

2007

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Recommended Citation

Knebel, Uta; Leimeister, Jan Marco; and Krcmar, Helmut, "Potentials of Tracking and Tracing Technologies - The Perspective of IT Decision Makers in Germany" (2007). *ECIS 2007 Proceedings*. 61.

<http://aisel.aisnet.org/ecis2007/61>

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POTENTIALS OF TRACKING AND TRACING TECHNOLOGIES – THE PERSPECTIVE OF IT DECISION MAKERS IN GERMANY

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Abstract

RFID-technologies have been described as major enabling technologies for automated, contactless data collection. We conveyed a quantitative survey of 463 executives across various industries in Germany to investigate about the perceived strategic importance of RFID among IT decision makers, current RFID usage, companies' intentions to invest in RFID and visions of RFID application.

The survey results showed that:

- *RFID is currently not very widespread.*
- *The importance of RFID will rise significantly over the next few years. However, RFID is neither considered a strategic issue, nor a topic of high priority.*
- *Companies' RFID budgets will rise over the next 5 years and IT decision makers are willing to invest in the technology.*
- *Only a minority seems to consider RFID as a source for competitive advantage.*
- *Companies do not seem to worry much about issues such as data security, or integration of RFID systems into their IT landscape.*
- *The high-level concepts often associated with RFID, above all the “real time enterprise” or the “internet of things”, have not yet entered companies' RFID visions. The greater part of them has not yet thought about RFID at all.*

Keywords: RFID, IT strategy, Diffusion, RFID vision, CIO, Competitive advantage.

1 RADIO FREQUENCY IDENTIFICATION – TECHNOLOGY AND POTENTIALS

RFID is currently widely discussed throughout the media. Although it is not a new technology - the first publications date back to 1948 (Landt 2005) - it has only recently come to the awareness of the public. New auto-ID technologies, most notably RFID (Sarma 2004), have drawn the attention of many companies due to factors including: the need for more efficiency and security in supply chains, cost pressure, standardization initiatives, and prominent promoters such as Wal-Mart or Metro. When the Society of Information Management (SIM) conducted its last survey among IT executives, RFID was rated among the top 20 developments in application and technology (Luftman 2005).

The aim of this study was to explore CIOs' perspective on RFID technology. We investigated the strategic importance of RFID, RFID as an enabler for RTE, and how CIOs plan to act in regard to this issue. The research was conducted among members of an independent, non-profit German CIO network organization.

1.1 RFID Technology

RFID is a technology for automatic identification and data collection (Auto-ID). It allows an object or person to be automatically identified at a distance using an electromagnetic exchange (Want, 2004; Finkenzeller 2002). In comparison to other well-known Auto-ID technologies such as the barcode, RFID offers the following advantageous characteristics for the user (Agarwal 2001):

- Unique identification: Applying e.g. the "Electronic Product Code" (EPC) standards, RFID tags can identify classes of products as well as individual items.
- No line of sight: RFID tags can be read without direct line of sight even if the tag is covered, dirty or otherwise obscured from view.
- Bulk reading: If they are in range of a reader, multiple RFID tags can be read at the same time.
- Storage capacity: RFID tags can store significantly more information than just an identification number.
- Dynamic information: RFID tags with read-write capability allow information to be updated or changed whenever necessary.

Unfortunately, RFID is not yet a mature technology. There still are a number of issues that remain to be solved. For example:

- Effects of metal and liquid: Radio Frequency signals can be attenuated or detuned by metals or liquids in their close vicinity.
- Multiple standards: In the past, several different frequencies and standards have been used for RFID solutions. Although the standardization organization EPCglobal has now designed a comprehensive new framework, it will take some time to establish.
- Amount of data: Collection and communication of enhanced object information inevitably leads to huge amounts of data. It is unclear how this data should best be integrated into the enterprise information systems. Moreover, enterprises still lack reasonable services and do not know what to do with the additional data.

