

ADOPTION BARRIERS OF RADIO IDENTIFICATION TECHNOLOGY

Bachelor's thesis in Informatics

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Abstract

Radio frequency identification technology (RFID) has during the past decade seen an upwards trend among logistics companies in the supply chain. With increased e-commerce, demand for new and more efficient solutions are ever-increasing. RFID is a technology which Schmidt, Thoroe & Schumann (2013) call the next 'evolutionary step for auto-identification technology'.

The purpose of this research is to investigate and describe how previously found barriers for RFID adoption are perceived by Swedish logistic companies. The significance of barriers often accompanies the choice of investing or not.

This thesis was conducted with mixed qualitative research design and used multiple case studies as a pilot study as well as a survey based on the results from the qualitative study to look at different logistic companies in Sweden. The authors collected data using semi-structured interviews with a purposive sampling technique. Through thematic analysis, predetermined barrier themes emerged and that were strengthened by coding and categorising the transcripts. The survey data has been collected and analysed in IBM SPSS.

The findings in this thesis conclude that RFID has matured over the last decade, and that cost is no longer the most significant barrier when it comes to implementing RFID technology into logistic processes. The most significant barrier now is lack of understanding and the popularity of barcodes. Lack of business case and an extensive knowledge gap surrounding RFID impedes Swedish logistic companies to adopt the technology. Another significant barrier was the popularity of barcodes. It has long been the industry standard, and companies are heavily invested in the infrastructure developed for barcodes.

The target group for this research is both companies thinking of investing in RFID technology and RFID solution providers who want to know what challenges logistic companies face regarding RFID. For future studies, researchers should try to investigate how postal services could feasibly adopt this technology or analyse and compare barriers between different logistical segments within the supply chain.

Keywords: RFID technology, Barriers, Logistics, Supply chain, Sweden.

Sammanfattning

Radio frequency identification technology (RFID) har under det senaste decenniet sett en uppåtgående trend bland logistikföretag i försörjningskedjan. Med ökad e-handel ökar efterfrågan på nya och effektivare lösningar. RFID är en teknik som Schmidt, Thoroe & Schumann (2013) har kallat 'nästa steg i evolutionen för auto-identifikations teknologi'.

Syftet med uppsatsen är att undersöka och förklara hur tidigare funna barriärer kring RFID uppfattas av svenska logistikföretag. Valet att investera eller inte är allt som oftast relaterat till signifikansen av barriärerna.

Denna uppsats genomfördes med en blandad forskningsdesign. Uppsatsen inleds med en kvalitativ design med ett flertal fallstudier som strategi. Datainsamling gjordes genom semistrukturerade intervjuer med ett icke-slumpmässigt urval. Genom tematisk analys har teman identifierats med hjälp av kodning och kategorisering utifrån intervjuerna. Resultatet från intervjuerna har lagt grunden till frågorna i enkätundersökningen. Enkäterna har samlats in och analyserats i IBM SPSS.

Resultaten i studien visar att RFID har mognat under det senaste decenniet, och att kostnaden inte längre är den mest betydande barriären när det gäller att implementera RFID. Den viktigaste barriären nu är 'lack of understanding' och 'popularity of barcodes'. Brist på klara affärsområden och ett omfattande kunskapsgap kring RFID hindrar svenska logistikföretag att anamma tekniken. Strekkodsteknik har länge varit branschstandard och företag har investerat mycket i den infrastruktur som utvecklats för strekkoder.

Målgruppen för denna studie är både företag som tänker investera i RFID-teknik samt leverantörer av RFID-lösningar som vill veta vilka utmaningar logistikföretag står inför när det gäller RFID. Framtida forskning bör enligt författarna försöka undersöka hur postbranschen på ett lönsamt sätt skulle kunna implementera denna teknologi, eller analysera och jämföra hinder mellan de olika logistiksegmenten i försörjningskedjan.

Nyckelord: RFID technology, Barriers, Logistics, Supply chain, Sweden

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1 Introduction

Warehouses are continuously growing since people all around the world consume more and more; this pushes companies to adapt to changes more quickly than before. This increased consumption is putting more focus on warehouse efficiency to meet customers' demands. In the era of smart devices and the possibility to collect data faster and more reliably, new technology is needed to meet the future endeavours of the industry. One of these technologies is Radio frequency identification (RFID), a possible replacer to the current barcodes.

RFID has been around for many years now, and the industry has had cautious optimism towards this technology. The main obstacle to become a standard in the industry and to replace barcodes has been costs according to (Kaur, Sandhu, Mohan & Sandhu 2011). The popularity of barcode is still dominating most of the supply chain, mainly due to its well-established standards and low costs. Kaur et al. (2011) state that it is not a question of if, but when, the costs of RFID will fall below a certain price point for companies to invest in this technology.

The use of RFID creates many opportunities for a logistic company and allows them to keep track of goods that move through their warehouse with high precision and with less human interaction which could minimise the risk for human errors. The considerable upside for RFID tags comes from the fact that there is no need for a line of sight when scanning goods, the tags can be reprogrammed and reused. They also have better resistance towards physical damage and moisture than barcodes (Kaur et al. 2011). Big companies like Walmart and Amazon have already implemented this technology with good success rates. Keeping track of inventories has improved to rates well over 90 % and decreased out of stock goods with 50%, according to Napolitano (2012).

In this report, the goal is to combine the data from a qualitative research method followed up by a quantitative research method known as a double-phase, sequential research design. Firstly, a qualitative approach with semi-structured interviews will lay the foundation and act as a pilot study to support the quantitative method and help the researchers design the survey questions so they are relevant and will be able to answer the research question.

1.1 Definitions

RFID Technology

Radio frequency identification relies, just as the name reveals, on transmitting and receiving radio waves between tags and readers. There is no need for a line of sight, and there are mainly two different tags, 1) active ones with battery and 2) passive ones that activate when receiving a signal from a reader. The tags consist of a microchip and an antenna. Readers communicate via middleware software with the company's systems.

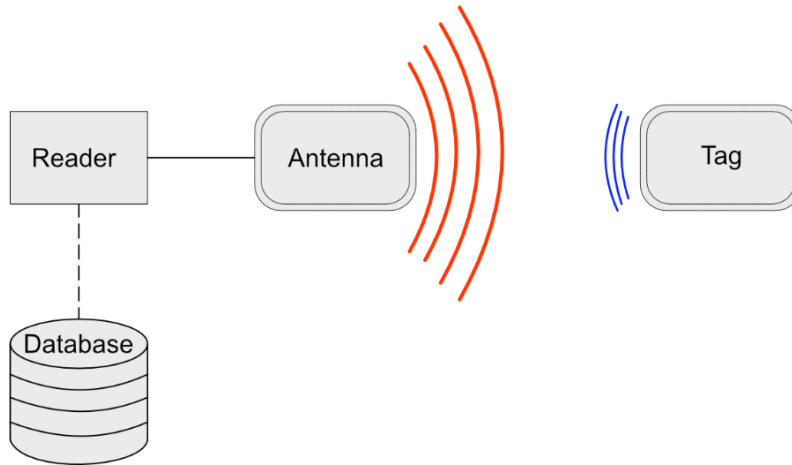


Figure 1: Overview of RFID.

In logistics and warehouses, RFID tags can be placed on parcels in order to make tracking and tracing more efficient. The tags do not need to be in the line of sight to the reader to be registered. If readers are placed by the entrance, the parcels can be automatically scanned when passing through the door, sending the information to middleware and then stored in an information system within the organisation.

1.2 Problem discussion

New technology and innovation are changing rapidly in today's society (King & Anderson 1991) and studies have shown that in order to keep competitive advantages, adoption of new technologies is vital for organisations (Lin 2008). Lin (2008) discusses different factors that affect the adoption of RFID and concludes in their paper that many organisations are willing to adopt this new technology, but few do. Reyes, Li, & Visich (2016) pinpointed four barrier categories for companies that had a direct relationship towards not implementing RFID technology: 1) Cost issues, 2) Lack of understanding, 3) Technical issues and 4) Privacy concerns.

