbreviations

RFID	Radio frequency identification
EAS	Electronic Article Surveillance
Auto ID	Automatic Identification
OCR	Optical Character Recognition
HF	High frequency
UHF	Ultra-high frequency
LF	Low frequency
EPC	Electronic Product Code
ISO	International Standards Organisation
EAN	European Article Number
USP	Unique Selling Proposition
CM	Container management
CDMSS	Container Depot Management Support System
3PL	Third-party logistics
VMI	Vendor Managed Inventory

1. Introduction

There is probably no other technology in logistics which currently attracts more attention than radio frequency identification (RFID). This thesis presents the RFID technology and discusses several ongoing projects and implementation barriers for use in local and global logistics management. The research motives of this thesis are to analyse how RFID technology improves efficiency within the supply chain and the individual company. Another point which will be examined is the question of whether RFID has any influence on the consumer's behaviour. Most literature deals with the conventional methods which explain the advantages of a company using this technology. This study aims to demonstrate these advantages based on various economic models. Furthermore, a selection of specific companies which use or plan to use this technology will be presented and analysed with the aim of gaining a deeper insight into their motives for using RFID and its fields of application. Mainstream literature usually reports on the benefits provided by this technology. In addition, there are only rare empirical studies about the last member in the supply chain in touch with RFID, the consumers. This thesis also tries to figure out whether RFID tagged products are acceptable to consumers or even influence their shopping behaviour.

1.1 Research objectives, motives and structure

The overall aim of this research is to explore why companies and logistics managers increasingly invest in automated identification technology. Thus, the first two chapters will explain the technology's origins, its predecessor (barcode) and the technology itself. Chapter 4 is dedicated to the use of RFID in logistics management and demonstrates its benefits for the individual company by using examples of different economic models. These models ensure that the reader will easily understand why RFID means a revolution for the efficiency of supply chains. In chapter 5, the use of RFID in specific companies and its fields of applications will be discussed and presented. Chapter 6 outlines the consumer's worries and uncertainties. The results from a survey will allow conclusions to be drawn in respect of any influences on the

consumer's behaviour. Finally, the last chapter will be a forecast regarding the future of RFID.

Research Questions
1: How does RFID improve the supply chain efficiency?
2: What are the fields of application of RFID?
3: Does RFID influence the customer's behaviour?
Research Motives
A demonstration of advantages caused by RFID and based on simulated examples.
To obtain a deeper insight into specific companies which use RFID.
To obtain the consumer's perception of risk, behaviour and consumer confidence.

Table 1: Research questions and research motives

The research is structured into eight chapters. The following table presents the outline for the following research.

Chapter 1 Introduction
The first chapter provides the background of the study and introduces automated identification technology. A comparison with its predecessor (Barcode) is made.
Chapter 2 Technology and standards
The second chapter provides a literature review of RFID technology itself.
Chapter 3 Research Methodology
The methodology chapter expresses the research purpose and justifies the chosen strategy to analyse the data collection. Research philosophy and paradigm as well as the research strategy and research ethics will be explained.
Chapter 4 RFID impacts on economic models
The forth chapter deals with RFID in the logistics management. Priorities of a logistics manager will be introduced. Key areas of RFID's application will be discussed, and RFID impacts on economic models.
Chapter 5 Use of RFID for specific companies
This Chapter presents analyses of various companies which use RFID. Interviews with responsible actors of the companies were done to get a better understanding for their motives of using RFID. A self-developed questionnaire in order to answer the research questions is used. This questionnaire can be seen as a guideline for the interview whereby many open questions turned to discussions.
Chapter 6 Problems and dangers of RFID
The problems and dangers of RFID were discussed. Data protection, marketing exploitation and the problems of too less standartisation in a globalized world create the key elements of this chapter
Chapter 7 Influenced consumer behaviour
A self made questionnaire were made and. A sample of 100 consumers answered it and discussed with the researcher whether RFID is accepted or even influences the consumer behaviour.
Chapter 8 Discussion
The final chapter critically reviews of the current situation A forecast for the development of the RFID technology will be given.

Table 2: Research Outline

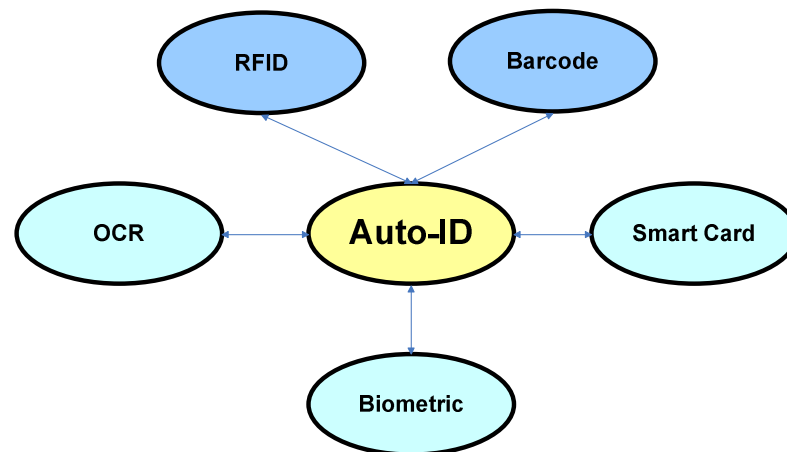
1.2 History of origins

The technology of information transfer for the purpose of identification between a stationary and a mobile unit via radio waves has been known since the 1940s (Rieback et al., 2006). At the time of the Second World War, Americans tested and used a system which helped to distinguish between their own and enemy aircrafts (Violino, 2005). Over time, this technology has evolved and been put to use in other areas. Since 1960, RFID technology has been successfully used in department stores and serves shops and stores to protect against theft (Smith, 2008). These product security systems, EAS (Electronic Article Surveillance), are based on microwave technology or induction. The original models were able to save only one Bit of information, but are still used today in their capacity as EAS (Glover and Bhatt, 2006). This technology has been developed over the years and is used today in many more areas. Examples of current areas of application are airports, where the technology serves the managing and tracking of luggage (Bartneck et al., 2009), for toll collection systems, passports, car keys and animal identification (Neumeier, 2008). In the meantime, even smartphones include so-called NFC readers which can read out RFID chips by means of an app (Fraunhofer-Institut, 2013). Advocates argue today that RFID will replace the barcode from its present position as the most commonly used Auto-ID method in the near future.

1.3 Automatic identification

RFID systems for logistics management are currently mainly used for the automatic identification of objects within the logistical system. Under the name of Automatic Identification, or Automatic Identification (Auto ID), techniques for identification, data collection and data transmission are grouped (Zeisel and Sabella, 2006). The objective of Auto-ID systems is to eliminate manual tasks (McFarlane and Sheffi, 2003) and to reduce data entry errors (AIM Global, 2013). The barcode is one of many Auto-ID systems. As you can see in the graphic representation p.4, there are also many other possibilities of Auto-ID. Biometrics (which can include the identification of fingerprints) or Smart cards (prweb, 2013) and Optical Character Recognition (OCR) which is automated

text recognition within images are some examples which belong to the family of techniques performing automatic identification (Eikvil, 1993).



Graphic 1: Auto-ID Technologies (Adapted from: <http://sswahyudi.blogspot.de>)

Not every enumerated Auto-ID technology is suitable for use in the area of Logistics Management. Application areas for Auto-ID systems in the logistics context follow the supreme priority of sorting goods flows and manage the distribution of goods (Flörkemeier, 2005). Dynamic storage location management, with strategies for the optimisation of put-away, picking and replenishment, as well as parcel tracking, also belong to the main tasks of Auto-ID technologies; in particular, the core task of securing the availability of goods cannot be reached by using optical procedures, such as Biometrics or OCR. Additionally, the format of Smart Cards is designed from their conception for use in personal identification and access control (SC Alliance, 2002). For these reasons, RFID and barcode Auto-ID technologies are currently used mainly in logistics. To give an important insight into the topic of radio frequency identification, the following part of this dissertation illustrates the differences from the barcode.

1.4 Compared to the barcode

The barcode (pictured in the graphic below) is currently the most popular automatic identification method.



Graphic 2: Barcode (Source: Barcoding.com)

It is installed on almost any man-made object. Its main task is to provide information to an object group. The retrievable information is stored centrally in an enterprise resource planning system (Helo and Szekely, 2003). Centrally, an enterprise resource planning system can be connected; for example with cash registers in supermarkets or department stores. By reading a barcode, the scanner transmits a set of numbers to the enterprise resource planning system. The set of numbers is matched in the data base and can thus be audited to transmit the necessary information required for the transaction. The necessary information which might be transmitted to the cash registers is usually the object type and price. By reading the barcode, the labelled object is automatically identified and assigned to the associated price.

The use of RFID systems is based on the same three steps previously described: Read data, matching with central data storage and information output. Compared to the barcode, RFID technology is able to provide more detailed data (Lin et al., 2014). A prominent difference to the barcode is also the option of an RFID system to distinguish single individual objects from each other within an object group. These advantages can be illustrated with the following example from the everyday logistics business: Meat is packaged in the slaughterhouse and equipped with a barcode as well as with a RFID tag. As soon as the package is placed in the transport box however, the barcode cannot be read anymore. It may need to be issued a new barcode and

connected to the box. For this to occur, an entry must have been carried out in the database of the central enterprise resource planning system. Compared with the barcode, a RFID tag would be still readable. The technology in fact also permits more complex applications, such as bulk capture, which enables a large number of loading devices or individual articles on a single pallet to be identified in a matter of seconds (Motorola, 2009). Determining whether the cooling conditions have been controlled during the transportation can be difficult for the receiver. However, if an RFID chip is fitted with a temperature sensor, the receiver of the goods can immediately experience whether the specified temperature requirements have been properly satisfied. The temperature sensor stores temperature fluctuations on the chip and communicates the information within seconds to the receiver of the packaged meat when the data is read out. When the merchandise is received at the destination, employees are able to check by reading out the barcode how many packages of meat should have been delivered. Nevertheless, the number of packages actually delivered in the sample box is not possible to discover by reading out the barcode. RFID technology enables this to happen. In the next step, a seller whose warehouse and retail space are equipped with RFID readers, can then automatically recognise the actual state. Furthermore, the reading can determine how many packages of meat are in place and whether there is a sufficient number available on the sales floor. In addition, the storage temperature of the meat packages can be continually reviewed thanks to additional information provided by the RFID tags. Meat with an expired shelf life expiration date can be detected and removed from the sale. The use of the RFID technology improves the identification of goods, logistics operations and supply chain management. Therefore, it can be predicted that it will replace the barcode in the near future (Ramanathan et al., 2014). As shown in the example, RFID technology does the same as the barcode, but also provides other options for data storage or sensor coupling. Another important advantage of RFID systems is that the read rate is much higher. In contrast to barcodes, RFID tags do not need direct visual contact and have to be scanned individually. It is possible to read out all tags within range simultaneously (via the so-called bulk reading) and without direct contact. A higher data processing rate can be achieved and so it shortens detection

times and improves supply chain efficiency. Furthermore, the fact that RFID-Systems are able to distinguish between the individual objects (Item-Level-Tagging) (Hardgrave et al., 2013) and the advantage of the large volume of information which can be stored on the RFID tags make this Auto-ID-System tool so valuable in logistics applications. Another aspect that makes this solution especially user-friendly is the fact that the system is no longer limited to binary information transmission. A variety of data can be saved and overwritten multiple times (Visich et al., 2009). The main differences are shown in the following table:

RFID	Barcode
Simultaneous read (Bulk reading)	Individual dispatch
Higher costs (system dependent)	Economical
Rewritable	Unwritable
Automatic reading	Usually scanning by hand
Environmental resistant	Read errors caused by dirt / damage
Radio transmission without visual contact	Direct line of sight required

Table 3: Comparison of the barcode and RFID system

Barriers for the implementation of RFID and replacing an existing barcode system include the high cost of readers and tags (Zou, et al., 2013). Missing software applications, as well as trained staff, also create a barrier for many companies (Baidwan et al., 2011). The current users of the RFID technology are mostly large companies. Large scale enterprises often have highly qualified staff and spare no investments in order to increase the logistics efficiency. These enterprises implement pilot projects with the aim of integrating RFID technology into their corporate structure and to apply the developed system in the entire value chain. What motivates these companies to begin this modernisation process, and what benefits will it have? The medium-term to long-term prospects for the use of RFID is an increase of the transparency of the processes within the company to ensure that a high level of information is always available (Wamba et al., 2008). This enhances customer service and both sides can save time, money and staff resources, therefore increasing their productivity. RFID technology has created huge new

markets apart from numerous pilot projects and has, in many cases, already been incorporated into our everyday lives.

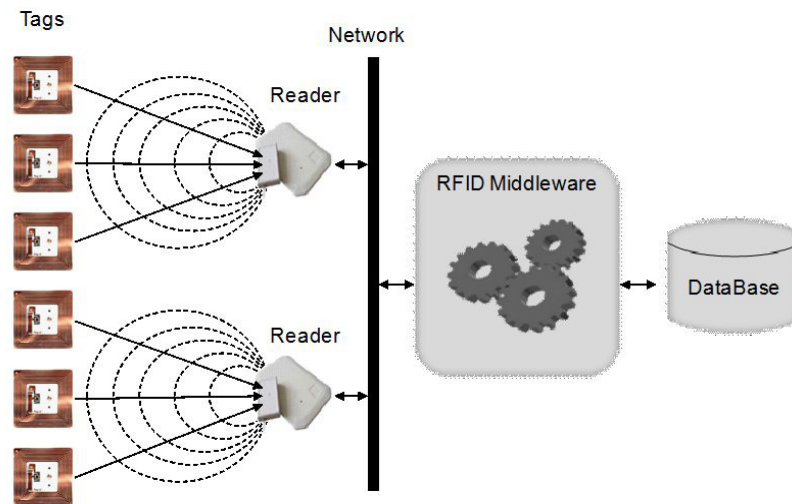
2. Technology and Standards

2.1 Technology

RFID is a technology of contactless data transmission. It is used in various regional and operational areas. The operative use will be described by using examples and demonstrations in the 4th chapter. From a legal point of view, the regional areas of use in particular will be discussed with an emphasis on frequency ranges (2.1.2). The technical construction of a RFID-Tag which may be attached to any objects to be identified is pictured in graphic 3 and later explained.