1.2 Improve Efficiency, Enable New Products and Services and Gain Competitive Advantage

There is empirical (Loebbecke et al. 2006, Karkkainen 2003), conceptual (Asif et al. 2005) and simulational (Lee et al., 2004) evidence that RFID has the potential to accelerate, enrich, and automate, in short, change the information flow in business processes. Contemplating its characteristics, it is not difficult to derive potential to improve process efficiency and effectiveness as

promised by the RTE visionaries. Non line of sight avoids an object having to be turned several times before the tag can be read, as is often the case with barcode labels. Hence, less manual intervention on the object is required. Tags can still be read when the respective objects are already assembled or integrated in a product. Moreover, multiple reading reduces process lead time. Increased storage capacity allows enhanced product data to be stored on the tag and the ability to add information during an object's life cycle. In combination with sensors, the tag could carry additional up-to-date information about temperature, humidity or pressure in the object's environment (Haller et al. 2004). Accurate information and identification increase process transparency, making processes more secure.

But the potential of RFID goes beyond improving the efficiency of existing processes. RFID already enables new products, services and solutions. Application areas are versatile and span various industries. RFID is, for example, used to improve issues in anti-counterfeiting (Staake et al. 2005), asset/product tracking, industrial warehousing, product handshaking, safety and security, condition monitoring, positioning/locating, and theft or tampering detection (Wilding and Delgado, 2004). Other examples highlight the potential for completely new services such as enriched museum tours (Hsi et al. 2005). The following selected examples illustrate this point:

- **Healthcare:** Combating counterfeit drugs. Individual identification and seamless tracking of drugs from production to consumer would ensure their authenticity, thus protecting consumers from harmful or useless drugs as well as making it more difficult for counterfeiters to place their products on market. The U.S. Food and Drug Administration rates RFID as the most promising technology to achieve these goals (U.S. Food and Drug Administration 2004).
- **Automotive:** Facilitating highly targeted recalls. If a specific delivery unit of a specific car component turns out to be defective, automotive manufacturers usually have to recall all cars of a certain type produced in the critical time span. If each component could be traced individually during the complete assembly process, the manufacturer would know exactly which cars carry the relevant components and avoid expensive and useless inspections of all vehicles. BMW, for example, sees RFID as a major opportunity to cut costs of recall actions.
- **Transport / Logistics:** Logistic enterprises often transport sensitive goods under specific conditions (e.g. frozen food or vaccines). RFID tags with sensors could allow inspecting and thus controlling if required conditions were met throughout the entire transport, thus increasing product security.

RFID can enable enterprises to bridge the gap between the real world and its representation in information systems (Haller et al. 2002; Fleisch 2005), thus paving the road toward the "real time enterprise", promising optimized processes across organizational boundaries, improving decisions through higher data quality, and integration of supply chain partners.

2 THEORETICAL BACKGROUND

2.1 The Strategic Importance of RFID

Michael Porter describes strategy as "performing different activities from rivals" or "performing similar activities in different ways" and emphasizes that although operational effectiveness is crucial for profitability, it is not strategy (Porter 1996)¹. According to this, Metro's success in improving operations and cutting cost through RFID (Collins 2005) may not be of a strategic nature yet, but applications are still developing (Lange 2004) and, as discussed in the previous sections, indeed can enable a company to offer new services not offered by its competitors. Various major consulting firms stress the impact of RFID on strategy. According to Gartner Research, RFID could not only revolutionize the way items are tagged and traced through distribution channels (Roussel et al. 2005),

¹ In this article, we follow the view of Porter 1996. It has to be acknowledged that other authors, such as Treacy & Wiersema 1995 do consider "operational excellence" as strategy.

but also hold “great potential for reshaping business strategies” (Woods et al. 2003). Research questions 1 and 2 addressed this topic:

RQ 1: What is the diffusion rate of RFID?

RQ 2: How do CIOs assess the strategic importance of RFID?

2.2 Determinants on Perceived Strategic Importance

The first sector to use RFID technology was military (Schmid 2004), but bit by bit RFID made its way into other industries and institutions. Companies are optimistic about RFID’s potential to optimize and rationalize supply chain management (Lange 2004). ABI research projects that certain industries will be particularly active in the field of RFID, including consumer packaged goods and retail, automotive, military and homeland defense (Maselli 2003). This suggests that certain industries are more inclined to adopt RFID, forming the basis for research question 3:

RQ 3: Do characteristics of the responding companies such as industry and size influence the perceived strategic importance of RFID?