Compared to the traditional barcode, RFID technology comes with some benefits and Reyes et al. (2016) found in their research that a company's internal motivation is what drives the adaptation for implementing RFID technology. Reyes et al. (2016) list four distinct benefits with adopting RFID: 1) Customer service, 2) productivity, 3) asset management and 4) communication. All of these benefits should attract logistic companies in Sweden to adopt RFID technology and to strengthen their competitive advantages. Looking at the logistics performance index (LPI), which the World Bank measures, Sweden is at number two when it comes to logistics performances worldwide (World Bank 2019). Logistics companies in Sweden need to tag along and not be left behind with old technologies when the industry moves forward. The most significant barrier concerning RFID technology is, according to Reyes et al. (2016) costs. In order to adopt and implement RFID, companies need to invest in tags, readers and software (Reyes et al. 2016).

Few studies on RFID technology have been conducted in Sweden, and earlier literature has focused on other countries, mostly in the US and on the Asian continent. Most studies regarding

RFID have been conducted a decade ago, where they concluded the technology was becoming the next hype in supply chain management. With RFID technologies, logistics companies in Sweden will gain better insight into their work processes, possibly minimise the risk of losing goods and create customer value. Still, many have not made any use of RFID despite all the benefits described. Why is that? RFID is said to have matured a lot in recent years, and according to Choy, Ho & Lee (2017), RFID is becoming the next generation of barcodes. Today, contrary to earlier beliefs of RFID becoming the next thing, not many logistics companies in Sweden have implemented RFID into their supply chain operations. This begs the question if Swedish supply chain companies face similar impediments of RFID technology as found in previous studies.

1.3 Problem statement and purpose

The purpose of this research is to investigate and describe how previously found barriers for RFID is perceived in a Swedish logistical context. Understanding how these are perceived will contribute to better understanding RFID from a Swedish perspective when adopting the technology which Schmidt et al. (2013) call the next evolutionary step for auto-identification technology. By utilising previous theoretical propositions regarding barriers of RFID, this research aims to investigate and describe how these are perceived from a Swedish logistics perspective. By first conducting multiple case studies as a pilot study, and then follow up with a broader scope survey based on the findings of the pilot study, will contribute to a more in-depth insight to the barriers and answer the following research question:

1.3.1 Research question

- How are previous found barriers of RFID perceived in Swedish logistics companies?

1.4 Target group

This thesis aims to investigate and describe the most significant barriers for logistics companies when it comes to either beginning or considering piloting RFID technology into their warehouse operations. With the findings, the thesis provides RFID solution providers and other stakeholders in the supply chain with the challenges faced in the industry. The barriers found in this paper will also help other academics understand the impediments of RFID from a Swedish perspective and act as a reference for future research.

2 Theoretical framework

In order to conduct an exploratory study, previous literature has been reviewed in this chapter. The articles collected have been done so by using the search engine; ‘Primo’, provided by the library at the University of Borås. Keywords such as ‘Radio Frequency Identification’, ‘RFID’, ‘Warehouse’, ‘Barriers’ have been used to try and convey the area. In order to assure the reliability and quality of the articles, every paper in the review has been ‘peer-reviewed’. Reviewing articles included or cited in first found articles has also been used as a means to exhaust the subject (Webster & Watson 2002). The authors have chosen to limit the period of the research papers to only include studies made this millennium, the authors did this due to the rapid pace of technology and not to include irrelevant facts but focus on knowledge up to date.

Most of the barriers found in this study’s theoretical framework come from the constructs derived in Reyes et al. (2016) research, seen as the first four barriers in table 1. below.

Table 1. *Barrier framework*

Barriers	Literature
1. Costs	Srivastava (2004) ; Madleňák, Madleňáková & Kolarovaszká. (2016) ; Osyk et al. (2012) ; Tajima (2007) ; Kapoor et al. (2009) ; Reyes et al. (2016)
2. Lack of understanding	Reyes et al. (2016) ; Tajima (2007) ; Kapoor et al. (2009) ; Lim, Bahr & Leung (2013) ; Srivastava (2004)
3. Technical issues	Srivastava (2004) ; Tajima (2007) ; Kapoor et al. (2009) ; Lim et al. (2013) ; Reyes et al. (2016)
4. Privacy & Security concerns	Hossain & Prybutok (2008) ; Srivastava (2004) ; Osyk et al. (2012) ; Tajima (2007) ; Kapoor et al. (2009) ; Lim et al. (2013)
5. Competition & Customer mandates	Cheng & Yeh (2011) ; Kapoor et al. (2009) ; White et al. (2008)
6. Government support	Laosirihongthong et al. (2011) ; Lin (2008) ; Ramanathan et al. (2014) ; Cheng & Yeh (2011)
7. Popularity of barcodes	Tajima (2007) ; Smith (2005) ; Twist (2005)

2.1 Previous studies

The earlier literature and studies surrounding barriers of RFID technology have been, for the

most part, quite agreeing that costs have been the most cited impediment of adoption. Other barriers have been found contextualised regarding what industry the company exists within, and some differ regarding what country they operate their business in. Srivastava (2004) concluded that the significant barriers needed to overcome were cost, integration with existing systems and global standards. Kapoor, Zhou & Piramuthu (2009) also emphasised the economic and technical issues as the most challenging, while White, Johnson, & Wilson (2008) found that mandates from customers were found to be costly and challenging for receiving companies upstream.

Since these earlier studies, more modern studies have shown that the barrier of not having standards have mainly been resolved. Both Reyes et al. (2016) describes how with the EPCglobal standards many previous issues are solved and Osyk, Vijayaraman, Srinivasan & Dey (2012) which compared a study from 2004 and one from 2007, found that while concerns still exist regarding standards, it has decreased in later years.

Contrary to White et al. (2008), a lack of mandating customers or catalyst drivers such as Walmart or even competitors may slow the adoption of RFID. Cheng & Yeh (2011) found this to be the case in Taiwan, in which case they suggested government support to aid in promoting the implementation of the technology. How governments stand in the adoption of innovation and whether they encourage or discourage have been found to affect in both (Laosirihongthong, Punnakitikashem & Adebajo 2011; Ramanathan, Ramanathan & Lorraine-Ko 2014) studies regarding RFID.

Aligned with earlier studies ranking costs as the most prominent barrier, more recent papers have also found that to be true. Laskowska (2018) examined factors influencing the decision and found that costs were among the top factors and Osyk et al. (2012) also found that costs, while not having as much weight as in 2004 were still high on the factor list. Osyk et al. (2012) concluded this to be a sign of the maturity of the technology. Li, Godon & Visich (2010) found that both considering companies and the ones that were underway with pilots and implementing RFID ranked financial i.e. costs as the highest barrier and then lack of a business case. Even though RFID has matured during the years, costs still seem to dominate, as Laosirihongthong et al. (2011) found to be the case in supply chain companies in Thailand.

2.2 Cost issues

The costs of implementing RFID in the supply chain is considerably higher than that of its counterpart, the barcodes. Srivastava (2004) stated in his paper that one of the major impediments of adopting RFID was that the cost of tags and readers are too high. RFID tags do unlike the barcode contain a chip with an antenna embedded on the etiquette and this chip, be it of passive or active nature costs more. The readers are sending out radio signals at a frequency, communicating with the tags which are according to Srivastava (2004) too expensive for broad implementation in the supply chain. The tags and readers are often connected to the company's systems via a middleware which acts as an intermediary between the hardware and software; these too cost a lot depending on functionality (Madleňák, Madleňáková & Kolarovaszka 2016). Osyk et al. (2012) also mention the cost of tags to be the biggest obstacle for a business when implementing RFID. They further identify costs for training employees and costs for software licenses concerning RFID.

Tajima (2007) extends the usual cost issues of tags also to include hidden costs such as new equipment for material handling the RFID tags as well as even changing the current layout in the operations area to fit RFID. Kapoor et al. (2009) found that one major cost impediment is the “vagueness of its cost-benefit analysis”, Kapoor et al. (2009) state that the costs associated with RFID are infrastructure installation, meaning readers and tags and the marginal costs of these as well as the opportunity cost.

Besides the initial costs of hardware and software, there are also costs in the form of maintenance for failed tags or readers and consulting regarding the reshaping of the IT infrastructure to cope with the many different systems that suppliers or customers use (Smith 2005).

Reyes et al. (2016) found that costs were the only significant barrier when it comes to adopting RFID.

2.3 Lack of understanding

Understanding the use of RFID in the context of the supply chain and how companies can create a business case with RFID is another barrier which the industry faces (Reyes et al. 2016).