2.1.1 Design and operation

The design and operation of a RFID is based on a read/write module and on a storage medium (Zhu et al., 2005). In this way, the RFID technology does not differ from other various ID technologies. The wireless technology consists of an antenna combined with a data storage medium. The antenna-data-storage union, the RFID tag, is a transponder consisting of a microchip (Sarma et al., 2003) which is attached to the object to be identified is the key factor of this technology.



Graphic 3: A typical RFID System Architecture (Source: Vecchia and Esposito, 2011)

The term transponder is a combination of the words transmitter and responder (Flor et al., 2003) and thus, a description of its functions and activities. It is a composition of a chip transponder and an antenna circuit (Valentin, 2004). Usually, a RFID tag has no internal power supply and is therefore, referred to as a passive system. The transponder is activated as soon as an electromagnetic field of a read/write module comes close to it (Knospe and Pohl, 2004). Through the inductive coupling process, passive tags (microchips) draw their voltage from the transmission of the reader over the antenna, thus allowing the transfer of data (Roberts, 2006). Passive RFID tags offer the advantage of being inexpensive and new technologies are constantly making them cheaper. In addition, they are quite small and can be attached as a simple label on the goods to be pursued (Weinstein, 2005). Hitachi Chemicals presently sells one of the smallest available tags on the market, measuring just 2.5 millimetres (0.098 inch) square and 0.3 millimetres (0.012 inch) thick (Roberti, 2013).

Compared to passive tags, active tags need their own supply of power. The access to power is provided via a battery (Hung, 2014). The food industry in particular is one of the application fields which uses passive tags. In the case of perishable goods, it is very important to reliably maintain the cooling chain.

Chips can be combined with a digital thermometer (Virtanen, 2014) which

measures and stores the temperature fluctuations during the transport of the goods; thus allowing transport conditions and the condition of the goods to be checked.

Mixed forms of active and passive systems, so called semi-active systems, are also used (Chu et al., 2013). In semi-active tags, their own power supply is only used with integrated services. The semi-active RFID chip with an integrated thermometer uses its own voltage supply source to measure the temperature and to record the data. The energy which is required to read out the chip is provided by the inductive coupling with the read/write module.

The performance of RFID systems is defined as a combination of reading rate and reading distance (Nikitin and Rao, 2006). Read rates of up to 100 percent have been achieved, so far only under laboratory conditions. For operational use, this rate has not yet been reached (Pique, 2012). However, a RFID system must be able to guarantee a 100 percent reading rate in order to ensure the reliability of the system. Even small deviations can lead to significant losses when using this Auto-ID technology for large quantities.

Apart from the distinction of the energy supply of the active and passive RFID tags, there are also other criteria by which RFID systems can be distinguished. In the following sections, frequency ranges and reading/writing ranges will be analysed in detail.

2.1.2 Frequency ranges

Many properties of RFID systems are influenced by operating frequency. Therefore, it may happen that a passive tag system by means of the read/write module cannot be detected due to too large a distance. For this reason, the used operating frequency is highly important to the success of this technology. The frequency of the RFID tags varies from 125 kHz to 5.8 GHz (Sheu et al., 2010). Three main types of frequencies exist which are distinguished into UHF (ultra-high frequency), HF (high frequency) and LF (low frequency) (Zhu et al., 2011). The choice of the frequency depends on several factors, such as the

international standards in frequency allocation or external influences (environmental influences) that might cause electromagnetic disturbances (Kaur et al., 2011). LF systems transmit on a frequency between 100 and 135 kHz, and are widely used as animal ID or auto key (Shih et al., 2011). The following operating frequencies belong to the ISM (Industrial-Scientific-Medical). The ISM frequency band is unique in the way it provides interference-free and reliable wireless communication between individual products. Worldwide, they are kept free for industrial, scientific and medical applications (James, n.d.). HF can interfere with radio navigation, safety services, computers, and communications equipment. The frequency band is located at 13.56 MHz in order to enable higher reading and writing ranges. The UHF range varies from 860 MHz in Europe, to the U.S with 915 MHz as standard. Micro-Wave (MW) has a frequency band of 2.45 GHz and 5.8 GHz and is mostly used in pallet and container tracking. It therefore provides the highest communication rate (Ruiz-Garcia and Lunadei, 2011).

2.1.3 Reading and writing ranges

The read and write range of the system depends on the frequency used and the energy supply. As previously mentioned, passive and semi-active systems get their operating voltage from the signal generated by the electromagnetic field of a read/write module. This coupled inductively powered transponder can be operated only within a distance called the near-field radius (Fuschini et al., 2010). In the table below, you can see the communication ranges of the frequencies listed in Chapter 2.1.2.

Frequency	Communication range
125 kHz	20 cm - 100 cm
13,56 MHz	10 cm- 1.5 m
860 MHz	3 m -15 m
2,45 GHz	3 m -30 m

Table 4: Communication ranges

In the literature, the range of RFID systems is described from different angles and can be present depending on the operating frequency. The range of RFID

systems can be classified depending on their application group. The distinction usually comprises four systems:

Close-Coupling-Systems, tags are usually used for shorter distances (from a few centimetres to approximately half a meter) (Merilampit al., 2007). Passive RFID tags are mostly used to exchange data which is used for safety-relevant applications like storage of personal data bank-/insurance information. They can be supplied inductively with a sufficient voltage for the short distance.

Remote-Coupling-Systems, passive RFID tags are used to exchange data because the induced voltage for the exchange of data is sufficient (Zhen et al., 2005).

Long-Range-Systems, are used for a range higher than one metre. Active RFID tags are used. To initiate the data transfer, the read/write module sends a wake-up and a sleep signal to the tag at the end (Wang and Yeung, 2013).

2.1.4 [Data transmission](#)

One of the biggest advantages of the RFID technology is the possibility of data transmission between the RFID chip and the read/write module over the air interface without direct visual contact. The method of data transmission depends on the complexity of the application field of the RFID system. RFID can be used as a pure identification system wherein there is a communication in the direction of the reader. Nonetheless, it is also possible that the read/write module is in active dialogue with the RFID chip and a continuous (real time) data exchange is performed (Lin et al., 2014). The actual data transfer takes place by the mutual inductance of the read/write module and the RFID tag. An electro-magnetic field which is generated by the read/write module, as well as the inductance on the side of the transponder, builds the prerequisite of data transmission. The data exchange itself can be split up into two groups.

Full duplex transmission (FDX): Communication takes place on a full duplex basis. The data rate between the RFID transponder and the reader in the UHF area occurs normally in real time. In practice, it means that data transmission

is performed simultaneously from the transponder to the reading unit and the writing unit to the transponder (Day et al., 2012). The energy supply by the read/write unit is permanent.

Half duplex transmission (HDX): In contrast to the FDX transmission, the transponder does not receive energy during the data transmission from the read/write module. A data packet is sent by one system and received by the other. Data transmission is separated and the receiving periods are temporal (Burnett et al., 2013).

2.1.5 Transponder forms

Depending on the functionality, RFID tags were divided into classes.

Class	Minimum functions	Energy supply
1	Tag identification Deactivation function Password protection (optional) Additional memory (optional) Rewritable	Passive
2	Functions of class 1+ Advanced tag identification Extended memory Read control Additional functions Authenticated access (authentication)	Passive
3	Functions of class 2+ Transponder with sensors Energy source	Semi active
4	EPC ID Tag-to-tag communication Possibility of formation of ad-hoc networks Advanced tag identification Read control Energy source Additional memory (optional) Additional memory (optional)	Active
5	Functions of class 1, 2, 3 and are able to cooperate with tags of class 4	Active

Table 5: RFID transponder classes (Source: Lehpamer, 2012 and EPC global 1, 2007)

2.1.6 Middleware

The middleware is very important in RFID systems. It ensures that the data read from the chip is fed into the company's own IT system (Günther, 2008). Another object of the middleware is the processing of the raw data by filtering, error correction or format transformation (Jeffery et al., 2007). Since it is quite a costly affair to develop a specific middleware for each individual RFID solution, it makes sense to develop a system which can adapt to specific projects through the use of additional elements. Nevertheless, the basic structure is universally applicable (Li et al., 2012). A standardised middleware also means lower programming effort for system integrators and provides the right framework to enable expansion in the long term (Regtmeier, 2013).

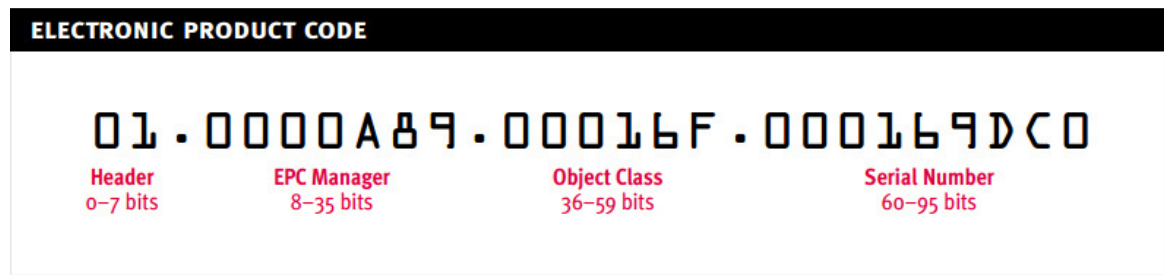
2.2 Standards

A standard is an approved quality type; a standard to unify materials, products, processes and services (ISO, n.d.). The ISO (International Standards Organisation) and the EPCglobal (EPC - Electronic Product Code, S.U.) are two cooperating organisations who set down guidelines for supply chain applications concerning automatic identification and data collection which have prospered in practice (Aqirre, 2007). For the development and deployment of RFID systems and standards, current international and regional regulations must be taken into account. Occasionally, the global standardisation of this technology leads to problems, because regulations for the use of frequency ranges sometimes deviate in different countries.

2.2.1 The Electronic Product Code (EPC)

A 12-digit barcode standard called European Article Number (EAN) creates the international standard for the barcode (Gleißner and Femerling, 2007). For the RFID technology, the Electronic Product Code (EPC) was developed. The EPC allows a globally unique identification of goods/objects (Brock, 2011). The EPC is part of the EPC Network and was developed in collaboration with different companies at the Auto-ID Center at MIT Boston (RFIDBASIS, 2012). Several versions of the electronic product code (EPC) already exist. Basically, electronic product codes have a binary structure and are divided into sections

of different length for the purpose of encryption and storage of information (Engels, 2003). On the following page is an example of a 94 bit EPC.



Graphic 4: Example of a 94 bit EPC (Source: Brock, 2012, p.5)

Header	EPC Manager	Object Class	Serial Number
EPC version number	Manufacturers (e.g. Coca Cola) Number range: 268 million	Product-Type (e.g. Fanta 250 ml can) Number range: 16 million	Unique number of the unit Number range: 68 billion

Table 6: EPC explanation

This EPC has been further developed and modified, so that an EPC currently exists comprising the following six elements: header to store the EPC version, filter value, which includes the lot, partition base number with the manufacturer ID, item number to indicate the product type and serial number to uniquely identify the object. The development of the second generation of EPC means an increase in performance. Now, there are three different read settings that allow an optimised data transmission. Different types of coding allow operation among competing applications. Finally, the read speed can be doubled as compared to the first generation (RFIDBASIS, 2012). Thanks to the EPC standard, only minimal information is locally stored on the transponder itself. The complete information corresponding to the object is stored centrally in the company's back-end system in order that the RFID readers can just pull the required information from the databases (Bhero, 2014).

2.2.2 National and international RFID frequency regulations

As previously mentioned, frequencies build one of the greatest challenges for the creation of uniform standards. If large enterprises decide to use a specific frequency for the automatic identification of their goods, it might happen that different standards exist in other countries. For example, if the Metro Group, which is a globally diversified German retail and wholesale/cash and carry group, uses specific frequencies, it might happen that they do not meet the standards in other countries (Domdouzis et al., 2007). The used frequencies are not permitted for commercial use in many parts of the world. Currently, only one, the high frequency band 13.553–13.567 MHz, is used internationally as a global standard. This frequency is mainly used for Industrial, Scientific and Medical (ISM) applications (Domdouzis et al., 2007). The remaining frequency ranges for RFID systems vary from country to country.