Diffusion of innovations theory identifies five attributes of innovations influencing their adoption: relative advantage, compatibility, complexity, trialability and observability (Rogers 1995). Supposing that adoption will only take place if an individual sees a certain importance or usefulness in an innovation, these factors could also influence the perception of strategic importance of an innovation, in this study, RFID. Trialability is the degree to which an innovation may be experienced. The better the individual understands how the innovation works under his or her conditions, the more likely he or she will be to adopt it. Observability is the degree to which the results of an innovation are visible to others. Although the diffusion of RFID is currently low (Lange 2004) many companies have launched pilot projects, thus creating a certain trialability. Along with vendor’s demonstration projects and other available information, these pilot projects provide observability for others. Consequently, research question 3 refers to RFID experience:

RQ 4: Does the level of experience with RFID influence the perceived strategic importance of RFID?

Relative advantage is the degree to which an innovation is perceived as being better than the idea it supersedes (Rogers 1995). A similar approach is taken by Davis in his technology acceptance model (TAM), describing perceived usefulness as a determinant on adoption (Davis 1989). Perceived benefits have also proved relevant in Iacovou and Benbasat’s study about the adoption of EDI (Iacovou et al. 1995) and as well were considered in research conducted by Sharma and Citrus on the adoption of RFID (Sharma et al. 2005). In this study, relative advantage describes potential benefits and improvement due to RFID in comparison to barcode technology. Hence, research question 4 addresses perceived potentials of RFID:

RQ 5: Do perceived potentials of RFID influence the perceived strategic importance of RFID?

2.3 Willingness to Invest in RFID

Since wholesalers such as Wal-Mart in the USA, Metro in Germany, or Tesco in the UK, and public authorities such as the US Department of Defence have declared RFID a key technology, market forecasts have outbid one another (Lange 2004). Frost & Sullivan Research predicts a growth in the RFID marketplace of over 30 percent by 2010 as compared to 2003 (Frost & Sullivan 2004). Accenture estimates the growth will be 40 percent (Accenture 2005). In a recent study, AMR research found that 69 % of respondents planned to evaluate, pilot, or implement RFID. They also forecast a market growth of about 40 %, to be reached within two years (Reilly 2005). Research question 6 aims to verify if potential users share this view and research question 7 links the above described strategic importance with the willingness to invest.

RQ 6: Do CIOs plan to invest in RFID?

RQ 7: Does the perceived strategic importance influence the willingness to invest in RFID?

2.4 RFID in Comparison to Other IT Topics

The SIM's 2005 study on application and technology developments concerning issues that IT decision makers are most concerned about (Luftman et al. 2005) showed that RFID ranked 16th, suggesting it is a relevant matter, but not one of primary concern. To put these results into perspective, the position of RFID among our study's respondents IT priorities will be examined in research question 8.

RQ 8: How important is RFID in comparison to other IT topics?

3 RESEARCH DESIGN & RESPONDENTS

The research questions deduced from literature review were supported by the findings from 15 semi-structured interviews with IT executives in various industries. Design and execution of the survey are based upon the model describing the phases to gain information by Nieschlag, Dichtl and Hörschgen (2002). The model was applied and customized to fit the research questions addressed in this study. Table 1 summarizes important design parameters of the study undertaken.

Research framework	Explorative study
Research method & period	Online survey, 11th November 2005 – 2 nd January 2006
Universe	3171 companies' top IT executive from various industries in Germany
Sample type	Census
Approach to contact participants	Personal letter containing personal unique access code for survey website
Rate of return	Approx. 14,6 % (463 data sets)

Table 1: Study design parameters

463 companies of various industries and company sizes took part in the survey (return rate 14.6%). The industry most represented was manufacturing (36.9%), other relevant industry groups were automotive (18.4%), services (16.0%), retail (14.3%), consumer goods (11.7%), IT (11.7%), transport / logistics (11.0%), pharmaceuticals / healthcare (8.4%) and other (22.9%). Companies with less than 2500 employees represented almost 75% of the participating organizations. Most respondents are CIO (72 %) (Figure 1).