The high costs of implementing RFID in the supply chain for the different logistics organisations have shown to be the most referred obstacle when it comes to implementing RFID due to the unclear return on investment (ROI) which it brings. Tajima (2007) states that in the short term with organisations accustomed with high or visible return on investment, the high costs associated with RFID becomes a barrier for any large-scale implementation. According to Kapoor et al. (2009), most RFID investments are not in the short-term payback category, which has discouraged many firms from adopting RFID. The ROI of RFID is, as it stands now with costs of infrastructure still high, not a technology with fast returns on investment. Lim, Bahr & Leung (2013) found that in order to cope with the lack of clear ROI, businesses need to thoroughly review its most essential processes to see what areas are most critical and what the gains are in these areas from RFID.

Kapoor et al. (2009) state that with uncertain ROI comes a higher fear of tech obsolescence, implying high risk. Knowing how a new tech such as RFID will hold up in the future of supply chain development is not an easy guess, and it is made even more difficult when showing unclear future payback on the initial investment.

With RFID comes a more considerable amount of data, creating a need for new applications with the capabilities of managing and supporting the company's existing systems. Srivastava (2004) mentions that most of the existing systems can process data from RFID equipment, but not the infrastructural capabilities to realise it in large-scale deployments.

2.4 Technical issues

As RFID is a technology based on sending and receiving radio frequencies, certain materials such as metals or liquids have been shown to cause disruptions between the signal waves. Srivastava (2004) also mentions other wireless devices which interfere with the tags. Tajima (2007) brings up the readability issue of the tags as the number of tags and readers increase so does the chance of signal collisions between the items, as well as problems with defective tags

sending wrong data.

Kapoor et al. (2009) further discuss the readability issue with tags readings becoming subject to (true negative reads) which means that readers register tags as present while in fact absent, or (false positive) which is the opposite and implies that the tag is not present when it is. Lim et al. (2013) expand on how these reading failures affect the middleware, which in turn affect the larger logistics systems, with discrepancies in the different management systems.

Integration between RFID software and legacy systems have been shown to present a troublesome obstacle, with RFID software generating more amounts of data, which in turn overloads existing systems with data that is in many cases not formatted correctly (Lim et al. 2013).

Standards have been another concern of RFID. Without real guidelines on tag specifics, frequency spectrum and communication systems (Srivastava 2004). Kapoor et al. (2009) mention that with various tags and readers from different vendors across the world, the need for universal standards is a necessity to be able to operate cross-borders. The mass of different standards makes for inconsistency, and Kapoor et al. (2009) and Lim et al. (2013) both state the problem with having different regulations for RFID in different countries, making the widespread adoption of RFID slower. In recent years, global standards have emerged by EPCglobal, which has, according to Reyes et al. (2016) resolved some of the previous problems.

2.5 Privacy and security concerns

When it comes to privacy and security while using RFID technology, there have been mixed discussions and a general lack of really understanding what RFID will entail for both consumers and companies (Hossain & Prybutok 2008).

When it comes to privacy, Srivastava (2004) states that consumers may feel that the tagged products will become intrusive since RFID tags can send and receive information without them knowing. Information can then be linked to specific customers and hence discard all anonymity and privacy. Osyk et al. (2012) mention in their paper that many experts are not worried about the privacy issues and big corporations like Walmart have stated that they will not listen in at their checkouts and that the tag is to be removed as customers leave the stores. Osyk et al. (2012) do, however, also state that there is industry contextual concern that information about customers may be collected in an intrusive way.

Tajima (2007) also mentions RFID tags as being small as “grains of sand” which will make it difficult for consumers to even know that they are being tracked or that information is still collected after purchase, Tajima (2007) mentions “surveillance” in homes as concerns and other profiling possibilities with RFID tags.

Kapoor et al. (2009) further discussed the problems with privacy contra benefits. They found that while concerns about having the tag not removed at the store, some tags on refrigerated products need to stay on in customers’ homes in order to receive full benefits, or if the tag is removed from the goods by the consumer and then returned, it is no longer visible for the store (Kapoor et al. 2009).

Lim et al. (2013) discussed privacy concerns from companies’ perspective, with the possibility

of corporate espionage growing in industries where products are mixed with other companies' products sharing storing facilities. Another issue arises with the RFID tags being used to monitor employees which corresponds to the privacy concern above, but in a work-related context (Lim et al. 2013).

Regarding security, issues arise with tampering, unauthorised tracking or eavesdropping and maintaining the integrity of the RFID tag (Reyes et al. 2016). Kapoor et al. (2009) mention that even if many security protocols have been or are being developed, there are continuously threats and vulnerabilities being identified.

2.6 Competition and customer mandates

The different stakeholders in the supply chain may affect the choice of technology to be used by the company. These stakeholders may come in the form of other competitors, who have adopted RFID or other solutions into their daily operations, or it can come in the form of customer mandates from business partners. One of the biggest catalysts of RFID technology into the supply chain has been Walmart. They demanded RFID tags to be added on their products from their suppliers, not having this kind of catalyst may impede adoption-rate (Cheng & Yeh 2011).

Kapoor et al. (2009) further discuss the problem of having such mandates in that they are only beneficial for the downstream partners and that the suppliers uphold most of the costs and risks. White et al. (2008) also mentions the complication for suppliers and firms upstream with the increased costs and lesser benefits of receiving mandates to implement RFID into their organisation.

2.7 Government support

One way of fast-tracking technology and promoting wide-spread adoption is by government incentives and promotions. Laosirihongthong et al. (2011) mention the attempt by the Thailand government to advance and promote RFID for the country's supply chain actors, by establishing regulations in frequencies and creating a "road map" for the coming five-year period. Ramanathan et al. (2014, p. 232) state that government regulations can "either encourage or discourage adoption of innovation". Government support can, according to Lin (2008) come in the form of tax reductions to promote innovation, financial incentives or government-funded piloting projects. Cheng & Yeh (2011) adds to this by mentioning consultants and other government experts aiding logistics companies with adopting new technologies, like RFID.

2.8 Popularity of barcodes

The widespread popularity of barcode practices in the supply chain is another significant obstacle for RFID. Barcode has been used for a long time and is now well implemented in almost all aspects of the logistics infrastructure, hence the slower adoption of RFID (Tajima 2007). barcodes also cost less, has global and well-established standards and according to Tajima (2007, p.263) "already achieves satisfactory performance". Smith (2005) proclaims that with the enormous popularity of barcodes, the investment and mind-set changes of RFID will be a tremendous task for companies and might even imply fundamental changes to

existing business processes.

The popularity of barcodes with reading rates up to as much as 98% will not quickly fade as new technologies emerge, but coexistence with RFID will continue until one is exchanged (Twist 2005).

3 Methodology

Choosing a suitable research strategy is a key factor to successfully conducting a proper research project, and Recker (2013) states that the strategy must be driven by the research question as well as the researcher's knowledge and what they feel comfortable with. A research strategy can take different forms, and the three most popular methods in information system research are; 1) quantitative, 2) qualitative or 3) a mix of both quantitative and qualitative methods (Recker 2013). A quantitative method emphasizes collecting and measuring numbers to see the relationship between different variables. The interpretation of the numbers becomes the foundation of how a phenomenon works (Recker 2013). On the other side of the spectrum, a qualitative method does not focus on numbers to explain why a phenomenon behaves in a certain way, but focus on the text, observations, and real-life context (Recker 2013).

3.1 Research strategy and design

For this research, a mix of both qualitative and quantitative method approaches has been used to investigate and describe previously found adoption barriers of RFID technology and applied in context to Swedish logistics companies. A mixed-method was chosen due to ensure a higher generalisability of the research and to combine data gathered from semi-structured interviews with the results from a survey (Saunders, Lewis & Thornhill 2016). The results from the semi-structured interviews will act as a pilot study for the quantitative method and help the researchers create relevant questions to their survey in order to collect precise data needed to answer the research question (Saunders et al. 2016). Recker (2013, p.88) also states, “qualitative methods are strategies of empirical inquiry that investigate phenomena within a real-life context. They are helpful, especially when the boundaries between phenomena and context are not apparent, or when the purpose is to study a particular phenomenon in-depth”. In order to investigate if the barriers proposed in the theoretical framework persist or are similar for Swedish companies, a sequential exploratory research design will be conducted with a qualitative approach, followed by a quantitative. Firstly, a deductive approach based on previous theories is tested with found new data, providing a context-rich empirical layout that allows the researchers to conduct semi-structured interviews to collect data (Saunders, Lewis & Thornhill 2016; Recker 2013). A mono method was used for both the pilot study and the quantitative study. This will enrich the research question of how companies perceive the barriers encountered with this new technology. Data collection from several interviews with experts in this particular subject has been conducted to ensure validity and credibility to the survey questions used in the quantitative study (Saunders et al. 2016). Case studies have a downside when it comes to clear procedures on how to conduct the case, this, in turn, affects the rigour of the design and puts a higher demand on the researchers to follow the chosen design systematically (Yin 2014).