2.2.3 RFID in the stage of development

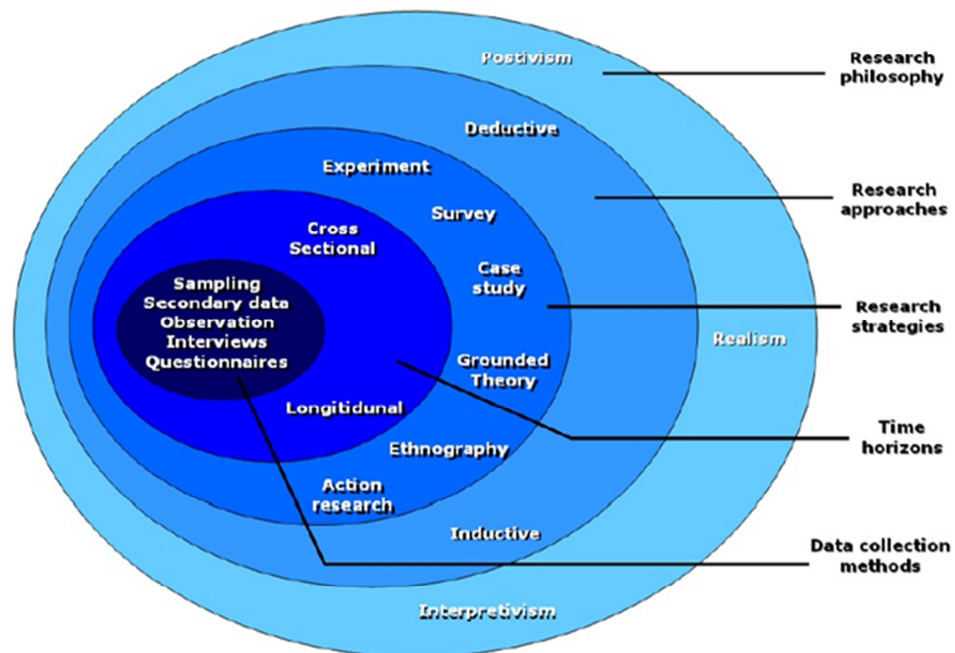
Many RFID service companies develop to their customers' tailored systems (Scemtec, n.d.). Adjustments mainly take place at the middleware level. The aim is to improve the automatic identification by increasing flexibility and efficiency, through the integration of the transponder data into the company's back-end system (García-Valls, et al., 2010). Nevertheless, the aims are primarily focused on the standardisation of the hardware, so that transponders and readers from different manufacturers may be used together and thus, company cross-network cooperations may be implemented.

3. Research Methodology

This chapter focuses on how the research is conducted and aims to explain the use of data collection and analysis methods (Saunders et al., 2012) in order to express the philosophy of this dissertation.

The term research methodology means the way of solving a research question in a systematic way and developing it into a research project. The research methodology used in this dissertation includes literature review, verification by

statistical techniques, different economic models and interviews with various responsible actors and experts from different companies whose key areas lie in the field of logistics. In addition, surveys were performed to demonstrate the perspective of the usual customer who enters into contact with the relatively new auto-identification technology. To achieve the objective of a dissertation in a clear and comprehensible manner, it is crucial to conduct the research by way of a clear process that is guided by theoretical pre-considerations. This method makes it possible to refer to secondary data, to analyse the material and to draw one's own conclusions (Seuring, 2008). The research process is flexible, but follows the suggestion of Saunders et al. (2003) as to an “onion” model as pictured in the Graphic below.

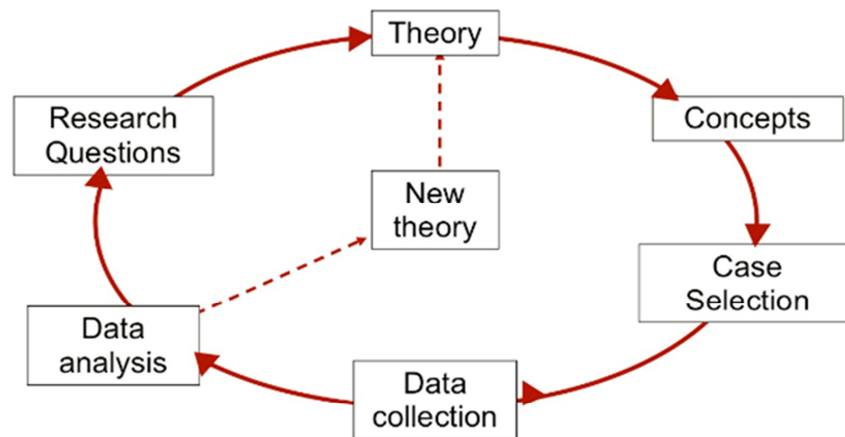


Graphic 5: The ‘onion’ research process (Saunders et al., 2003)

Starting from the outside and working inwards, the research onion highlights the different steps to create a philosophy and justify the used models, as well as explaining the chosen techniques. The core of the onion is dedicated to data collection and data analysis.

To provide a better overview of the structure, the research process is pictured in the research cycle below.

The research labyrinth (or research cycle)



Graphic 6: The research labyrinth (University of Warwick, 2012)

The framework pictured in the Graphic 5 shows the fundamental principles of a research process. Beginning with the development of the research questions by reviewing literatures, and following with the creation of a theory which is confined to a core statement of theories, the dissertation obtains its special character. The process is then continued with concepts which are able to apply theoretical knowledge gained in a practical manner. The following stages are dedicated to data collection and analysis. Finally, an examination is conducted into whether the theories are compatible with the current state of economic theory. In conclusion, a future forecast will be given.

3.1 Research philosophy and paradigm

Under the term 'research philosophy', Saunders and Thornhill (2007) understand the development of the research background, research knowledge and its nature. In order to ensure an effective collection of data in an appropriate manner, it is very important to see the research philosophy as an important part of the research methodology. According to Wang (2013), the research philosophy determines the researcher's view of the world and reality. More importantly, as the researcher deepens his knowledge, a precise procedure is created, which involves various steps through which a researcher

creates a relationship between the research objectives and questions. Easterby-Smith et al. (2012) stated that research methodology requires an in-depth exploration of philosophy to ensure the evaluation of the suitable methodology and method. Research philosophy has three different terminologies: positivism, interpretivism and the realism paradigm (McNabb, 2007). According to Gliner and Morgan (2000), "paradigm is a way of thinking about and conducting a research. It is not strictly a methodology, but more of a philosophy that guides how the research is to be conducted (p.17)". The realism paradigm can be seen as the middle position between positivism and postmodernism, with the belief that an entity can exist independently of our knowledge, whilst affirming that access in the social world is always subjective (Bryman and Bell, 2011). A rational and objective view to the topic is necessary for an empirically-based research. It distinguishes between direct and critical realism (McMurray, Pace and Scott, 2004) for understanding the social structure and its meaning for what happens in the real world. Business and management research is a part of the social cultural world and makes it necessary to develop critical realism to argue about experiences for a particular situation (Sekaran and Bougie, 2010). By referring only to the direct reality, which means what an individual feels, sees and hears, an objectively determination of the nature is not ensured. Thus, a common interpretation is not warranted right from the start.

This research applies critical realism philosophy as it seeks to understand the benefits and disadvantages of the RFID technology in various types of enterprises. The study then continues to examine examples on the basis of economic models to demonstrate the usefulness of this technology. Later interviews with notabilities from different companies will be performed with the aim to get a better overview about the fields of application of RFID. Finally, surveys were done with a target group of usual customers to demonstrate the way the RFID technology influenced customer behaviour. In practice, problems concerning data protection are causing uncertainty among consumers. The factors which influence the implementation of this technology are affected by the social reality on various levels. As the topic is already well documented, the reviewed existing theory also contributes to developing the conceptual framework as a portion of the bigger picture. Therefore, the

realism paradigm that accompanied the research is the most appropriate paradigm.

3.2 Research Purpose

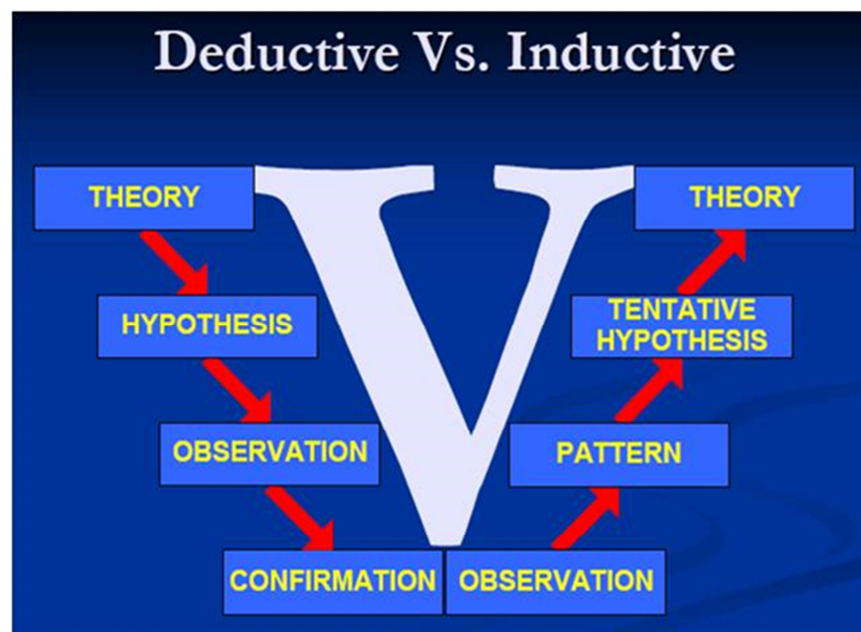
The study's nature is a mixture of descriptive and causal design. An exploratory research aims to provide background knowledge where a small amount of information exists. It is necessary to use a variety of concrete economic models and interviews as examples for the purpose of gaining information to build up familiarity with the phenomena in the situation. The descriptive research aims to collect data which describes the characteristics of variables relevant to a situation (Wang, 2013). According to Hair et al. (2007), a descriptive research based on data collection requires a structured process, such as a survey accompanied by well-structured questions.

The purpose of this study is majorly descriptive and partly exploratory. Although the RFID technology is already well documented in various literature, the subject of how this technology improves the supply chain and influences the customer behaviour can be deepened in an informative way. The research is done to investigate the correlation between the use of RFID technology and the increased competitiveness of various enterprises. The survey consists of questions of "who", "how" and "what" influences the customer's behaviour and creates the descriptive part of the research of this study. The aim of the survey is to describe the characteristics of the influences to the customers, and to offer this study a descriptive purpose for the research.

3.3 Research Approach

According to Saunders et al. (2012), it is of highest importance to understand the theory regarding the design of the research. The research approach has to be determined as deductive or inductive, or as a mixture of both (Wang, 2013). Wilson (2010) stated that it needs to develop hypotheses which are based on existing theories, before designing a research strategy to test the hypotheses. Wang (2013) stated that a deductive approach has to start with detailed observations of the world, before creating more abstract generalisations and ideas. In other words, deductive research can be described as "reasoning from the general to the particular" (Pelissier, 2008, p.3). In this study, the

hypothesis was made that RFID technology improves the flow of information within the supply chain and also increases the competitiveness of the companies which use that technology. The hypothesis is confirmed by various economical models which demonstrate the advantages of that technology. In addition, interviews and an extended literature review confirmed the hypothesis that RFID influences the competitiveness of the different members of the supply chain. Another hypothesis which was made is the fact that RFID technology makes the customers insecure and influences the consumption of goods in a negative way. Surveys with different consumers of all ages were made to support the reliability of the conclusion. In this case, the inductive reasoning is used to prove the theory of changed consumer behaviour. The process of how each approach is conducted is presented in Graphic 6.



Graphic 7: Fuelling Innovation: Deductive vs Inductive Thinking (Saleem, 2008)

3.4 Research Method and Strategy

This study intends to take both sides of the coin into account. The benefits and the disadvantages from the management side and also from the

consumer's point of view will be examined with quantitative and qualitative methods.

The quantitative strategy is based on numerical or quantifiable data from a determined sample size employing observation or survey, such as structured questionnaires (Joseph et al., 2007). The characteristics of a survey can be described as questions which have the aim of answering "what", "who", "where" and "how much". Saunders et al. (2012) argued that survey strategy is therefore often suitable for exploratory and descriptive research. "Questioning individuals on a topic or topics and then describing their responses" (Jackson, 2011, p.17) creates the essence of a survey. Jackson (2011) divides the survey methods into three categories: mail survey, telephone survey and personal interview. This study uses all of these techniques.

Qualitative data collection methods (interviews and questionnaires) are dedicated on feelings and other non-quantifiable elements (Patton, 2005). Open-ended questions allow a deeper view as to the motives and generalisations and therefore, also count towards the qualitative research methods (research-methodology.net, n.d.). The outlook of the data collection explores a particular issue, situation or an interaction, comprehending phenomena and evaluating the study object (Locke et al., 2007). The evaluation of exactly what is required and the measurement of the relevant variables (Sekaran, 2003) is the biggest challenge for the researcher in the case of open-ended questioning.

3.5 Research Ethics

In this thesis the rights of potential and real participants are secured and respected. Thus there is a "maintenance of the confidentiality of data provided by individuals or identifiable participants and their anonymity" (Saunders et al., 2012, p. 185). This explains the absence of the names of the participants and in any related document.

4. RFID in the Logistic Management

This chapter deals with the aims of a successful logistics management and presents the key areas in which RFID may improve the efficiency of an individual company as well as the of the entire supply chain. The findings are based on literature review. Later will be shown based on economic models how the requirement planning, warehousing or the bullwhip effect may be influenced by using RFID:

Trends like technological change reduce transport and information costs (Andersen and Herbertsson, 2005) and thereby support the continuing process of globalisation. Globalisation has helped turn the logistics sector into one of the most important sectors of the economy. Companies from around the entire world interact with each other through logistical operations, and the logistics and supply-chain sector ensures the development of logistics processes due to progressive globalisation and growing competitive pressure. This has the consequence that logistical focus lies on the design and optimisation of processes with the aim of increasing the supply chain performance.