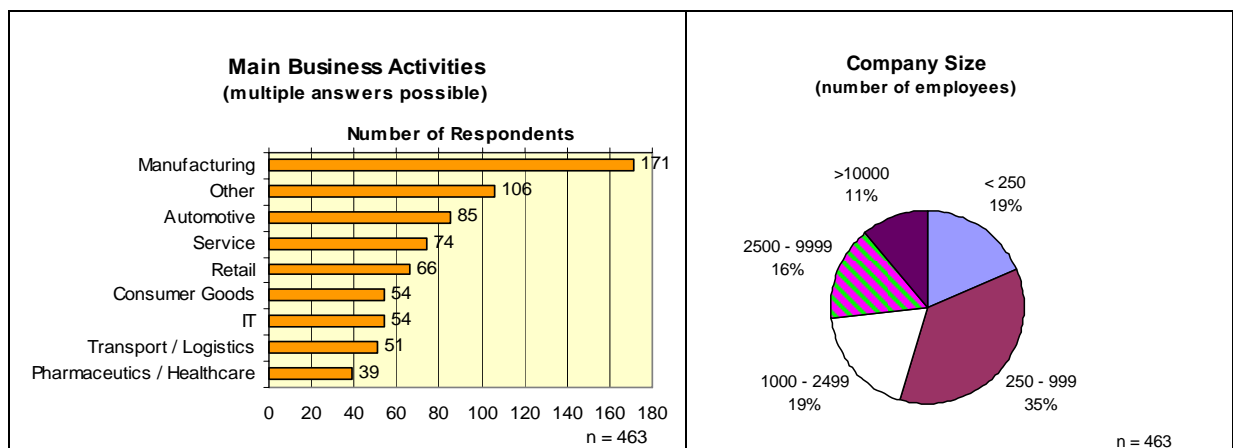


Figure 1: Participants of the survey – main business activities & company size

4 EMPIRICAL FINDINGS

4.1 Status Quo: RFID is still in its infancy

Auto-ID technologies are relevant for the major part of the companies. 87 percent of the responding companies apply some identification technology, mostly barcodes. RFID is still rather insignificant, about 9 % use the technology, however not exclusively, but in combination with barcode.

Asked for their experience with RFID, only 10 % are currently using or implementing it, most of them large-scale enterprises (> 10000 employees). About a third is analysing its potentials. Of the remainder, 14 % have decided against an implementation, mostly because they feared high costs and did not see any real benefit in RFID for their company. 38 percent have not yet dealt with the topic, many of them deciding to take a waiting position until a business partner will bring up the topic of RFID application. In the following sections, IT decision makers' view on RFID will be examined in more detail. Naturally, only those participants will be considered who stated to have already heard and somehow dealt with the topic of RFID.

4.2 Strategic importance of RFID: RFID is on the rise, but not yet a strategic issue

A clear majority of almost 65% of the participants foresees the importance of RFID to be rising over the next 5 years. 60% even believe the technology will get critical for the success of their company within the next 6 years. A shrinking importance is predicted by scarcely 2 % (Figure 2).