In earlier studies, other research strategies have been used, most notably surveys, but also longitudinal case studies (Wamba & Chatfield 2010; White et al. 2008). Many of the previous studies have focused on sending out surveys, like Lin (2008) and Laskowska (2018), to understand the factors influencing the adoption of RFID technology. Surveys tend to cover a wider part of the industry and potentially provide a stronger ‘how’ answer to the thesis research question.

3.2 Collecting data

The researchers have, with the help of earlier studies and findings, deepened their understanding of the studied phenomenon. Most of the scientific articles have been found with the help of the University of Borås's Library search engine Primo. After that, the researchers have used the snowball effect and scanned those articles reference lists to gather even more articles. Keywords in Primo were "RFID technology", "Barriers", "Logistics", "Supply chain".

The primary source of data comes from interviews with logistics companies in Sweden who are in the process or thinking of implementing RFID technology. The researchers have chosen both large companies, together with smaller ones. A total of three interviews were conducted, and the people interviewed were specifically chosen due to their managerial roles within the companies. Their knowledge and expertise when it comes to decisions regarding the implementation of new technologies played a vital role to get a deeper understanding of the barriers they are facing with RFID.

Primary data was collected in the form of interviews and email documents. Having multiple sources of evidence gives according to Yin (2014) the researchers a broader angle on the issue and helps triangulate. The interviews have been, as previously mentioned, conducted in a semi-structured way. This provides the interviewee with some directional guidelines as well as providing additional flexibility. Recker (2013) also mentions that individuals interviewed in a conversational way rather than a structured one are more likely to discuss sensitive issues. Formulating the interview questions in advance provides a structural protocol for the interviewer, and the semi-structured nature of the interview creates as Recker (2013) describes a bidirectional atmosphere, where two- way communication is encouraged.

The other primary source of data comes from survey research done with Swedish logistics companies. The purpose of survey research is, according to Recker (2013), often descriptive or explanatory. In this study, the purpose has been more descriptive in that the authors have tried to find the "perception" of the current situation when it comes to previously found RFID barriers. Using a survey will allow the researchers to collect a span of respondents, and this will increase the generalisability and strengthen the credibility of the report (Saunders et al. 2016). The survey was created with Google Forms, a simple yet effective and free online questionnaire tool, well suited for this type of survey. The convenience of using an online survey means that the participants were able to answer the questions when it suited them.

3.2.1 Sampling

For this thesis, which is a mix of qualitative and quantitative research methods, the researchers used the qualitative research method as a pilot study to support the quantitative research design. The researchers conducted three semi-structured interviews. Finding the right people with the right knowledge is of importance to ensure that the data is of a good sample. Therefore, a purposive sampling technique was used so that the researchers could interview informants that could answer open-ended questions regarding the subject (Recker 2013). Finding participants for the study, the researchers first used the web to locate Swedish 3PL and other logistics companies. Emails were then sent to find if any firm had prior knowledge of or considered implementing RFID into their organisation. The people interviewed were chosen due to their position and ability to give qualified answers to the interview questions.

Table 2. *List of interview informants*

Date	Informants	Time
14-12-2019	Interviewee A, Head of Production Technology	~30 minutes
17-12-2019	Interviewee B, Head of Logistic	~30 minutes
27-12-2019	Interviewee C, Operations Manager	~30 minutes

Interviewee A works at one of the larger logistic companies here in Sweden, and they operate all over the country. They handle everything from parcels to letters. As head of Production Technology, interviewee A has a good understanding of different types of logistical solutions and brings valuable knowledge to the table.

The second informant, Interviewee B, is head of logistics at a medium-size 3PL company. They always try to meet customers' demands and are in the process of adopting RFID technology due to a request from one of their customers. Interviewee B, therefore, is particularly interesting, given that they can provide information regarding the process of overcoming some of the barriers that were found in previous literature.

The last informant, interviewee C is Operations Manager at a small company in the retail market. The reason this person was interviewed was because of their history with RFID technology. They have used RFID solutions previously in their day to day operations and worked closely with 3PL companies that also use RFID in their organisations.

To get a good sample of representatives participating in the survey, the researchers used a list of 3PL companies, made by Intelligent Logistik (Intelligentlogistik 2020). Intelligent Logistik was founded in 2005 and writes reports, industry analyses and has partnerships with all the significant branch platforms in Scandinavia. In their second edition for 2018, Intelligent Logistik had mapped out and listed the biggest 3PL companies operating in Sweden. The researchers then used that list, made by Intelligent Logistik to target all the 3PL companies and sent out a survey with questions based on the pilot study to them. Out of the 141 surveys sent, 41 companies responded, giving a response rate of 30%. Using Intelligent Logistik's list ensured that all the representatives were relevant to the main topic of the thesis. Each name on the list received an email with a short description and background story of the thesis, together with a link to the survey. A reminder was sent out to all companies one week later to increase the number of representatives.

3.2.2 The semi-structured interviews

At the start of each interview, the researchers briefly explained the background of the thesis as objectively as possible. This was done in order to avoid influencing and becoming biased to the person being interviewed. The topics for the questions were mentioned so that the interviewee had some idea of what they were about. The interview with Interviewee A was conducted through the use of Skype due to the distance between their office and the researchers. The rest was done face to face at the head office of each company. The interviews and the transcripts were done in Swedish due to the native language of all participants.

The interviews took place in conference rooms so that the interviewee would feel comfortable, which hopefully would lead to a more relaxed and honest interview (Recker 2013). Each informant was asked if they were okay with being recorded. This allowed the researchers to focus on observations instead of needing to write down what was being said. To interpret and analyse everything that is happening during the interview is important. Things like expressions, the tone of the voice and body language also play a role when doing a qualitative study (Recker 2013).

3.2.3 The design of interview questions

Formulating and creating the questions for the semi-structured interview was done through modifying and extending previously found barriers from earlier literature. Technical barriers, for example, questions like “Does the integration of RFID into legacy systems present problems?” see (appendix 8.1) for a complete list of interview questions used. These questions were then sent out to a test panel for prior feedback on both the formulation, choices, and format. Interview questions can be of an open-ended nature, which lets the interviewee provide answers of more free and opinionated character and is contrary to closed questions which more or less provide the answer in a predetermined choice format. Closed questions are more suited for questionnaires and open-ended for interviews (Hussey 1997). Given that this is a qualitative study with semi-structured interviews with experts on the subject as a primary data source, all the questions are open-ended. This gives the interviewee the chance to elaborate and talk more freely around a specific question and also, the interviewer room for follow-up questions, related to the given answer (Saunders et al. 2016).

3.2.4 The design of the questionnaire

When using a survey as a means to collect data, the researchers only have one chance at collecting data from each of the respondents. Contrary to open-ended questions, where the researchers can discuss each topic and answer questions that arise along the way, a survey is often fixed to the questions used. To ensure the internal validity and reliability of the data, the researchers must minimise the possibility of misinterpretation of the questions by the respondents. It is equally important that the researchers do not misinterpret the answers given by the respondents (Saunders et al. 2016).

All the survey questions were designed from the data collected from the semi-structured interviews in the pilot study. This ensures that the data collected is more relevant and can answer the research question. The survey is designed in such a way that the respondent doesn't need to put a lot of time on it. Time is of the essence and to get as many respondents as possible to take part and answer the questions, Recker (2013) states that a survey should be short and the questions need to be easy to understand. Therefore the researchers chose only to focus on the barriers companies in the pilot study found to be relevant when it came to adopting RFID technology or not. The respondents had a total of 8 questions to go through, and it only took a couple of minutes to complete. See (Appendix 8.2).

The first two questions are designed to split the respondents into different nominal categories so that the researchers can analyse and compare companies by users and by size. This was done to see if there were any significant differences due to company size. They need to choose one

of the checkboxes in order to continue with the survey. The remaining questions are based on the found barriers from the interviews and are designed in a 5-point Likert scale.

3.3 Data quality

The researchers must make sure that the quality of the data has a certain standard to qualify as scientific research. According to both Recker (2013) and Saunders et al. (2016), there are certain criteria the thesis needs to address in order to achieve a trustworthy interpretivist research; 1) dependability, 2) credibility, 3) transferability, 4) Bias and 5) Ethics.