Logistics is increasingly becoming an enterprise-wide and cross-functional coordination with focus on the growing importance of information flows (Ellinger, 2000). Against this background, it is not unreasonable to conclude that the RFID technology is integrated into logistics processes and leads to the optimisation and automation of the flow of goods and information (Ngai and Gunasekaran, 2009). With these aims in mind, many enterprises have already planned and implemented insular solutions. Insular solution means that a system is specially adapted to the company or even specifically developed for a company (Orella, 2010). These internal company logistics systems are also called Closed-Loop-Systems (Jayaraman et al., 1999). Insular solutions are of interest to businesses, as it can be predicted in advance whether the internal use of an RFID system can optimise the processes and is economical. An RFID-based "Intra-logistics" has to be constructed, designed and calculated from the outset to the company's goal. Large enterprises, especially in the automotive industry, could optimise the automation of the production process

with the use of the RFID technology. The identification of individual components is faster, more reliable and takes place automatically. Because used components can be tested and adapted to the environment, the reliability of the used RFID technology can be better guaranteed in closed systems. Thus, tags which are affected by their interference with the environment (metal, liquid etc.) can be excluded from use (Michael and McCathie, 2005).

However, as mentioned in the previous chapters, the greatest challenge for the future is the development of standardisation in order to establish business-wide processes that reduce the complexity of collaboration between different members within the supply chain (Staake and Fleisch, 2008). For that reason, the used RFID technology in closed loop systems has to be further developed, so that it can be also used in open logistics systems (Open-Loop-Systems). Thus, data exchange and the world trade between business partners become easier (Cheung and Choi, 2011). Existing insular solutions have to be opened and made available to the market. Firstly, suppliers have to be integrated into the existing system to track the flow of goods. Secondly, the consumer will come into contact with the technology. The problems and dangers of the latter step will be discussed later. The integration of suppliers represents the problem that used interfaces may be different. The solution may be a certain self-regulation by the market. Metro Group may act as an example here; whereby suppliers were prompted to equip packages with RFID tags in their production facilities (Andreae et al., 2013). The standards for the used tags were developed in the company's own research facilities.

Standardisation, as described in the second chapter, is not the only absolute prerequisite for the successful use in the consumer goods and retails industries. Furthermore, the customer has to be informed about this technology and acquire familiarity with it. The researcher comes to this assumption on the basis of interviews with a sample of 100 customers.

Simplifying the inventory turnover (Ting and Tsang, 2012), automating the inventory control in the warehouse and sales areas (Lim et al., 2013), automatic data collection (Wang et al., 2013) and theft protection (Ilie-Zudor et al., 2011) belong to the preferred objectives when using RFID technology in supply chain management. Customer Relationship Management (CRM) and

Product Lifecycle Management (PLM) can also be optimised through the new Auto-ID technology. In addition, new services can be designed and offered. In the VMI strategy (Vendor Managed Inventory), the supplier takes over the monitoring of his customer's inventory and autonomously controls the delivery of replenishments. VMI optimises the logistic chain because the supplier has access to the inventory and requirement data of his customer (Danese, 2006). The communication between customer and supplier can be improved and more reliable forecasts on customer demand become possible (De Toni, and Zamolo, 2005). Plan production volumes become more accurate and boost the flexibility at warehouses and distribution centres. The stock of the intermediary, or even of the customers, can be determined in real time and automatically if the deposits are equipped with a particular technique. The supplier may be informed of the system if the stock level falls below the safety stock. Therefore, the supplier can better plan ahead and react faster. An inventory which is guided by the supplier avoids the bullwhip effect of safety stocks based on increasingly exaggerated demand estimates (the further you move backwards along the supply chain). The bullwhip effect will be discussed in greater detail in section 3.6.3. Information management costs can be reduced and planning precision increased.

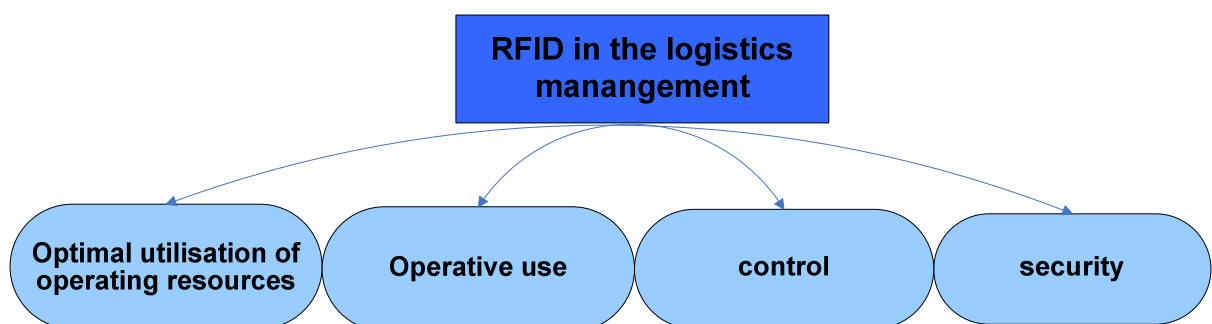
By using RFID technology in logistic systems, a value-based payment becomes possible. The customer pays exactly the right amount for the transportation services which he has received. It can be better understood how much per customer was transported, especially if providers of logistic services (3PL) provide the same services to different customers at the same time, and it becomes easier to realise a Unique Selling Proposition (USP) by way of tailor-made solutions (Sweeney and Evangelista, 2003). More accurate cost control and accountability for the provided services can be reached and the optimisation of the used space for transportation ensures costing transparency.

4.1 Priorities of a logistics manager

“Cheaper, faster and more reliable at the same time”, are the most important priorities of a logistics manager when building up or improving a distribution system. In order to achieve the objective, the access to current data is essential. This data has to include all available information existing in the whole supply chain. Here, RFID can be a cost-effective supplier of this data. The vision of the project is important for the further development of RFID systems. One of the main goals must be to improve the overall communication with suppliers and customers, and not only to pay attention to the internally proceeded operations it processes. This communication requires good contact with the relevant persons of partner companies to obtain the relevant information. The different members of the supply chain have to collaborate with each other in order to optimise customer satisfaction, communication, information flows and logistic costs. With good project planning and implementation, the use of RFID can cause a significant reduction in inventory levels, more efficient deliveries and a reduction in the out-of-stock risk in a company (Chow et al., 2007). The following four fields of logistics for which the use of an RFID system is advantageous will be presented and analysed.

4.2 Key areas

According to Angerer, there are 4 main areas in which RFID technologies support logistics management: (A) optimal utilisation of operating resources, (B) operative use, (C) security and (D) control (Hoffmann, 2005). Every individual area can already benefit from the use of this technology.



Graphic 8: RFID technologies in logistics management

4.2.1 Optimal utilisation of operating resources

"Utilisation of resources" is a self-explanatory term. It is a process which aims to avoid idle or non-productive time. RFID enhances the informative capability, but requires a fast data processing and data transmission to determine the current actual state of the resources (Real Time Positioning). The result is an increased response time of the logistics manager. Containers, the most important example of which is the container management (CM), can here be seen as the applied utility. The requirements for a successful CM depend on the system architecture which has to ensure that a continuous localisation of the containers and trucks is possible (Ngai et al., 2007). Ngai et al. list 5 principal elements which belong to the basic structure of the system: (1) an RFID system, (2) a wireless network, (3) a Container Depot Management Support System (CDMSS), (4) communication interfaces and (5) key functions. According to the authors, these 5 connected elements optimise the CM and order management, as well as the customer service and the possibilities of control in real time.

4.2.2 Operative use

Besides the optimised utilisation of the resources, automatic identification reduces manual activities and also reduces errors, such as products placed on the wrong shelf (Rekik et al., 2008). RFID technology can also help to control the inventory in real time and thus, increase the reliability of supply and service, because out of stock situations can be recognised at an early stage. Not to be forgotten is also the practical use of transponders that can be attached to the objects so that they are protected against environmental influences and can convey the stored information permanently. For comparison, the readability of barcodes could be affected by dirt, moisture or fade with time and might get unusable (Shih, et al., 2006).

4.2.3 Security

Compared with the barcode, RFID tags can be attached inside of a container and thus the tag can be protected against manipulation and environmental influences. Another advantage of the RFID technology is that the use of additional services is possible. The opportunity is given to pursue the transport route in real time and retrospectively. Furthermore, the RFID tags can be equipped with environmental sensors to monitor the environment of the transported goods during transport (Cho et al., 2005).

Another advantage of the RFID technology is that it saves time by electronic customs clearance; the legal security can be enhanced while at the same time reducing the costs of control (Hsu et al., 2009). The basic idea is that data about the content of the container is given on a chip which is attached inside. A seal shall be affixed to the means of transport before it leaves the production facility. Therefore, at the individual duty stations, no complicated document and inventory control needs to be done. The data is retrieved and compared with a reading module. Only the identification and integrity of seals must be checked at both sending and custom locations. This approach has already been successfully adopted and is used at customs stations worldwide. Transport times and control expenditure can be reduced and lead to shortened transport times by lowering waiting times at the various border crossings.

4.2.4 Control

Fictitious inventory caused by unsupported journal entries, inflated inventory count sheets, bogus shipping and receiving reports and fake purchase orders poses problems (Wells, 2001). A product is listed in the inventory list, but it cannot be sold to consumer because it is wrong diversified and untraceable. It needs valuable storage space and also brings no profit. This problem can be solved with the help of RFID technology. If the product is equipped with a transponder and the warehouse or the retail space with the corresponding readers, the system can immediately detect when and where a product has been stored incorrectly. Thus, the problem that an object is not in its intended place becomes apparent before the customer demands rectification of the

situation. In addition, costly and time intensive manual searches can be reduced and, at the same time, the service increased.

Through the use of RFID, third-party logistics (3PL) have the option to pursue a shipped object continuously and record the path with the object's own transponder. Later, it is possible to show the customer in detail that the transport has been running smoothly. This process can thus serve as insurance when it has to be clarified whether the goods were damaged during the transportation through the fault of the logistics service provider, by force majeure, or even by the client itself. RFID makes the delivery process more transparent and is able to strengthen the base of mutual trust and foster an atmosphere in which the client/customer relationship can develop together.

4.3 RFID in the individual enterprise

Consumer goods with an extremely short life cycle are a potential application area for RFID. Reduced items, items that are out of stock and improved visibility reduce time-to-market (Koh, 2006) with the consequence that it becomes more efficient and more profitable to sell the product. The information about the products can be stored locally on the objects. This procedure reduces the feed of complex information and data into the inventory management system of individual sales agents; not only saving cost, but the products are also more quickly prepared for the sale. This process therefore improves marketing, making it faster and more cost-efficient; helping to keep a competitive edge, support sales and, finally, to differ from the competitors by gaining competitive advantages.

4.4 Process innovation

RFID can not only be used to speed up existing processes, it can change the process structure fundamentally. An example is the use of locating objects in production processes. Due to increased data quality and greater continuity of the data flow, production optimisation with individual machines becomes possible through integrated workflow solutions that assist in cutting down on costs, driving efficiency, adding value and reducing error rates. In manufacturing processes, RFID can provide up to 100% transparency of the

position of objects in the value creation process. This not only allows optimisation of the production efficiency of existing processes, but also the redesigning of existing processes can be initiated.

4.5 RFID impacts on economic models

Because RFID systems generate more data, and a greater variety of data, this affects the results of existing models. For logistics management forecasting in particular, it is a significant advantage to get the necessary data in real time. Delays in the information flow primarily have the consequence that higher safety stocks are required and thus more space for inventory is used than necessary. In addition, thanks to the available data, the expected demand can be calculated more flexibly and also more accurately. In logistics, many different models exist which help to forecast the demand and calculate the necessary stock levels and required space for storage.

It is possible to enter variables into quantitative models. These variables, with the help of RFID obtained data and based on historic data as well as real time available data, can replace the unknown variables. It should be noted that RFID is not a new method to make predictions; it just supports generating data. RFID technology generated data will be later highlighted by way of examples and demonstrations as to how RFID technology impacts selected examples of the models.

4.5.1 Requirement planning

Two warehouse management systems will be compared. Each system is represented by a company. For any business, an actual customer demand is assumed, which must be met by each company. It is to be considered that each company has to deal with shortfalls in quantities of the good. Actual customer demand (D_c) is given in the table below. It is assumed that shrinkage is 2 units per period.