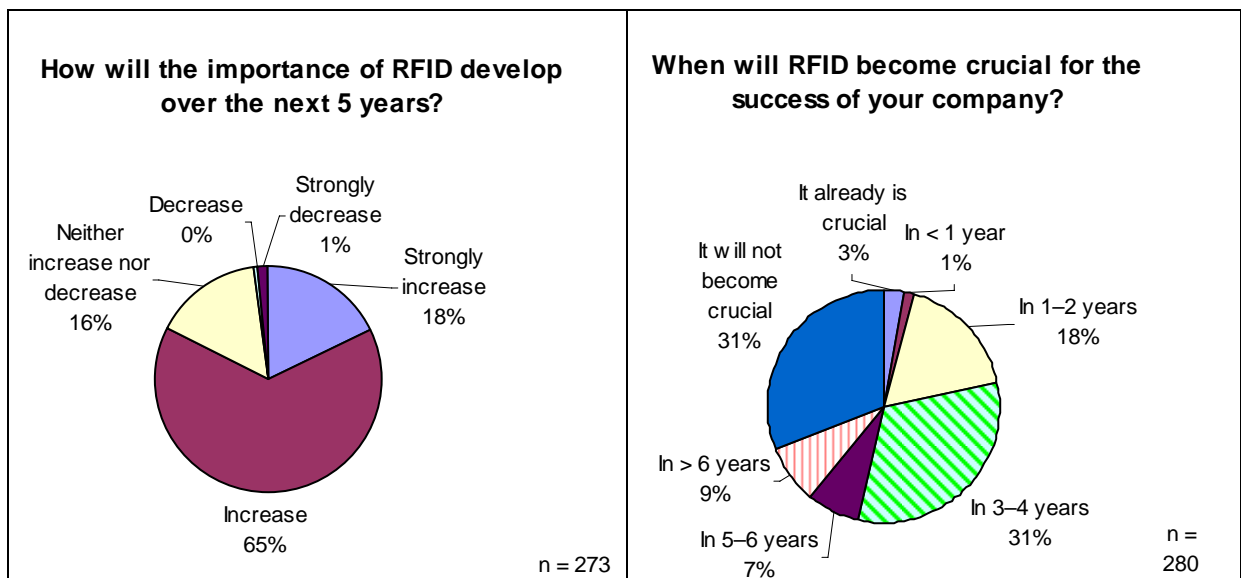


Figure 2 Importance of RFID within next 5 years & importance of RFID for company success

However, when asked if RFID was of strategic importance for their respective company, respondents react rather neutral (mean = 3.24 on a 5-point scale from 1= very important to 5 = not important at all). Given the before-mentioned fact that most participants believe the technology to become crucial for their success, this is somehow surprising. But when looking at each industry in detail, the answers vary considerably. Especially in IT, logistics and pharmaceuticals, a great part of the respondents judges RFID as a strategic issue (Figure 3). Large-scale companies seem to assess the strategic importance of RFID slightly higher than small-size companies (Spearman's rank correlation coefficient $r=-0.221$; $p<0.001$).

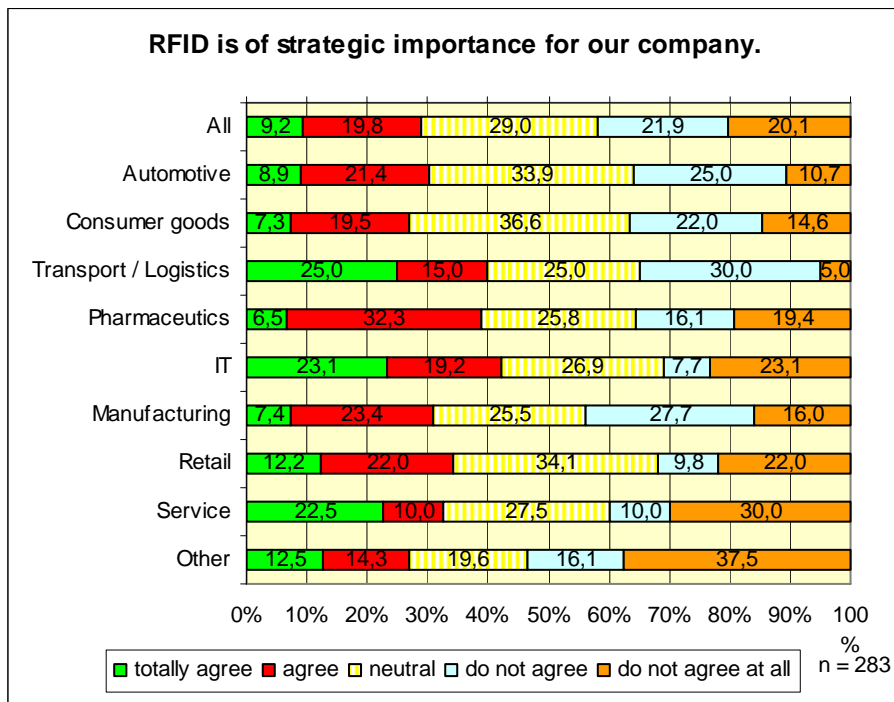


Figure 3: Perceived strategic importance of RFID by industry

For some industries, RFID might be a chance to better exploit their existing core competencies. Logistics, IT and retail affirm this. IT is the only one though to see an opportunity to develop new core competencies. This might of course be more in the role of a vendor, not necessarily as a user. It is IT again that thinks that RFID will enable them to offer new services, along with logistics and the service sector. Although the others judge this slightly negative, all industries tend to agree to the statement that RFID could enable new competitive advantages (mean = 2.87).

4.3 Willingness to invest: budgets are growing

On average, participants tend to affirm that their company will invest in RFID (mean = 2.7 on a 5-point scale from 1= totally agree to 5 = do not agree at all). As expected, there was a high strong positive correlation with the perceived strategic importance (Spearman's rank correlation coefficient $r = 0.630$; $p < 0.001$). Asked for their estimate on budget development, companies expect RFID budgets to grow in the course of the next five years. The strongest increase is anticipated within 3 years, with the pharmaceutical industry assuming the highest growth rates. Unlike the others, consumer goods foresees the peak of budget growth to arrive not until about five years from now (Figure 4).