3.3.1 Dependability

Some challenges this type of research might encounter will be the problems with replicability of the same results in other studies because only three logistic companies were investigated. Barriers these companies face might not be the same for others which may prove difficult ensuring dependability and generalising findings to a larger population. Semi-structured interviews do not follow a standardised guide and interviews can and will behave differently depending on the person being interviewed and semi-structured interviews are flexible and create a more conversational environment between the interviewer and the interviewees (Recker 2013). In order to establish generalisability, the researchers used the findings from the interviews as a pilot study to design the survey that was sent out to hundreds of logistic companies in Sweden. Saunders et al. (2016) argue that the use of mixed methods helps to produce a complete study if data from one method is insufficient.

In order to ensure dependability of this research, a detailed description of all the necessary steps and procedures are documented which allows others to follow these steps and try to reproduce the results and confirm similar findings. Interviews were recorded with sound only to ensure that nothing was lost (what has been said, heard and observed during the interview). Then transcribed the day after by the researcher to make sure everything from what has been said, interpreted and experienced was still fresh in memory (Saunders et al. 2016; Recker 2013).

3.3.2 Credibility

In order to achieve credibility for the research, observations by the researchers during the interviews and the final transcript of them were checked and confirmed by the participants. As Saunders et al. (2016) point out, this will ensure that what is being said by the participants match with what the researchers interpret during the interview and will strengthen the overall credibility. One of the interviews were conducted over Skype which limits the observations to only being able to analyse voice tone and the actual words that were spoken and not being able to read body language or facial expressions from the participant. To add further credibility to the research, all data have been analysed by more than one person. The survey questions were all short and specified to avoid confusion, and the survey as a whole took less than five minutes to complete so that CEOs and managers would be able to participate.

3.3.3 Transferability

For others to fully understand and to be able to put the findings in this thesis in other settings or contexts, it is important to give the reader a clear and detailed description of all the steps, choices of research design, research question, what's been discovered and in what context. This allows outside viewers to transfer characteristics and generalise into other fields of research (Recker 2013). This thesis provides a detailed description of how the researchers have executed every step on the way to achieve transferability. Following a mixed design approach that relies both on subjective interpretations in a specific time and place by the researchers and interviews, and also statistical numbers over some time with the help of a survey, transferability and generalisability will be achieved to a higher degree than just relying on one method over the other Saunders et al. (2016).

3.3.4 Bias

Saunders et al. (2016) mention response bias, and further explain that taking part of an interview is an intrusive process, especially when it comes to semi-structured or in-depth interviews like the ones in this thesis. This could lead to the person being interviewed participating, but reluctant to share or discuss sensitive information regarding the chosen topics of the interview. Another type of bias is interviewer bias, and this is when the body language, verbal tone or a comment from the interviewer may influence the person being interviewed (Saunders et al. 2016). During the interviews, the researchers tried to stay as objective as possible so as not to influence the interviewee but at the same time, keep the conversation going during discussions surrounding each question.

3.3.5 Ethics

Ethical issues often arise in social sciences, and it is crucial, as Recker (2013) mentions that the authors strive hard to protect both the information gathered as well as the subject itself. Prior to each interview, the informants have been asked to give consent to being recorded, and that the information shared during the interview may be used in the study. The interviewees were also asked if they would like to remain anonymous in person. In this paper, the authors have chosen to exclude the names of the participants, both in the interviews and in the surveys as a confidentiality measure. Sensitive information has been respected to further strengthen the trust and ethics of the study.

3.4 Data analysing

In this research, a thematic approach has been used for the qualitative pilot study. This approach is viable due to the paper's deductive path, the interview questions have been based and shaped from previous studies, and so, themes emerging from the interview transcripts may strengthen previous theories or add new ones to the mix. The thematic analysis approach does not come from traditional heritage like grounded theory or discourse analysis, but in this study, as the research is done in a deductive way in that it's based on previous barriers, grounded theory is not as suitable according to the researchers. Grounded theory is concerned with coding data as is done in thematic analysis, but that data is later theorised as part of finding new theories regarding the said phenomenon. According to Saunders et al. (2016), a thematic analysis approach is suitable

when having an interpretivist study of exploring different interpretations of the said phenomenon, like barriers in this case.

Applying a thematic analysis approach, themes are found according to Bryman & Bell (2015) through categories identified in the transcripts via coding and often relates to the research questions of the study. This way has been conducted in this paper, and themes have been identified after rigorously reading and rereading the transcripts collected from the interviews as well as reading through the numerous email documents gathered.

The audio or data generated from the interviews was recorded on a phone and other devices using recording software. These audio files were later processed multiple times and transcribed verbatim into text in Microsoft Word documents. Through thematic analysis, themes emerged by coding and categorising the transcripts. ‘a priori’ codes were the focus when analysing the transcripts for themes as these are based on existing literature and theories, hence deductive (Saunders et al. 2016). Codes that were emergent were matched for patterns and categorised based on ‘a priori’ themes. ‘in vivo’ codes were also used for finding themes, ‘in vivo’ are codes that are not based on existing theories and literature, but are instead codes that emerge from participants and researchers own account (Saunders et al. 2016). The latter coding approach is mostly used when conducting an inductive approach, but as Saunders et al. (2016) states, only relying on one coding approach may become problematic. These themes were then used in pattern matching, which seeks to match correlating patterns; in our case, previous theoretical propositions and the empirically found themes from the verbatim transcripts. Using pattern matching successfully is said to create better internal validity (Yin 2014).

For the quantitative analysis, the results from the survey were analysed in the statistical software program IBM SPSS statistics. The raw data from the survey was first exported into an excel file and then imported into the statistical software program. Most of the questions from the survey are of type ordinal data, and they are mostly in “scale” format. As such, the raw data was coded into numeric values in SPSS. The raw data was probed for errors in excel before exported to SPSS. This was done as a measure to validate the quality of the data and to deal with any missing values. Data were analysed by using T-test. A T-test is applicable because there is no need for prior knowledge regarding the data distribution. T-test also has the advantage of being reliable for small sample studies.

4 Empirical findings and analysis

The authors hypothesised that there would be a significant change between company sizes and how they perceived the RFID barriers. This was initially analysed; results showed that no significant changes were depending on the size of the company. Data and findings that have been gathered and analysed from the interviews and survey will be presented with each barrier found in the pilot study as a subtopic, giving the reader a clear overview of the findings. By comparing the findings done in the interviews and survey with those in earlier literature, the researchers will be able to explain and discover how barriers are perceived by Swedish logistics companies.

Figure 2. compares the mean scores of barriers based on company size. There are minor differences between the two groups, which indicates that the perception of barriers is similar regardless of company size. An independent T-test was done to examine further the significance levels between company sizes dependent on barriers. There was no found significance between small and medium Swedish companies. The significance levels of an independent T-test are often best shown with larger sample sizes. The non-significance found between company sizes in this report was based on a smaller sample, and so the result should be viewed with this in mind.

Payback time had the most difference in mean scores as we see in figure 2. where medium-sized companies perceive payback time to be slightly higher than small companies. The significance levels of the independent T-test can be viewed in (appendix 8.3).