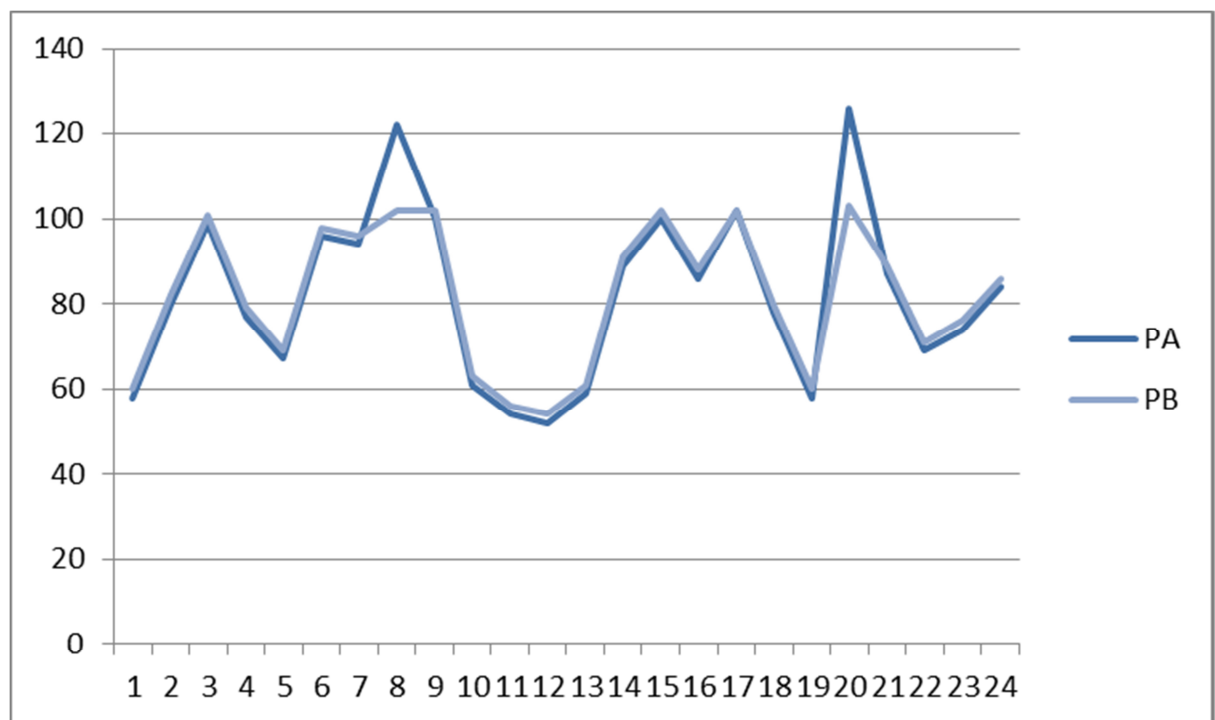
In company **A**, employees work in the storage area according to the FIFO (first in, first out) principle, and the demand of company **A** (P_a) is determined based on a warehouse input minus warehouse output calculation. The order (P_a) is made on a fixed order point (T). The company is legally required to carry out a

physical inventory of warehouse stocks once a year (equal to a Seasonal Effect) to balance the physical stocks with the book figures. If an inventory management system determines that goods are out of stock, they will be added to the order quantity in the following month.

Company **B** uses an RFID system by which the inventory stock is controlled. Incoming and outgoing goods are recorded automatically in real time, so that the actual warehouse stock can be quickly and easily displayed. Companies A and B order for fixed order point (T). Table 7 shows the periodically determined orders of each individual company. In the periods 8 and 20 the shrinkage was reordered in company **A**.

Time Period (T)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Demand customer (D_c)	58	80	99	77	67	96	94	100	100	61	54	52	59	89	100	86	102	78	58	101	87	69	74	84
P_A	58	80	99	77	67	96	94	122	100	61	54	52	59	89	100	86	102	78	58	126	87	69	74	84
P_B	60	82	101	79	69	98	96	102	102	63	56	54	61	91	102	88	102	80	60	103	89	71	76	86

Table 7: Customer demand and orders of the companies for periods T_1 to T_{24}



Graphic 9: Demand of the companies for periods T_1 to T_{24}

As can be seen from the Graphic above, an annual stock inventory has an impact (equal to a Seasonal Effect) on the required quantity, which also has a negative effect on the demand forecast.

If both companies now predict their demand by an exponential smoothing, company **A** calculates with incorrect or misleading information. For comparison, for both companies demand forecasts were performed with the exponential smoothing factor ($\alpha = 0.3$).

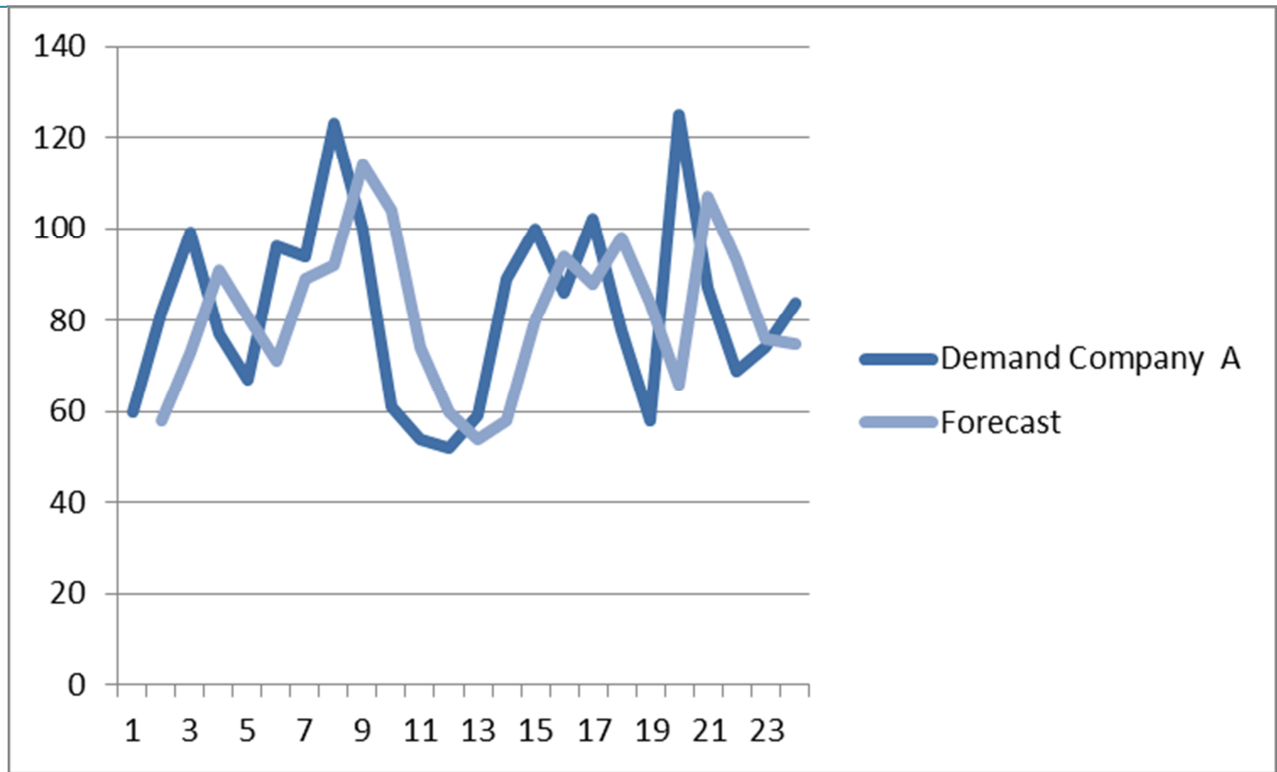
The used formula for the exponential smoothing is: $pT+1 = \alpha dT + (1 - \alpha)pT$ (Sloan, 2007). The exponential smoothing is a technique for continuous demand and can be applied to time series data to generate forecasts (Garder, 2006). A previously calculated forecast value is compared with the actual changes in consumption and thereby takes into account the deviation. Weighting the data, the smoothing parameter α is used (Prestwich et al., 2013).

In Table 6 and Graph 8, the periodical and forecasted demand of company **A** (without the use of RFID) is pictured. In Table 8 and Graphic 9, the periodical and forecasted demand of company **B** (warehousing with the use of RFID) is pictured.

Time Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Demand Company A	60	82	99	77	67	96	94	123	100	61	54	52	59	89	100	86	102	78	58	125	87	69	74	84
Forecast		58	73	91	81	71	89	92	114	104	74	60	54	58	80	94	88	98	84	66	107	93	76	75
total error		22	26	14	14	25	5	31	14	43	20	8	5	31	20	8	14	20	26	59	20	24	2	9
relative error in %		39	33	15	19	38	6	33	11	44	34	15	9	55	23	8	16	20	34	106	16	28	3	13

Ø relative error in: 27%

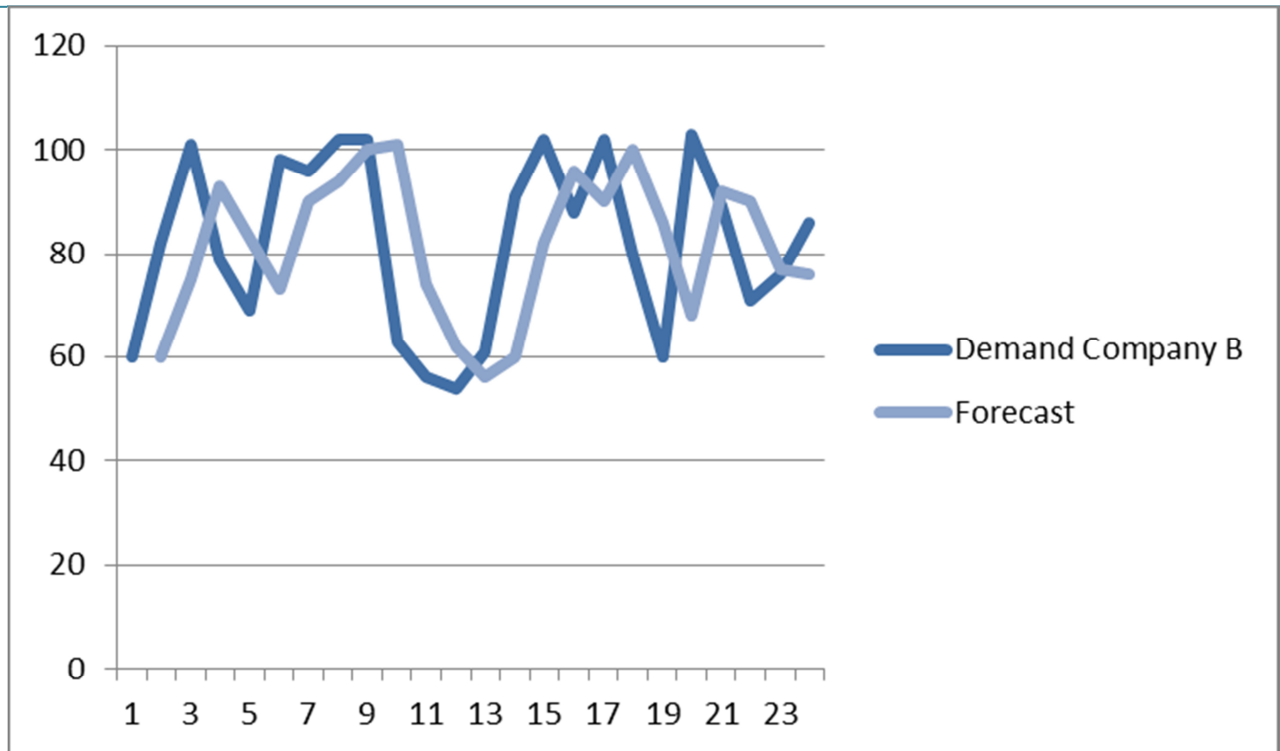
Table 8: Demand forecast by exponential smoothing without RFID

Graphic 10: Demand forecast by exponential smoothing without RFID

Time Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Demand Company B	60	82	101	79	69	98	96	102	102	63	56	54	61	91	102	88	102	80	60	103	89	71	76	86
Forecast		60	75	93	83	73	90	94	100	101	74	62	56	60	82	96	90	100	86	68	92	90	77	76
total error		22	26	14	15	25	6	8	2	38	18	8	5	31	20	8	14	20	26	35	3	19	1	10
relative error in %		39	33	15	20	39	6	8	2	39	31	15	9	55	23	8	16	20	34	63	3	22	1	14

Ø relative error in: 22%

Table 9: Demand forecast by exponential smoothing with the use of RFID



Graphic 11: Demand forecast by exponential smoothing with the use of RFID

The advantage of RFID in warehouse management can be found in the demand forecast error. On average, company **A** has a relative forecast error of **27%**. As can be seen from Table 7, the average of the relative error forecast is **22%** in company **B**, and thus **5% lower** than in company **A**.

4.5.2 Warehousing

Procurement models which aim to optimise the desired levels of service have to deal with stochastic influences on the relevant planning factors. Within these procurement models exist different causes of insecurity: order quantity which is related to the quantity of demand (Teng et al., 2013), replenishment time for a warehouse order which has to be minimised and supports a short cycle time without the loss of productivity (Kim et al., 2010), incoming stock quantity as well as the documented flow of goods (Kang and Gershwin, 2005). The last two mentioned insecurities: incoming stock quantity and the actual documented flow of goods can be influenced by the use of RFID technology. Electronic systems can ensure that the automatic reading and recording of stock levels can be transferred into modern database management systems.

Automatic documentation decreases the danger that incoming stocks are not captured and thus, reduces a falsification of data. Another aspect of the automated documentation is that it allows the performance of a continuous-type inventory and thus, avoids inaccuracies in the stock levels (Lee and Özer, 2007).

In respect of the example of warehousing, two different order policies with variable order quantities will be used. The first order policy is characterised by a given order interval and is called (t,S) policy. The target stock is refilled up to the stock level (S) in every given order period. The second order policy is characterised by a variable order time interval and is called (s,S) policy. As soon as the stock level runs below the target stock level (s) , an order is placed in the quantity which is necessary to reach the stock level (S) .

The use of RFID technology aims to reduce the inventory costs of a company. This target can be reached by using RFID technology and is shown in the following example: two different companies produce an identical product. The demand for the product is the same in each company, and the observed time period is one month (30 days). Both companies have the inventory capacity (S) of 840 items. The value 840 consists of the aggregated amount of the reorder quantity $(S-s)$ and the expected demand within 7 periods. The reorder level (s) is calculated with the help of the expected demand during the replenishment lead time of 2 and a safety stock. The expected variance of demand during the lead time is calculated with an α -service level of 99%. The α -service level is an indicator of the probability that a shortage does not occur (Günther and Tempelmeier, 2012). The storage costs per item are £0.15 per day. The set up costs for the order (C) are £50. It is assumed that the reorder level is reached as soon as the inventory falls below 240 items.