Companies' investments in RFID systems are probable, provided that these systems will amortize in an adequate time span. On average, this time span is 21 months, but the number varies significantly between the industries. Automotive and services for instance expect a faster amortization in about 18 months. In contrast, consumer goods and retail would allow them about 22 months, logistics and pharmaceutics even 23 months (Figure 4). The fact that IT represents the lower end of the scale with requiring an amortization in only little less than 17 months might be explained by its probable function as a vendor. Being a party outside the users' enterprise world, they on the one hand have superior insight and experience regarding RFID systems. On the other hand they may underestimate the complexity of RFID implementation in a specific enterprise environment, both resulting in the assumption of a faster amortization.

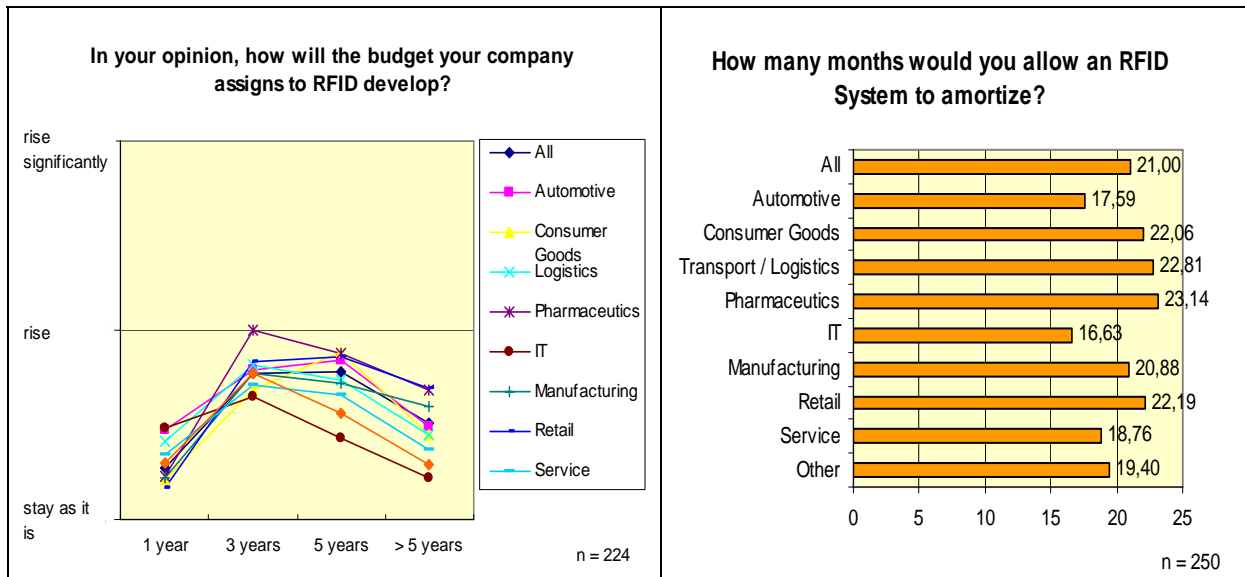


Figure 4: RFID budgets & expected amortization period

4.4 Potentials: RFID for reducing errors

The participants consider unique identification as most relevant for their company. Multiple reading, non-line-of-sight reading, durability and storage capacity for additional information are also rated positively. Additional features are perceived as not very relevant (Figure 5). This may indicate that companies do not yet see enriched product information as a source for new business or service offerings. In general, logistics tends to rate all factors as more relevant than all other industries.