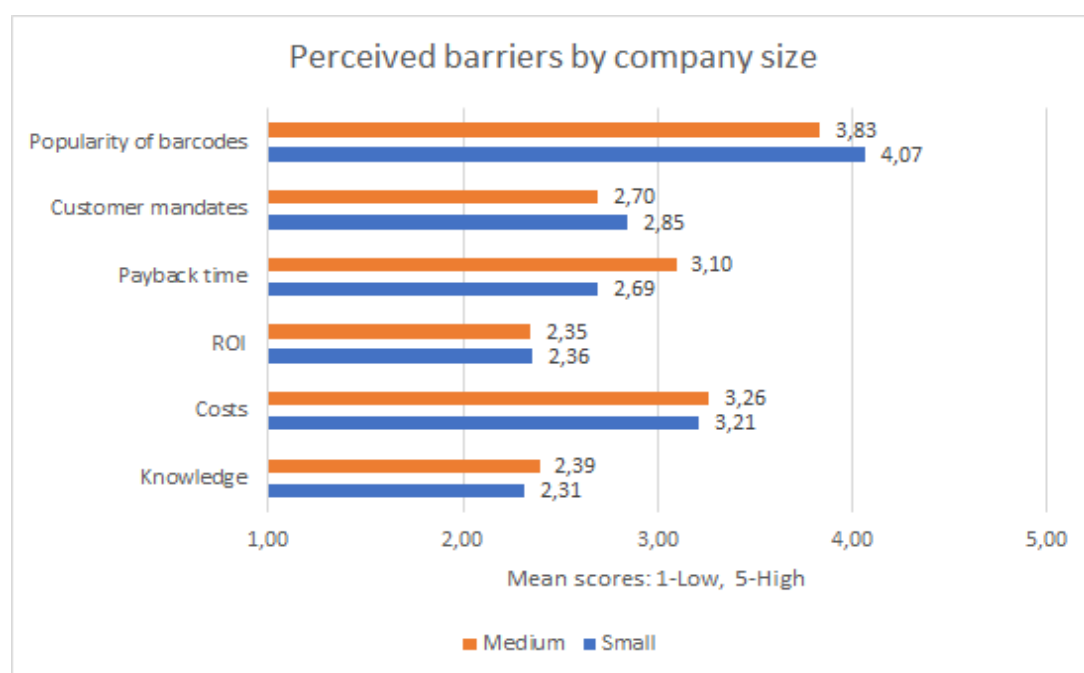


Figure 2. *How barriers are perceived based on company size.*

In the survey, the company sizes ranged from micro to large company. In the analysis, the size groups were combined into two groups: small size, which included micro and small, and medium- size, including medium and large. The total number was 41 respondents, and of them, 40% was represented by small companies. Medium-sized companies were overrepresented, and therefore Welch method was used in order to account for unequal variances.

Figure 3. shows the number of RFID users in the study. Close to 80% of the total respondents said that they did not have RFID. This indicates that the potential technological disruption that RFID is labelled to have is still very much at hold and that the current barriers are still prominent factors.

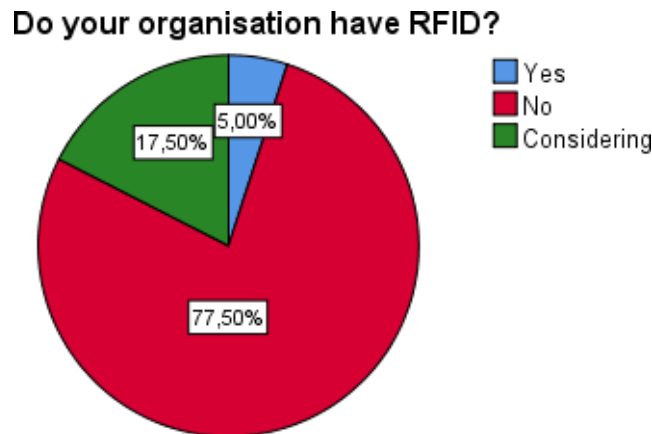


Figure 3. Shows the percentage of Swedish logistics RFID users.

The non-significance between company sizes resulted in the use of a combined mean score, indicating the perception of barriers from the broader Swedish perspective. Figure 4. shows the mean scores with a middle score of 3 indicating 'average'. Only costs and popularity of barcodes are above average. The ROI barrier is measured on uncertain to certain, with a score of 2.35 indicating more uncertainty.

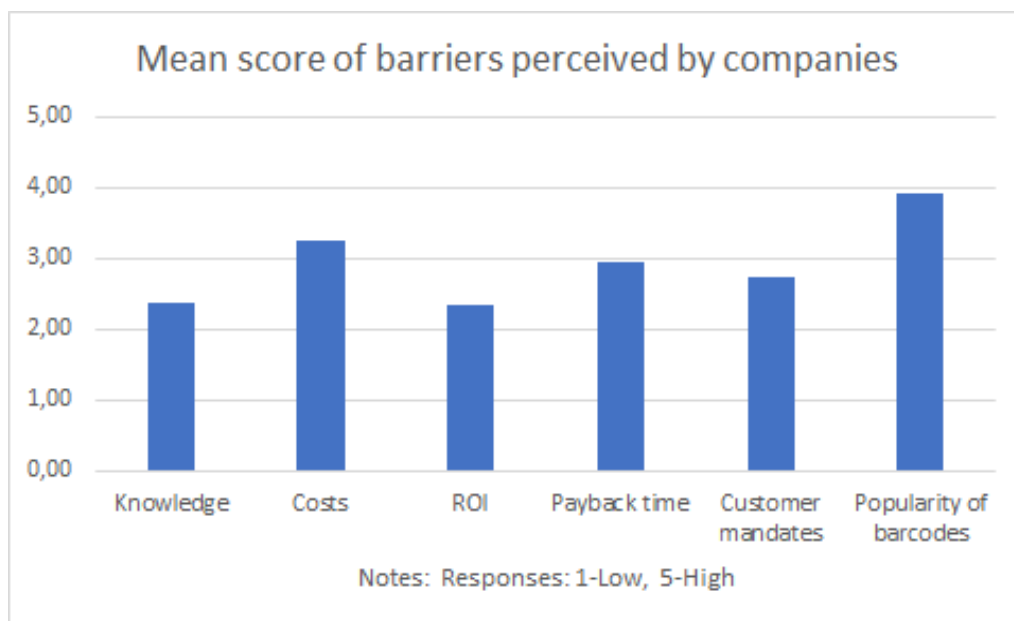


Figure 4. Shows the mean score of barriers perceived by Swedish companies.

Costs

The cost barrier was found to have still a significant role as one of the main barriers for implementing RFID, but the findings differed depending on the operating context. Costs are still considered high according to some informants, not for the individual tags which were the case in the study made by Srivastava (2004), but for larger infrastructure investment in many tags, readers and software. Kapoor et al. (2009) found similar concerns to high infrastructure costs in their study.

The importance of costs is clear from the results, but the findings differ from the different informants' perspectives. Interviewee B mentions that RFID technology is expensive, but that costs have decreased during the past years. For Interviewee A, the investment costs in infrastructure are still too expensive and make up for one of the most prominent barriers for their organisation. In the study by Reyes et al. (2016), they found that the cost barrier was the only significant determinant of RFID implementation. In this study based on Swedish logistics companies, the cost barrier is still relevant for companies, but the perception of costs is now more towards 'average', an indicator that costs are decreasing and a sign of technology maturity. The mean value of costs from the survey was 3.24, making the perception of costs close to 'average' with some indications towards 'high'.

Lack of understanding

The basic knowledge of RFID and how the technology can be used in logistics were found to vary. From the interview informants, there was a clear understanding of what RFID is, and the knowledge has been in these companies from some time. However, the main barrier for the majority of those not interviewed was that knowledge did not exist in their companies. From the email documents, results showed lack of understanding being high and that RFID had never crossed their minds. Hence, they thought extended interviews unnecessary. Reyes et al. (2016) found similar results in their study that a lack of understanding regarding the use and general knowledge of RFID makes it challenging to create business cases. Findings from the ones interviewed show that lack of understanding is not an issue from their perspective. For both Interviewee A and Interviewee B, understanding of RFID had existed well over 10 years, when they first started looking at it. In Interviewee A's case, the knowledge has decreased in recent years due to lack of clear business case with RFID, and Interviewee A stated they have tried it before and are now focusing on other technologies.

Tajima (2007) states that in the short term with organisations accustomed with high or visible return on investment, the high costs associated with RFID becomes a significant barrier for any large- scale implementation. Kapoor et al. (2009) stated that most RFID investments are not in the short- term payback. In this study, findings showed uncertain ROI with long payback time is still a concern. For Interviewee B the ROI could be justified depending on depreciation time and contract length, they found costs to be acceptable for the added value of RFID. In contrast to Interviewee A, who explained that it is not the cost per se, but that the ROI was not good enough in their case, with long payback time and no clear added value.

The mean for knowledge is 2.36, indicating that knowledge surrounding RFID is below average for Swedish logistic companies and more towards 'low'. These results differ from the interviewees, who had more knowledge about RFID. They do, however, correspond strongly to the many email document responses which could not participate in interviews due to lack of knowledge. The mean for ROI was 2.35. This indicates that the perception of ROI is below average, ranging closer to 'somewhat uncertain' than 'ok'. The mean score of 2.94 for payback time. This indicates that the perception of payback time on RFID is close to average.

Technical issues

With RFID technology, systems need integration and cooping standards with the legacy systems of each corporation, in accordance with Lim et al. (2013) findings of problems with system integration. The findings show that technical issues are still a potential barrier when it comes to RFID. The issue of RFID having problems with certain materials like Srivastava (2004) mentions, is also evident in our results.