Period	Demand
1	90
2	92
3	93
4	67
5	67
6	79
7	88
8	112
9	88
10	90
11	70
12	98
13	76
14	105
15	89
16	59
17	77
18	115
19	84
20	89
21	99
21	78
22	100
23	66
24	79
25	98
26	78
27	98
28	100
29	83
30	107

Table 10: Daily demand of company X and company Z

Period	abbreviation	ammount
Average value of the daily demand	$\bar{x}$	87, 5
Variance of the daily demand	s^2	197, 325
Deviation	s	14, 05
Service-level	α	99%
Inventory costs / item / period	C^*	£ 0, 15
Setup costs /order	C	£ 50
Delivery time	t	2 days
Bearing size	S	840
Initial inventory	I	840
Reorder point	R.O.P.	< 240

Table 11: Conditions of the example 3.5.2

Company X follows an order policy with a variable order quantity (t,S) policy. It does not use RFID technology and every week orders the exact quantity which is needed to refill the initial inventory. The inventory is calculated with the help of the documentation of the outgoing and incoming goods. Using the (t,S) policy means to order the quantity of goods which is calculated through the difference of the maximum storage size S of the warehouse and the current quantity of the goods.

Company Z follows an order policy which uses RFID technology which improves the flow of information and makes the (s,S) policy the better method of order policy. If company Z used RFID technology without adapting the warehousing policy to the improved data flow, there would not be any difference to the warehousing policy of company X in this example. For that reason, it becomes clear as to why, when using RFID technology, the processes and the company policy need to be adapted accordingly.

Period	Demand	Inventory	Order	Change of inventory
1	90		/	750
2	92		/	658
3	93		/	565
4	67		/	498
5	67		/	431
6	79		/	352
7	88	264	576	264
8	112		/	152
9	88		/	640
10	90		/	550
11	70		/	480
12	98		/	382
13	76		/	306
14	105	201	639	201
15	89		/	112
16	59		/	692
17	77		/	615
18	115		/	500
19	84		/	416
20	89		/	327
21	99	228	612	228
22	78		/	150
23	100		/	662
24	66		/	596
25	79		/	517
26	98		/	419
27	78		/	341
28	100	241	599	241
29	83		/	158
30	107		/	650

Table 12: Order quantity, change of the inventory and ordering time point of company X (**without** using RFID and a fix reorder point)

Period	Demand	Order	Change of inventory
1	90	/	750
2	92	/	658
3	93	/	565
4	67	/	498
5	67	/	431
6	79	/	352
7	88	/	264
8	112	688	152
9	88	/	64
10	90	/	662
11	70	/	594
12	98	/	494
13	76	/	418
14	105	/	313
15	89	616	224
16	59	/	165
17	77	/	704
18	115	/	589
19	84	/	505
20	89	/	416
21	99	/	317
22	78	601	239
23	100	/	139
24	66	/	674
25	79	/	595
26	98	/	497
27	78	/	419
28	100	/	319
29	83	604	236
30	107	/	129

Table 13: Order quantity, change of the inventory and ordering time point of company Z (**with** RFID and a reorder point as soon the inventory falls below 240 items)

It can be seen that within a 30 day time period, both companies had to order 4 times. In company Z however, the orders were placed later because, thanks to the RFID technology, an automated documentation of the goods flow is possible, and an order is not placed until the inventory level falls below 40 items. In turn, this reduces the inventory and therefore positively influences the inventory costs. The total order quantity of company X is 2,426 items and the total order quantity of company Z is 2,509 items. Although the total order quantity of company Z is 83 items higher than

the total order quantity of company X in the given time period of 30 days, it can be observed that the cost level is lower due a more efficient order policy in company Z.

	Total inventory of 30 days	Inventory costs per /item / period	Setup costs / order
Company X	12 835	£ 0,15	£ 50
Company Z	12 382	£ 0,15	£ 50

Company X: $12\,835 * £\,0,15 * (4 * £\,50) = \underline{£\,2125,25}$

Company Z: $12\,382 * £\,0,15 * (4 * £\,50) = \underline{£\,2057,3}$

If you compare the calculated values, it is noticeable that company Z is able to save £67, 95 (3.3%) per 30 days. Projected over a year, RFID technology enables company Z huge cost savings.

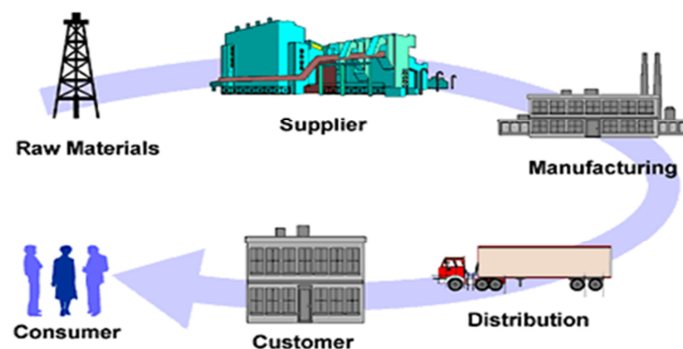
Besides the availability of products, its actuality is another challenge for the Logistic Management. Shorter product life cycles require shorter delivery times (Kotabe and Murray, 2004) and restrict the successful collection and analysis of statistics and indicators. The shorter the life cycle, the less statistical data is available to rate and to provide accurate forecasts of sales volume and location. The desire to increase efficiency and to reduce costs drives the economy to improve existing models. The Newsvendor Problem (Single Period Problem - SPP) is an example of these improved models which have to face the challenge of controlling the inventory of a single item with stochastic demands over a single period (Petruzzi and Dada, 1999). Callego (1995) explained the problem of determining the size of a single order that must be placed, before observing demand when there are overage and underage costs. The problem is particularly important for short-lived products with significant demand uncertainty and large overage and underage costs. By using RFID, the expected demand of a product is not affected, but it reduces the time for the transportation and the inventory and hence the risk of shortfalls. In transportation planning, transparency of all activities within the transport process (Voorst, 1998), minimised transportation costs (Burns et al., 1985), optimised resources and on-time delivery (Sum, 2001) are key objectives. Production, transport times and routes can be captured and recorded automatically by RFID at individual important logistical hubs. Through these automatically performed processes, it is possible to locate products faster and to store the position in a central database or on a RFID tag. The data can be analysed in the individual bearings and hubs before the goods arrive at

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the destination point. If the lead time is shortened, the order point(s) can be reduced, and thereby the safety stock is reduced. A positive side-effect of a lower safety stock is that this helps to reduce the inventory costs of the company.

4.5.3 Bullwhip Effect

The supply chain can be described as a system of organisations, people and activities through which products are moved from supplier to customer (Nagurney and Anna, 2006).

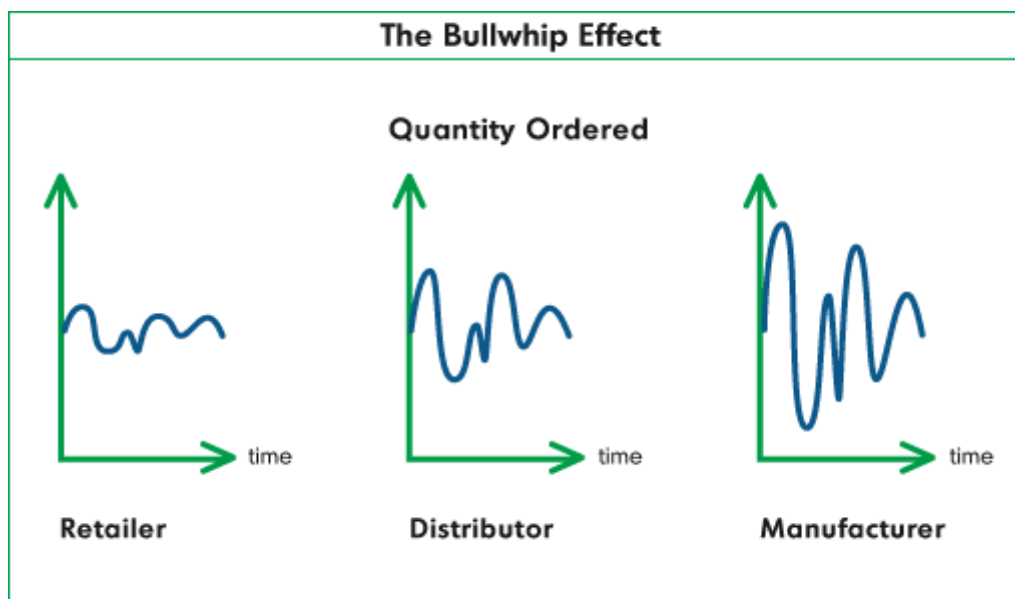


Graphic 12: Supply chain (Source: Weber State University, Utah, n. d.)

Lee et al. (1991) reported that the bullwhip effect occurs when the demand order variables in the supply chain are amplified as they move up the supply chain. Distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies. The bullwhip effect arises in forecast driven distribution channels, and is caused by fluctuations in the demand. It therefore develops through the numerous stages of a supply chain. The impact of the bullwhip effect starts with the demand of the single retailer and runs through the entire supply chain and through all components of the manufacturing process. The target of providing an immediate source of supply, and of buffering the production system from fluctuations in demand, builds up high inventory stocks and high stockholding costs. Factors such as time and supply of order decisions, demand for the supply, lack of communication and disorganisation, result in the bullwhip effect and decrease the product profitability by 10-30% (Metters, 1996).

A variation in demand causes a varying use of existing capacities. Here, the individual links in the supply chain, of which the inventory is based on an average amount of demand, have to face up to the dilemma that, in the event of peak hours, the demand cannot be satisfied. However, if the maximum demand quantity is chosen as inventory, this is an inefficient and poor utilisation of resources.

Another source which causes the bullwhip effect is the fluctuation in the inventory. The varying demand leads to fluctuations in the stock of every member of the supply chain. If the received delivery of a company is greater than the sales, the company's inventory increases. In contrast, the stock reduces if the delivered goods are less than can be sold. The problem is that a high inventory represents a high capital commitment. A lower inventory bears the risk of insufficient capacity to meet demand. This is evident, not least from the fact that each company in the supply chain builds its own safety stock which increases with every link in the supply chain. The reason for this is the lack or the delayed flow of information between the members which causes the bullwhip effect as shown in a simplified manner in the figure below.



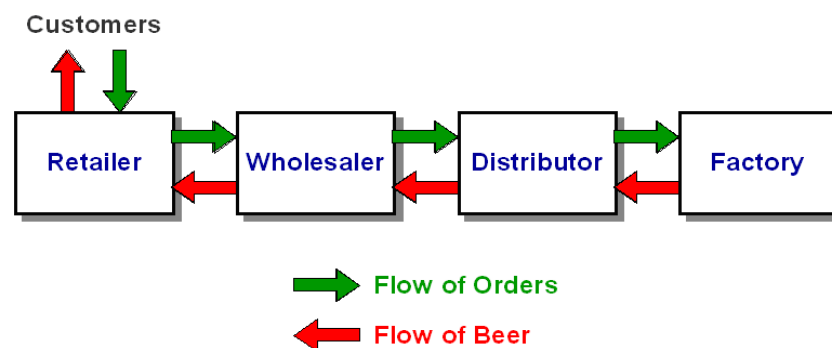
Graphic 13: The Bullwhip Effect (Source: itusozluk.com/gorseller, n. d.)

In summary, one can say that the bullwhip effect is caused by the delayed information flow (from the end-user to the producer) and the product flow (from the producer to the end-user). Additionally, a further factor has to be included for troubleshooting: the planning and behaviour of the individual supply chain members and their logistics manager. The planning is often founded on the basis of the data of

the direct neighbour's warehouse and order policy in the supply chain. The real demand of the end consumer is already affected and distorted in the first stage of the supply chain and so passed on to the next link. Furthermore, a fluctuating pricing policy may cause short-term fluctuations in the ordered quantity and may influence the planning of subsequent members of the supply chain in the long term. The long-term influence refers to inventory based on historical data.

In the early 1960s, an experiential learning business simulation game called the "Beer Distribution Game" was developed at the MIT Sloan School of Management (Goodwin and Franklin, 1994). This simplified example serves the purpose of representing the effects of the previously described bullwhip effect, which is a source of inefficiencies in supply chain performance (Nienhaus et al., 2006). Riemer (2012) stated that the game can be used to demonstrate the benefits of information sharing, supply chain management, and eCollaboration in the supply chain.

The structure of the game is simple. There are 4 players, each with a specific role in the supply chain (retailers, wholesalers, distributors and manufacturers), whose aim is to minimise cost.



Graphic 14: Supply chain (Source: Networked organisations, 2009)

The challenge lies in the fact that the order quantities are multiplied over the length of the supply chain, since the players each know only the ordering of the respective predecessor.

How can the use of RFID reduce the bullwhip effect? Primarily, RFID technology supports the flow of information between the different members of the supply chain. Decisions can be taken earlier. Furthermore, the different members in the supply chain are able to adjust their decisions to the fluctuations and new situations. In addition, the deliveries can be accelerated through a more efficient warehouse policy

thanks to the RFID technology. As a consequence, the complete supply chain can benefit from the advantages of the newly won flexibility, efficiency and outstanding adaptability.