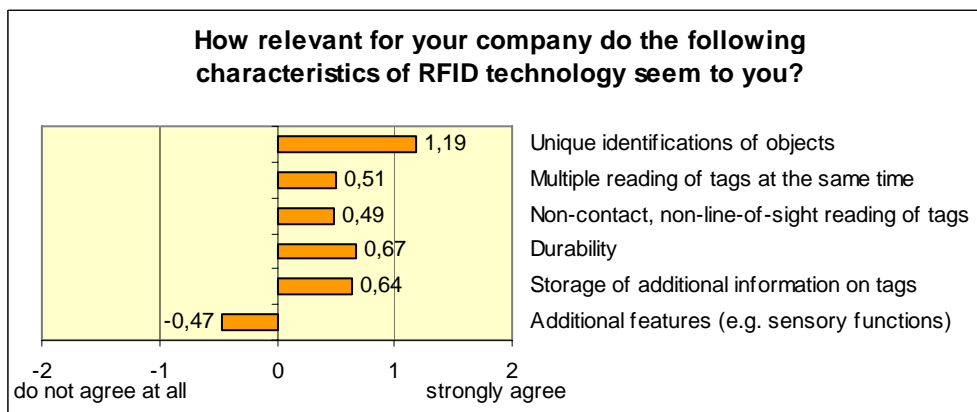


Figure 5: RFID characteristics

Asked about the improvements companies might be able to realize through RFID, on average all participants agreed that it will reduce errors. Concerning other areas, as optimised stock keeping, improved data consistency or improved customer service, they also saw positive potential (Figure 6). Reducing counterfeits was a minor point among these. The rating does not vary much between different industries, however, it stands out that transport / logistics tends to rate RFID's contribution to the mentioned improvements higher than the others. The pharmaceutical industry stands out in a single point, as it, more clearly than the others, agrees to the fact that RFID could contribute to reduce counterfeits.

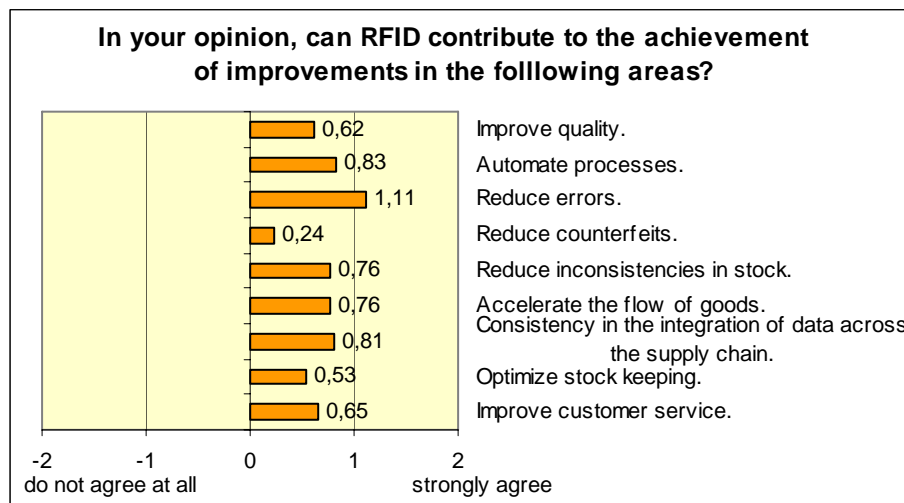


Figure 6: RFID potentials

4.5 Obstacles: standards, technical deficiencies, cost and financial insecurity are major sources of concern

Main sources of concern are the lack of standards, cost, above all tag costs, financial insecurity, technical deficiencies and a feeling that the RFID solutions offered on the market right now are not yet mature enough. In some companies internal circumstances, for instance lack of qualified staff, also play a role. Issues often stressed by consumer organisations, such as data security, are not judged as major problems. Neither does the integration of RFID systems into the enterprises' information systems, or the huge amount of data seem to be a matter of concern.

4.6 RFID and top IT topics

RFID certainly is an issue many IT managers have come across, a great part of them seeking further information or even planning tests. However, RFID is not on their top priority agenda. 368 participants provided their top 3 IT topics, of whom only 4.9 % included RFID in their list. Terms related to tracking & tracing were mentioned by 10.1 %.

4.7 Preparing for the future: RFID visions

In an open question, the participants were asked to provide their RFID vision for their company. Most of the statements could be easily grouped into the following four types of visions.

- Type 1: The visible enterprise. Respondents in that group (about 18.6%) hope for real-time information and identification throughout the supply chain, creating complete transparency of all processes relevant to the company at any time. Statements in this category tend to be highly abstract, e.g. one respondent expressed: "RFID-enabled continuous and integrated information chain including suppliers and partners – the vitreous enterprise".
- Type 2: Selected areas of application. Respondents in this group (about 9.5 %) also expect RFID to optimize certain processes, but their agendas are more precise, often suggesting a few specific areas of application. For instance, one participant thinks RFID holds potential for "warehouse management with position sensing by transponders in the ground".
- Type 3: Replace barcode. A relatively small percentage (about 3%) aims at replacing existing barcode technologies first, maybe later considering enhanced applications of RFID.