Interviewee A mentioned the issue of having RFID tags on their assets, which was made of metals and did not receive clear signals.

Interviewee B points out the issue of having so many different systems and integrating them all. He continues by stating the snake pit in which they have many clients all having different systems and then those clients with their suppliers also having different systems. Interviewee A mentions the significant change for current customers having to adapt to new systems as a concern and the change of labels and printers needed for this technology. As for standards, the results show that for RFID standards exists and are not an issue anymore, much like Reyes et al. (2016) found in their study, that universal standards like EPCglobal have emerged. Kapoor et al. (2009) found that having many different protocols makes for inconsistency which is also mentioned by one informant in this study. Interviewee B mentions that with many new technologies emerging all with different standard protocols, issues are rising with systems not being able to cope with all the different protocols.

Interviewee A:

“There is already a logical infrastructure in place, so there is no need to reinventing the wheel.”

Privacy and Security concern

When it comes to privacy and security, the findings showed that there is a concern in securing the integrity of RFID in the logistics context. There were, however, much like Hossain et al. (2008) found a general lack of understanding of what implications that came with RFID. All informants acknowledged that there existed risks, and that encryption of sorts is needed, but few had invested proper research into what the different issues might be.

The results do point towards different levels of concern on different contextual levels in the supply chain. Interviewee B mentions that security and privacy are perhaps not that important during the goods receiving stage as the information contained here is not of value. Interviewee B continues by saying that in the later stages where outbound goods and shipping occurs, here encryption might be needed, due to sensitive information regarding customers and suppliers, which is often embedded here. Interviewee A also thinks that security and privacy is an issue for RFID when people can scan delivering trucks to get information about the shipment and its value.

Competition and Customer mandates

The findings on competition varied in the sense of what competition meant to each informant. The potential positive effects of having a catalyst in the form of other competitors like Cheng & Yeh (2011) mentioned also showed to be the case in this study. However, competition showed to be an important catalyst for some companies and not so much for others. Each informant said that they looked at their competitors, but for different reasons.

Interviewee C mentioned that it was important to understand what the competition was doing as the business environment changes quickly, with current customer satisfaction and demand levels rapidly moving to new and higher standards. Interviewee B said they are interested in what the competitors are doing, but for them, the focus is more on customer mandates and contract length.

Customer mandates were found to be more dependent on the logistical context, for some informants', customer mandates were not even present, and for others, the most important factor. Unlike Kapoor et al. (2009) & White et al. (2008), having customer mandates did not result in lesser benefits, one reason being that the informants were often not upstream suppliers. For Interviewee B, customer mandates were essential as they dictate the use of RFID or not. Here the drive comes from the suppliers and the customers, but Interviewee B also mentions that the knowledge gained can later be promoted to capture new contracts with customers, using RFID. In the other informant's cases, the presence of customers mandates was not as significant. For Interviewee C, the lack of customer mandates was a barrier in itself. The survey result gave a mean score of 2.75 for customer mandates. This indicates that the perception of customer mandates is just below average.

Government support

The results showed that not much thought was given to this area, but a general agreement that incentives and tax reduction would help promote the technology. As the findings of having government guidelines in Laosirihongthong et al. (2011) paper, the informants of this study were of a similar mind. Further, the help of tax reductions which was found in Lin (2008) study was also found to promote a technology such as RFID positively, and like Ramanathan et al. (2014) stated that government could either encourage or discourage innovation, this was also found to be the case for some of the informants.

Interviewee B said that in Sweden, the government has yet to release 5g frequency spectrum unlike Germany and so guidelines are not clear yet, but that tax reduction in technology help making choices easier. Interviewee C mentions that government actions do influence, but that they just as easily can create obstacles for the business practice.

Popularity of barcodes

The findings here also tended to vary depending on the informant, where some did not consider the popularity of barcodes to be an impediment, and others did. As Tajima (2007) stated in their study, that barcode is global and well established in every aspect of the logistics infrastructure, and that barcodes in many ways achieve satisfactory performance. This is also found to be true for some of our informants.

For Interviewee A, the current barcode system is achieving such high-quality outputs in their organisation so that RFID does not give much-added value to the whole. He continues by stating that the added value in today's system is from a customer perspective good enough. This response is similar to Twist (2005) study, which found that the barcode technology has very high-performance levels which makes it more difficult to gamble on new technology. The mean value for the popularity of barcodes, which is 3.92. This score indicates that the perception of barcodes is just below high. The result corresponds to the findings from the interviews and previous studies such as Tajima (2007) that the popularity of the well-established barcode system is still a prominent barrier for RFID.

5 Conclusion

In this paper, the researchers have tried to convey the informant's perception of barriers in their logistic settings. Since technology and innovation move at a more rapid pace, so do the obstacles, some are no longer seen as impediments, and some are still significant. In this section, the authors conclude the results found in the previous section.

Previous studies have been rather unison in their findings, regarding costs and ROI to be the main barriers for RFID technology. Reyes et al. (2016) found in their study that costs were the only significant barrier for implementation. Costs have in some studies been seen to decrease, which has led those authors to believe a maturing of RFID has occurred (Osyk 2012). In the above findings, the authors have found similar indications that the technology has, in fact, matured, with informants stating that costs are seen to have gone down. Another indicator of the less significance of costs is that the findings showed less emphasis on the actual costs surrounding and more focus on ROI and finding a business case. Some informants still mentioned costs as the main impediment but pointed out that it was not the costs per se, but the long payback time and lack of added value.

ROI has been derived from the barrier 'lack of understanding', constructed through Reyes et al. (2016), and this barrier is still seen as a significant one. Through the findings, lack of understanding surrounding the general application and knowledge of RFID was found to be very significant, as many interviews were turned down due to lack of knowledge. The other aspect of lack of understanding was that the business case and ROI was not clear, and here the results of both previous studies and the authors were strengthened by the importance of ROI and business case. Even though some of the informants stated that ROI could be justified, the importance of the barrier was most evident, with dependents on variables such as contract lengths and depreciation times. In the 'lack of understanding' barrier, which we have used from Reyes et al. (2016) study, survey questions about this barrier included ROI, payback time and knowledge. These three were all found to have lower mean scores in the survey results, indicating that knowledge is low, ROI more uncertain and payback time just under average. Both knowledge and ROI is consistent with interviewees and other authors' previous findings, but payback time being just below average is quite interesting.

In line with earlier results about security and privacy scoring low in terms of significance, similar findings were found in this paper, with just a general concern about these issues, but not enough research have been invested into the areas. Results from the technical barrier showed that integration being a potential obstacle, with many different systems having to communicate with each other. Industry standards and protocols concerning RFID were however found not to be an issue, as the technology has matured, so has the adoption of global standards. The results do show that concern regarding multiple protocols and standards used from many different technologies may cause system inconsistency and reading problems.

Competition, customer mandates, government support and popularity of barcodes were all found to be informant case-specific in the pilot study. For some informants, the results found that customer mandates and competitors were significant for driving the choice of technology and in other cases not so significant. The popularity of barcodes was in similar fashion found to be a continuous strong barrier for some informants and less emphasised for others. In the survey, the researchers found that the popularity of barcodes, due to the well-established infrastructure that already exists, still seems to play a vital role among companies for not adopting RFID technology. This is something both Twist (2005) and Tajima (2007) brings up

in their papers. Government support was generally seen as being either a promoter or opponent of new technology. Interviewee A sums it up quite well regarding the popularity of barcodes versus RFID:

“It depends on the added value the customer sees, and as of now, they find the current system working good enough... RFID could give added value in some cases with higher priority inquiries, but the current high-quality of our barcode systems makes this added value next to nothing.”

The informants were asked to rank their most perceived barrier in the pilot study, and the results showed that lack of understanding and customer mandates were the two most significant impediments. Not having a clear business case and long payback time were key elements. Interestingly the survey results did not share the long payback time, and it was generally viewed to be just below average. Then the lack of knowledge surrounding the application and use of RFID in the logistics setting from the many email documents were found to be a significant barrier as well as the lower mean score from the survey. Customer mandates were the other prominent barrier, with these driving the adoption or not. For some informants, the mandates helped justify the ROI, and for others, the lack of mandating customers was the barrier itself. On a larger scale, customer mandates do not have that big of an impact on whether a company will invest in RFID technology or not. The popularity of barcodes was the one barrier in the survey to stand out the most, with a mean score of 3.92. This makes the popularity of barcode and lack of understanding the most significant barriers for Swedish logistics companies when it comes to RFID implementation.