To explore the possibilities of better information flow in the supply chain, the following scenario will be described: an end consumer orders beer cases every period from the retailer. The order quantity of the retailer is fixed before the game begins and has not been released to the players of the beer game. In the first 5 rounds, the demand of the retailer is 4 beer cases. In the sixth round, the demand increases to 8 cases and remains constant at 8 until the end of the game. The costs result in warehousing (£0.5 per round per beer case) and, as a result, delay in delivery (non-delivery costs £1 per round per beer case). The order enters the supplier with a delay of 1 round. The delivery occurs in the warehouse after 2 rounds. The initial situation is that each player has an inventory of 12 beer cases and, in each case, 4 beer cases in the supply chain. To achieve the common goal of reducing the costs, each player places his orders so that a worthwhile compromise between high inventory and stock-out can be found. The game is basically played in groups and repeats with changing scenarios. In the first round, each player has to get to know the bullwhip effect as described above. At the given stages of the supply chain, there is no information about the actual end-user demand available. For that reason, the bullwhip effect arises as a basic principle.

To show the advantages of RFID in the supply chain management, the second round of the beer game includes these technologies. In this case, the information about the demand of end consumers becomes visible throughout the complete supply chain. If the beer game is now simulated again under the condition of the simplified information flow, so it can be stated that the goal of minimising costs and bottlenecks can be achieved successfully.

5. Use of RFID for specific companies

For a better understanding and to illustrate the applications of the RFID technology practical examples of already established systems are described below. For each example is a brief analysis of the advantages and disadvantages of the RFID technology for the specific environment given. Responsible actors were interviewed based on the questionnaire which can be found in the appendix (2). This questionnaire can be seen as guideline for the interviews and its results are structured and explained in the following chapter. In order to make up for the information which could not been relieved through the help of the interview partner, the researcher worked with literature and internet-sources.

The industries in which RFID is already being used are versatile. Thus, not every use or switch to RFID systems is an improvement of the goods logistics. But all changes result in the optimization of the data acquisition and processing. Most common are pilot projects for RFID systems in the transport sector, the trade sector and in manufacturing. The object location and tracking is the primary task of the RFID system. There are also some solutions in which RFID is only used to identify objects. Among the innovative and pioneering products, are the products that exploit the possibilities of RFID tags: storing a variety of data, coupled with sensors, continuous exchange of information, ect. These application possibilities drive research and product development forward.

5.1 [Metro Group](#)

Metro Group is a German global diversified retail and wholesale/cash and carry group based in Düsseldorf. The company employs about 287 000 people the world over and is represented in over 33 countries (Metro Group.de, 2011). The company was the pioneer in many of RFID solutions in European commercial business and is critically involved in the publication of the technology in Europe. This company takes a determining part in the development of warehousing hardware and software, and processes. Up to the year 2007 already 80 German Metro wholesalers were

equipped for the use of RFID goods monitoring (Blache et al. 2007) and thus increased efficiency in logistics and warehouse management.

The internal startup for the use of RFID at Metro Group took place in November 2004 (Metro Group, 2004), which, however, in comparison to the American counterpart is late. The North American Wal-Mart Corporation has begun earlier with field trials and achieved promising results in a trial conducted in July 2003 (Violino, 2003). In different stores the performance of same product groups in classical and equipped with RFID sales transactions was compared. The shops which were equipped with RFID could reduce the out-of-stock situation to 21% within 29 weeks (Hardgrave et al., 2008). This result encouraged Wal-Mart and other companies to establish RFID as a future technology for trade.

To improve the possibility of out-of-stock situation and perform other performance optimisations, the Metro Group initiated the RFID Innovation Center in Germany. From initial studies of the possible applications of RFID in sales, the Metro Group has created a test field where the practical integration of technology in the areas of product ordering, inventory, wholesalers, supermarkets and also in private households were tested. Subsequently, the real Future Store has been built in Tönisvorst (Germany). This store followed the aim to give the interested end consumers the opportunity to test the increase in the purchasing quality developed by the Metro Group.

Effective RFID is currently used in supply chain management in the Metro Group. Suppliers of Metro are obliged to equip their products with RFID technology. This simplifies the insight on internal trade flows and deposits, thus reducing personnel and organizational costs in these areas. Up to the year 2007 already 100 suppliers from China and Vietnam and Hong Kong have equipped their cardboard packaging with RFID tags. The costs for the changeover to the RFID technology have to be paid by the suppliers to continue working with Metro AG (checkpointsystems.com, 2009).

5.2 [Media-Saturn-Holding](#)

Media-Saturn-Holding GmbH is a German corporate group consisting of consumer electronic retailers Media Markt and Saturn. The company is part of the Metro Group. The Group currently employs more than 65,000 people and generates an annual turnover of EUR 7.5 m (media-saturn.com, 2012). As things stand at the moment, the articles for sale are not equipped with RFID tags, even though the tags are already available for the employees in the branches and customer centers. The reason that is given in this context is that the employees do not have the time required to tag every product with an RFID chip. The main intention of tagging the sales articles in the consumer electronic branch is antitheft protection. Even small electronic articles like mp3 players can have very high values. These missing articles lead to high indifferences during the annual inventory.

In the near future mostly of the articles will be tagged with RFID chips. In the appendix (3) you can find examples of the used tags. The tags will be glued to the cardboard box or will be put inside. Some of the tags look like a usual barcode, but this is only a fake. It looks like a usual barcode with the aim to deceive the thief. The thief believes that the tag do not have to be removed from the article, and when the thief passes the RFID monitored exit the wire in the tag which looks like a usual barcode sends a signal to the transponder in the exit area and the thief can be captured. It is expected that these measures will help to relieve the hidden store detectives and reduce the value of quantities missing due to theft or other identifiable causes.

5.3 [C & A](#)

The C & A Mode GmbH & Co. KG is a clothing company based in Dusseldorf and Brussels. With 1,400 branches and a yearly turnover of 6, 8 billion Euros this prêt-à-porter store chain is the largest retail store in Europe (c-and-a.com, 2012).

Among the big players in the fashion industry that rely on RFID, is now also included C & A. In a pilot project, the new technology of RFID was tested in five C & A stores in Germany (Duisburg, Euskirchen Hürth, Mönchengladbach and Siegburg) (c-and-David Litwak

a.com, 2013). C & A has selected "Checkpoints software solution" for the RFID project to analyze the processes and procedures in terms of goods delivery, restocking and inventory. Checkpoint Systems is a leading global provider of solutions for retail security, visibility and apparel labeling. Checkpoint's core competencies are the source tagging of consumer products, electronic article surveillance (EAS), RFID applications, the award articles of clothing and promotion systems (Checkpointsystems.com, 2013).

On this basis, the reform aims a better availability of different sizes and colors, thus enables an optimization of the product availability. Considerable process improvements are the main user benefits as a better and faster service can be offered. "RFID technology enables us to optimize the processes of our supply chain, in the interests of customers and employees at the same time. (Rolfes, 2014)" The tag transmits a unique code. A reader in the vicinity of the label can assign the product this code exactly. In a split second, all (information size, color, material...) for this product get available. The signal is received by the company only from the immediate vicinity and should no longer have any meaning for the customer after leaving the store.

The supposed fears of the customer that radio frequency technology might endanger human health are denied by the company's management. In addition, is assured that the identified data from EC card or credit card information are stored separately from the RFID data and cannot be subsequently brought together (c-and-a.com, 2013). This corresponds to the current provisions of the data protection.

Wenzel (2014) stated that after a successful pilot phase RFID technology will be expanded to a total of 100 German branches in the near future. Thorsten Rolfes, Head of Corporate Communications Europe from C & A explains that the project has to be further extended to continue the improvement of RFID technology and to examine technical and organizational aspects based on a larger number of branches before a comprehensive introduction will take place (fabeau.de, 2014). In addition, a wider range should be tagged with RFID in the future. Hence C & A stores are supplied, which are perhaps not equipped with the corresponding technology. Rolfes also has made it clear that "The reasons for this lie in the production and logistics management. Only with a widespread introduction of RFID in our stores in Germany and Europe, the labels would fulfill its function (Sharma, 2014)".

5.4 [Siemens](#)

Siemens AG is an integrated technology company with four main areas: energy, medical, industrial as well as infrastructure. Siemens Group operates in 190 countries and ranks among the largest companies in the electrical and electronics (Ellrich et al, 2004). The enterprise employs 366 000 people and has a yearly turnover of 75,882 billion € (siemens.com/jahresbericht, 2013).

Since 25 years Siemens develops RFID systems for production and logistics. The group has more than 300,000 installed RFID read and write devices and is market leader in Europe for a variety of optimized wireless data carriers and all required software - by the RFID middleware to application software for different industries (Siemens.com, 2009).

RFID controls in-house production and intra-logistics processes. This ensures that complex products like generators with numerous variants can be made without errors. Additionally the use of these modern identification technologies in production logistics results in significant cost reductions through a better visibility and efficiency. Many of Siemens' manufacturing plants use wireless technology for a comprehensive process control of the first production steps to outbound. One of these production plants which use RFID is the generator production in Mülheim an der Ruhr (Germany). Each of the sheet metals which are needed for the construction is provided with an RFID tag and the database keeps track of where it is. The logistic job in this industrial production is to provide the right amount, the right object in the right place, at the right time, in right quality, at the right cost. The classic logistics task is the transport of sheet metals between several internal locations. A unique identification of the transportable sheet metals is essential to ensure that the right object arrives in time at the destination. The range of the used identification technologies is broad at Siemens Generator, ranging from simple barcode detection systems to the use of Radio Frequency Identification (RFID).

The ability to update the data on the transponder allows the tracking of the performed steps with connection to an IT system. Siemens cooperates with two of the world's largest software manufacturers (SAP and Intel). These software manufacturing giants help the concern with the integration of RFID in the merchandise planning systems.

Thus, RFID systems are constructed and coupled with SAP Software for example, for the automatic acquisition of goods issue (Schröder, 2005).

Another advantage of RFID in Siemens' production facilities is the fact that it reduces the chaos of paper. Because so far, it often happened that an employee collect the papers and simply enters into the system in the evening. If tags are used, one must leave the empty container only in the vicinity of the reader and replenishment will be ordered automatically. This demonstrates that even well-functioning processes can be further optimized with the help of RFID.

6. Problems and dangers of RFID

Beside all the advantages RFID brings, it requires great care with regard to the potential risks inherent in this technology, particularly regarding the security of RFID systems which is still frequently discussed. The most frequently expressed concerns include the incorrect application of the technology or data misuse. With RFID systems, people can be monitored and movement profiles are created, without the person noticing (Albrecht, 2005). This view is widespread, and customers who buy products with integrated RFID tags which are attached to goods perceive this as a gross vulnerability in times of global data misuse.

6.1 [Data protection](#)

In order to prevent the misuse of data, EPC global adopted policies that require that goods which are provided with an RFID transponder, have to be marked optically clear with a label that indicates the RFID chip on the object. Furthermore, many end customers call for a permanent disabling of the transponder from the goods at the handover. For example, companies from the Metro Group fulfil these requests without being asked in order to close the customer's trust gap (Metro Group, 2007). This issue has also attracted the opposition of the German government, claiming that

only through compliance binding data protection standards and the introduction of a privacy seal, can the acceptance of RFID technology be initiated by the end user (Krempel, 2008). However, it is not only the hurdle to convince the consumer that data protection is working and that data protection laws are sufficient. The confidence of the consumer in the retailer, who primarily has access to the customer data, must be ensured.

6.2 Marketing exploitation

With a high degree of probability, missing and not sufficiently guaranteed or defined data protection will meet the attention of market researchers and marketing experts concerning the possibilities of RFID. The technology can be used in cooperation with various bonus programs as a basis for personalised advertising (Hind et al., 2001). Thus, extended data sets with consumption profiles can be created. In 2005, personalised advertising based on RFID was tested in Seattle (USA). Users with active RFID transponders were detected upon entering the information zone and supplied with custom audio information (rfidjournal, 2005). In this case, the participants were aware that they were releasing personal data, but this awareness about the degree of disclosure of personal data might become blurred by a steady presence of the technology. This issue could be the weak point of personal advertising. The spread of personal RFID tags can in turn be done in cooperation with bonus programs, as it only needs the loyalty cards to be equipped with a RFID chip.

6.3 Globalisation as a source of danger

Even if the RFID technology can improve logistics in supply chains in the era of globalisation, at the same time, globalisation can also be an obstacle for the rapid diffusion of the technology. There are still no uniform global data protection regulations and technical standards (eg. frequencies, transponders). This deficiency

complicates a global expansion of this technology. More and more manufacturers are outsourcing the production of individual products and intermediate products. The number of service providers integrated into the product creation chain has grown in recent years. To use the RFID technology at its optimum on a global scale, it must be integrated not only into the logistics, but also into the production, processing and intermediate steps. The large number of possible variations of the transponders requires a deeper analysis which doesn't only take the logistics processes into account. At this point, further research should be commenced to examine in which industries it is sufficient to take standardised RFID solutions, and in which industries adapted and specially tuned systems should be integrated.