6 Discussion

As was found in earlier literature, RFID technology has the potential to become the next generation barcode (Choy, Ho & Lee 2017) and the use of RFID has proven to strengthen the overall competitive advantage for logistic companies (Reyes et al. 2016). That is why we wanted to investigate if the same barriers surrounding RFID technology could be applied in a Swedish context and thus answering our research question:

- How are previous found barriers of RFID perceived in Swedish logistics companies?

This thesis was done with a mix of both qualitative research design and a quantitative one. The reason we chose to do a mixed version was that we wanted to investigate and describe this specific phenomenon in a real-life context in order to see if the barriers found in earlier literature still were relevant. Due to the small number of participants in our qualitative study and the insufficient amount of data, we chose to complement with quantitative research design, using a survey in order to collect more data. We took the findings from the qualitative research and turned it into a pilot study to support the quantitative research study. This helped us to create relevant questions regarding how Swedish logistic companies perceive the barriers we found in the literature.

We found that the costs of the technology have decreased, an indication of maturity since the last decade, and our findings imply that the hype RFID technology had during the last decade have decreased and there has been a shift among which barriers are the most significant. In Reyes et al. (2016) research, they stated that cost was the significant barrier followed by lack of understanding. Now it seems that the tables have turned, and lack of understanding is the main obstacle for RFID to get a grip in the industry and to become a worthy challenger to the barcode. Another significant barrier was the popularity of the barcode. It has long been the standard, and all companies are heavily invested in the infrastructure developed for barcodes. The already high reading rates which Twist (2005) found to be as high as 98% with the enormous popularity that Smith (2005) proclaimed are likely still reasons that the popularity of barcodes still impedes the implementation of RFID.

As mentioned earlier, companies do not have clear business cases to rely on, which is related to the lack of understanding barrier, and therefore will not invest in this technology. This was especially noticed when we went through all the companies who declined to be part of the pilot study in the first section of the research. The reason most of them turned us down was that they did not have enough knowledge of this technology to be able to contribute according to themselves. This means that the barrier “lack of understanding” that Reyes et al. (2016) found is also a barrier for Swedish logistic companies, and even if Interviewee A said they understood RFID, they also said that they had had a deeper understanding of this technology back in 2009 when they looked into it. At that time, the ROI was more uncertain, and the lack of a business case was the main reason they did not invest. A lot might have happened since 2009 to the present day, especially when dealing with technology, so if they would investigate this again, they might find the outcome to be different.

6.1 Limitations to study

This thesis has focused on understanding RFID barriers and how they are perceived in a Swedish logistics context based on previous theoretical found barriers. Earlier literature has also used the technology acceptance model (TAM) to investigate the perception of barriers when implementing RFID technology. This model has not been used in this research, as the goal was to only look at the barriers and TAM is mostly used in a wider perspective, including customers' perception of technology.

The limited number of informants in this research is of concern and may affect the generalisability of this research negatively. The researcher's impediments were getting companies to participate in this research due to many companies' lack of understanding RFID, one of the significant barriers found in this thesis. This forced the researchers to go from a narrow perspective to a wider one, reaching out to logistic companies in general and not focusing on a specific logistical segment of companies, as was intended in the beginning. The researchers hoped that more companies were in the process or at least investigated RFID technology, but the majority that was contacted replied that they did not have enough knowledge regarding RFID to contribute. Sending out a survey to the list of Swedish 3PL companies (Intelligentlogistik 2020) and other logistics companies yielded in a total of 41 responses. Most respondents were medium to large-sized as opposed to small organisations which made the sample population unequally distributed. This limitation was countered with the Welch method in an independent T-test, and as the results showed that company size was not significant of barrier perception, the limitation proved minor.

6.2 Future research

Barriers are only one of many variables concerning whether a company should invest in new technology or not. RFID technology also comes with benefits which have not been included in this thesis. Two of the three informants said that benefits could justify the cost of RFID, and with this thesis, only covering barriers, other areas that need more attention may be benefits. The initial purpose of this study was to understand the barriers when adopting RFID technology in the logistical segment of post and parcels. Few studies have been conducted in this area, but some post companies around Europe have started using or piloting RFID in their processes. Bring Norway is one example. They have implemented RFID technology and are using it for track and trace on parcels. A comparison between Bring Norway, PostNord, DHL, DB Schenker would be interesting to see if the implementation of RFID technology has added any measurable value to the organisation that could justify implementing it. Future studies could try to deeper investigate the use of RFID in the post and parcel logistic industry.

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8 Appendix

8.1 Interview questions

Cost issues

- Are there any financial obstacles?

Technical issues

- Does the integration of RFID into legacy systems present problems?
- Is there a lack of standards when it comes to RFID?

Lack of understanding

- Is there a lack of understanding when it comes to the implementation area of RFID?
- Is there a clear return on investment when it comes to implementing RFID?
- Does implementing RFID affect the business model?
- Is there a lack of knowledge when it comes to system integration of RFID into corporations?

Privacy/Security issues

- Are there any concerns when it comes to ensuring integrity with RFID?

Other barriers

- Do competitors' choices affect the decision of implementing RFID?
- Do government support and incentives affect the choice of technical solutions?
- Are there any other barriers you feel affect the choice of implementing RFID?
- If you were to rank these barriers, which would be the most significant? And why?

8.2 Survey questions

RFID Barriers in logistics

A survey about the Radio Frequency Identification Technology (RFID) barriers as perceived by Swedish logistics companies. RFID is a signal technology that enables reading and sending of information through radio waves, communicated between tags and readers. RFID don't require line of sight as with barcodes, and the use areas are many e.g. more efficient goods receiving, inventories and better traceability. RFID has not had the breakthrough previously predicted, the barriers are still viewed as being stronger than the advantages. In our study, we'll try to find if previous found barriers for RFID are the same in Sweden and by doing so help clarifying the barriers surrounding the technology from a Swedish logistical context.

1. Your company/organisation belongs to

- ☐ Small (10-49 employees)
- ☐ Medium(50-249 employees)
- ☐ Micro (Less than 10 employees)
- ☐ Large (More than 249 employees)

2. Are you using RFID technology in your business

- ☐ YES
- ☐ NO
- ☐ CONSIDERING
- ☐ PILOTING

3. How do you consider your organisations knowledge about RFID is on a scale 1-5
(1-none,2-low, 3-average,4-pretty good, 5-high)

	1	2	3	4	5	
NONE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	HIGH

4. How do you consider the costs for RFID on a scale 1-5 (1-very low, 2-low, 3-average, 4- high, 5-very high)

	1	2	3	4	5	
VERY LOW	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	VERY HIGH

5. How do you consider the ROI of RFID on a scale 1-5 (1-uncertain, 2-somewhat uncertain, 3-ok, 4-somewhat certain, 5-certain)

	1	2	3	4	5	
UNCERTAIN	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	CERTAIN

6. How do you consider the payback time for RFID investment is on a scale 1-5 (1-very short, 2- short, 3-average, 4-long, 5-very long)

	1	2	3	4	5	
VERY SHORT	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	VERY LONG

7. How much do you consider customer mandates affect your decision of RFID on a scale 1-5 (1-none, 2-low, 3-average, 4-high, 5-very high)

	1	2	3	4	5	
NONE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	VERY HIGH

8. How much do you consider the popularity of barcodes affect your decision of RFID on a scale 1-5 (1-none, 2-low, 3-average, 4-high, 5-very high)

	1	2	3	4	5	
NONE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	VERY HIGH

8.3 Independent T-test

Table 11. *Independent T-test of RFID barriers compared to company size*

Group Statistics						
	Size company	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Knowledge	Small	16	2,31	1,195	0,299	0,819
	Medium	23	2,39	0,941	0,196	
Costs	Small	14	3,21	0,579	0,155	0,846
	Medium	23	3,26	0,864	0,180	
ROI	Small	14	2,36	0,929	0,248	0,975
	Medium	23	2,35	0,832	0,173	
Payback time	Small	13	2,69	0,751	0,208	0,202
	Medium	21	3,10	0,944	0,206	
Customer mandates	Small	13	2,85	1,573	0,436	0,755
	Medium	23	2,70	1,259	0,263	
Popularity of barcodes	Small	15	4,07	1,100	0,284	0,530
	Medium	24	3,83	1,129	0,231	

Notes: Significant at: *0.05 and **0.10 levels; responses: 1- Low, 5- High



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