7. Influenced consumer behaviour?

This chapter deals with the question, "how far RFID technology influences consumer behaviour?" In the appendix (1), you can find a questionnaire consisting of 9 questions which exactly 100 persons answered. The need for a creation of a representative survey has to meet several conditions. **Condition 1:** the newspaper or Internet must be selected to determine whether they represent the whole population or just the part whose mood, preferences or opinions are to be imaged. To achieve these criteria, the interviewees were selected by age and sex. A quantitative survey and qualitative individual interviews were conducted. On the one hand, certain age-groups are really unsuitable for a wide-ranging questionnaire survey and on the other hand, homogenous groups should be formed, such as middle-aged people and older generations. **Condition 2:** all persons from an examined population must have the same or a calculable chance of being included in the sample (Pusler, 2008). To comply with these basic criteria, this survey was done in a shopping mall in Germany. This shopping mall is called "Centro" and it measures 119.000 m² sales space with over 220 retail stores. It is Europe's largest shopping mall (Ruhr-guide.de, n.d). Visitors of all ages were asked randomly whether they would answer this short questionnaire in a face-to-face interview. **Condition 3:** the selection of a subpopulation has to be chosen in a way that "it can be concluded from the results of

the partial survey as accurately as possible and safely on the ratios of the total mass". This is the case, "if it corresponds to [the partial survey] in the distribution of all the features of interest of the total mass, i.e. represents a true scaled-down, but otherwise realistic picture of the whole" (Berekoven et al., 1999, P. 50). This criterion is difficult to meet, as it has to be selected from an infinite population (Williams et al., 2011). It is nearly impossible to ask all the visitors of the shopping mall, or even all citizens of Germany, for their attitudes. So, why make a survey if it cannot be confirmed whether it is really representative of the broad mass? The term "representative" is often used but rarely explained exactly. After all, whether the result of a measurement, observation, survey, etc. is representative or not, cannot be simply answered with yes or no. Instead, it is more about how accurate a measurement can be. Since it is impossible to make reliable statements on the accuracy, the researcher has the intention of developing an understanding of the influence of the RFID technology on the consumer. From this understanding, the researcher is trying to answer which tendencies and trends could be derived from this survey.

The questionnaire revealed that 76 of 100 interviewees have heard of RFID. A further remarkable fact is that the older interviewees more rarely answered this question with yes. From the 24 persons who answered this question with no, 17 persons were older than 50 years. It can therefore be concluded that 71% of all interviewees who do not know this technology are older than 50 years. Nearly all participants of this survey who are younger than 50 years know RFID from the television, newspaper and Internet. Only 5 persons from the 100 interviewees had heard about this technology in a positive manner. Several of the statements made by the interviewees were that RFID can guarantee the security of supplies by a better information flow within the supply chain. That fact improves the service level. The rest of the 76 (71) persons who had heard about this technology associated RFID with negative emotions. The highest proportion of interviewees was not able to remember the source of or reason for their negative impression. Strikingly in this context, is that 21 people said that they had developed a defensive attitude regarding automatic identification technology. The strong aversion to automatic identification results from a total surveillance system for electronic communication which seems to have been realised several years ago. Interviewees therefore were resistant to any form of

automatic identification, even if it was only to be used for ensuring the security of supplies. The doubts about a responsible use of this technology are too strong.

Of the answers to the question, “have the interviewees shopped in the various shops which use that technology within the last year?”, 68 % answered yes. However, none of the participants knew that these shops already use RFID to tag their products or plan to do it in the near future.

17% of the interviewees have a loyalty card. 13 of the 100 interviewees who use a loyalty card were female. Most of these cards are used for supermarkets. It is surprising that none of them knew or had ever thought about the fact that loyalty cards can be tagged with RFID chips.

On one thing however, all agreed; nobody wished to receive any advertisement without having granted their express permission. Letters were unwanted, as were e-mails which they found annoying and ended up in the spam folder unread. The most negative emotions were released in relation to phone calls.

In addition, their universal wish was that all RFID tags be destroyed at checkouts and points of sale. When asked whether “they would not shop in a store where RFID was used”, most answered that they would continue shopping there. 13% of the sample would avoid shopping there and search for an alternative. The others would act in the same way as before.

Question number 9 was an open question. The most common answer which appeared was that the development of this technology cannot be avoided. In particular, people under the age of 40 did not have any illusions in respect of secure privacy. Mobile phones are able to create movement profiles, social media platforms know someone’s interests, and even Google or Amazon collect the data of everyone who gets uses their sites. The benefits of these new technologies are too great to use alternatives and being a “glass consumer” is accepted without having any meaningful influence to the consumer behavior.

8. Discussion and Forecast

RFID certainly has enormous potential for the future. The possibilities of using this technology are almost unlimited. Proliferation of this technology often fails because the potential beneficiaries of RFID technology simply do not have sufficient information about the current state of technology or systems used, so it can be observed that large production workshops like Siemens Generator use this technology in order to improve supply chain efficiency. A continuous position monitoring system helps the production workshop to increase its efficiency and process stability. The most important arguments for the use of the technology for department stores like Saturn or C&A are improved inventory management and theft protection. RFID labels are reliably alert when a product leaves the store without the security tag being disabled first. In a store equipped with RFID readers the staff always knows how many items are still on the shelves and so can reorder if necessary. The literature review has shown that mainly the food industry benefits from the use of active RFID systems in the long term. Thanks to RFID technology, transport times and routes can be adjusted, and thus the problem with the perishability of the goods is easier to manage.

General uncertainty among customers due to the possible misuse of private personal data can be countered only by information and educational work as practised, for example, by C&A. To meet customer identification and retention, strict compliance with the applied data protection regulations are a basic prerequisite for the acceptance of RFID. If this is guaranteed, consumers can also benefit from these new auto ID technologies. For example, customers can shop faster if collections are available in the requested colours and sizes. Customer service can thus be significantly improved and out-of-stock situations can mostly be avoided.

For efficient use of RFID systems in logistics management processes, there is not really only one solution that can be applied to all problems. It is more the case that several basic systems have to be established through standardisation for individual sections of the supply chain. Software and

hardware have to be integrated into and adjusted to the companies within the supply chain in order to guarantee the use of the benefits of RFID technologies throughout the entire supply chain. To use the RFID technology optimally globally, it must be integrated into not only the logistics process but also the production and processing processes and intermediate steps. The large number of possible variations of different transponders requires a deeper analysis that takes more than the core processes into account. At this point further research should start to examine in which industries it is sufficient to use standardised RFID solutions and where it should be adjusted to meet the requirements of specially integrated systems. It may be doubted whether a forced introduction of an RFID system in a supply chain is efficient in the long-term. Metro AG, for example, benefits by issuing their suppliers with strict guidelines for RFID tagged products, but the costs of switching to this technology have to be carried by them alone. In order to assess this, it is necessary to observe the economic development of companies and their suppliers. RFID will result in improvement for the entire supply chain only if every member benefits from the use of this technology.

Many experts are of the opinion that the development of RFID technology is very closely related to the role of the Internet. "The Internet of Things" is a term which refers to the modern wireless telecommunications. In 1991, Weiser first described the main idea of this term in his essay "The Computer for the 21st Century". The computer will increasingly disappear as a unit, and 'intelligent objects' will replace it. The aim is to link clearly identifiable physical objects with virtual representations in an Internet-like structure.

"The pervasive presence around us of a variety of things or objects – such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones, etc. – which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbours to reach common goals." (Atzori et al., 2010, p. 2787)

The goal of the "Internet of Things" is to minimise the information gap between the real and virtual world (Fleisch and Mattern, 2005) and thereby to develop an autonomous system in which objects assign themselves and navigate

through the production and transportation process. According to Sharma, a journalist interested in the intersection of business, technology and society who worked for a number of years in the IT industry in India before shifting careers into journalism for the Forbes Magazine, there is still a long way to face up to the challenges of the “Internet of the Things”. These challenges include, in particular, the lack of a shared infrastructure. The “Internet of Things” is a complex interconnection of hardware, and for this reason open source platforms are necessary to reduce capital equipment costs for the information systems and encourage creativity and collaboration (Dedrick and West, 2003). Another challenge for the autonomous and continuous wireless connection to the Internet is a limited battery life. Energy-efficient machine-to-machine communication is crucial (Chen, 2012). Therefore, prolonged battery life that sources energy from unconventional power sources has to be further developed to guarantee an improved and continuous Internet of Things. A lack of standards creates the next challenge for the future. Only if the lack of standards within the different fields like retail, food, logistics, transportation etc. can be solved successfully with the help of specific application solutions, can a real Internet of Things be established (Tan and Wang, 2010). Data sharing and data control also are areas that need to be taken into consideration for achieving the objective of a safe and responsible management of this technology. The control and understanding of privacy settings is absolutely necessary for the use of the Internet. A development of a better and more accurate understanding of knowledge management has to make sure that the collected data cannot break the cycle of internal control (Malhotra, 2000). One can assume that RFID technology in the close future will be hardly an integral part of our everyday life. A frequently cited vision of the future is the “intelligent refrigerator”. It requires data to be exchanged between the refrigerator and food packaging. With absolute acceptance of RFID technology and a further drop in prices of passive tags, the following scenario can become reality: Foods are equipped with an RFID tag that contains the information about each object, including the expiration date. After a self-determined minimum level of the foodstuff the intelligent refrigerator can autonomously reorder food from the supermarket. The goods will be delivered to the home of the user and the order will be billed to the owner of the account

and charged to his credit card. This is only one of the many examples of how our life can develop in the close future. That technology is available today, but it is currently viewed with some scepticism by most customers.

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Appendix (1)

RFID QUESTIONNAIRE: Consumer

Question 1: What age range are you?

- < 20 ☐
- 20 – 29 ☐
- 30 – 39 ☐
- 40 – 49 ☐
- 50 + ☐

Question 2: Are you...?

- Male ☐
- Female ☐

Question 3: Have you ever heard about RFID technology?

- Yes ☐
- No ☐
- Don't know ☐

If yes, please provide brief details of how you heard about RFID (TV, newspaper, Internet etc.) and whether the technology was portrayed in a positive/negative/neutral manner?

--

Question 4: Have you shopped at the below stores within the last year?

- Saturn ☐
- C&A ☐
- Metro ☐
- No ☐

Question 5: If you have shopped at one of the above named stores, were you aware that they use RFID tags on their products?

Yes ☐

No ☐

Don't know ☐

Question 6: Do you have any of the loyalty cards specified below? (Please tick more than one if applicable)

Super markets ☐

Boots Advantage ☐

Shell/ Aral/ BP... ☐

Other ones, If yes which one?

No ☐

Question 7: Please rate how strongly you agree or disagree with receiving the below specified marketing media:

Strongly Agree Agree Neither agree nor disagree Disagree Strongly Disagree

E-mails ☐ ☐ ☐ ☐ ☐

Letters ☐ ☐ ☐ ☐ ☐

Phone calls ☐ ☐ ☐ ☐ ☐

Question 8: Please respond to the following statements:

	Agree	Disagree	Neutral
All RFID tags should be destroyed at checkouts or points of sale	☐	☐	☐
I would be reluctant to shop at a store that I knew used RFID technology	☐	☐	☐
I am conscious of identity theft	☐	☐	☐
RFID chipped passports are a good way to store personal details	☐	☐	☐

Question 9: Do you have any comments or thoughts regarding RFID technology and its applications?

Appendix (2)

RFID QUESTIONNAIRE: Company

COMPANY INFORMATION**Company Name:**

City : State/Province:

Main Phone :

PRIMARY CONTACT INFORMATION

Name : Title :

City : State/Province :

Main Phone :

1. What is the driver behind the RFID initiative?**2. What asset(s) would you like to track with RFID?****3. About how many assets have to be tracked?**

4. How granular does your visibility need to be?

- Handheld reader ☐
- Fixed Read point ☐
- Building- level ☐
- Floor- level ☐
- Room- level ☐
- Exact location ☐

5. How many "points" (e.g. rooms, buildings, sections, etc.) need to be tracked?**6. Is there an RFID project team and if so is both the business and IT represented?****7. Is there a consultant/integrator engaged, if so who?****8. Are there software providers involved, i.e. SAP, Intel, ERP, etc., if so who?**

9. What is your plan to implement the RFID solutions, site survey, commission the system?

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10. Please describe your objectives for the project and the value you hope to achieve.

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Appendix (3): RFID Tags used at Saturn

Appendix (4): Ethics form

UNIVERSITY OF PLYMOUTH FACULTY OF BUSINESS

ETHICAL APPROVAL OF ALL BUSINESS PLACEMENT REPORTS
AND RESEARCH-BASED DISSERTATIONS INVOLVING HUMAN SUBJECTS AND
MATERIAL COVERED BY CONFIDENTIALITY AT TAUGHT MASTERS LEVEL
AND BELOW

Please read the attached extract from the University of Plymouth's Research Policies and Procedures relating to Ethical Principles for Research involving human participants before completing and signing below.

Ethical Protection & Declaration

To the best of my knowledge and belief, the proposed research conforms to the ethical principles for research involving human participants contained in the University of Plymouth's Research Policies and Procedures with regard to the following (please tick appropriate box).

- | | | | |
|-----|----------------------|------------------------------|-----------------------------|
| (a) | Openness and honesty | Yes ☐ | No ☐ |
| (b) | Protection from harm | Yes ☐ | No ☐ |
| (c) | Right to withdraw | Yes ☐ | No ☐ |
| (d) | Debriefing | Yes ☐ | No ☐ |
| (e) | Confidentiality | Yes ☐ | No ☐ |
| (f) | Informed consent | Yes ☐ | No ☐ |

Note: I agree to abide by the ethical protocol. The Supervisor signs to state that he/she has read and is satisfied with the content of this application.

Sign below where appropriate:

Principal

Investigator:
Name

.....
Signature

.....
Date

This form is to be retained by the Supervisor and then kept in the relevant module box.

September 2004