- Type 4: Customer driven. About 3.2 % of the participants state that their RFID vision entirely depends on their customers' wishes. "Satisfy all important customers" or "do as little as possible and only if required by customers" are typical goals of that group.
- Type 5: No vision. About 26.8 % explicitly state they had no RFID vision. In most cases, either they do not see any benefits in RFID (e.g. "It is not relevant for our main processes") or the companies have decided to take an expectant, observant position (e.g. "curiously observing, costs still too high" or "there's no need for us to be an early adopter"). 3.9 percent of the statements could not be classified in the above categories. The remaining 37.2 % did not specify their vision.

5 CONCLUSION

5.1 Summary of results

This research presented quantitative data on IT decision makers' views of RFID across industries and companies of varying sizes. The respondents indicated that RFID diffusion is very low. Many IT decision makers have heard about, taken an interest in it, but are still far from implementation.

The opinion on the strategic importance of RFID is divided. The judgments seem to be influenced by the type of industry, company size and perceived potential of the technology. Pharmaceuticals and logistics, retail, and IT affirm that RFID is of strategic importance to them, whereas manufacturing, consumer goods, and consulting do not share this opinion. The study results showed that the larger the company, the higher it rates the strategic importance of RFID. A desire for quality improvement, acceleration of the flow of goods, and optimization of stock were characteristics that most attracted CIOs to RFID.

Across all industries, companies expected their RFID budgets to increase, especially within the next 3 years. As expected, a higher perception of strategic importance correlated positively with a higher willingness to invest in the technology.

However, RFID is not (yet) a topic of high priority on a company's IT agenda. The high-level concepts often associated with RFID in the media or in consulting, above all the "real time enterprise" or the "internet of things" have not yet found their way into RFID visions. A large number of respondents indicated that it was not necessary to define a vision. On the other hand, virtually all participants stated that the importance of RFID will rise significantly over the next years. The technology might well turn out to be a sleeping giant.

5.2 Limitations of the study

The explorative research approach of the study is associated with certain limitations. First, due to the self-selection of the participants, the research results are not necessarily representative. Second, the survey recorded individual perceptions which might not entirely reflect reality or the perceptions of the individual's employer. Third, we cannot be sure that all participants share a common understanding of the term "strategic importance", which may have biased results. Fourth, the study did not test cross effects of variables.

6 RECOMMENDATIONS AND SUGGESTIONS FOR ACTION

6.1 Recommendations for potential RFID users

Companies should look beyond the technology level when dealing with RFID. It will not only be a new technology to replace an old one, but will affect many more processes, products, and services. For

many companies, instant action is not necessary. But as RFID's importance is on the rise, companies are well advised to keep watch of the RFID activities of business partners or other relevant stakeholders. As in the case of retail, where Wal-Mart or Metro demanded RFID application from their suppliers, or in pharmaceuticals where the US Food and Drug Administration recommended RFID to prevent counterfeiting, companies may be forced to react quickly. Instead of acting just because of forced compliance, companies should explore how RFID-enabled solutions could generate competitive advantage if properly integrated into their IT strategy.

Companies might want to gain technical, economical and organizational RFID experience by moving along with (1) isolated, closed loop internal asset management processes on pallet/ cardboard box level; (2) open loop cross-enterprise asset management on pallet level; (3) item-based solutions as products and services, while continuously analysing potentials and pitfalls, preparing for a series of infrastructure decisions and avoiding early interorganisational complexity. Time frames have to be used carefully in order to build up the technical and business intelligence to exploit the long-term RFID caused paradigm shift towards automated, event-driven communication as basis for a real-time enterprise with new services and radically different business processes and value chains / networks.

6.2 Recommendations for RFID vendors

RFID vendors should not underestimate the complexity of the RFID topic. Customers appreciate the operative benefits that might be achieved through this technology, but they do not link it to abstract, possibly strategic long-term concepts such as real time enterprise. Vendors must improve their way of communicating RFID as an enabler for these visions and explain its impact on IT processes and IT strategy if they want to convince customers that RFID is more than just another technology. Some industries, e.g. healthcare, logistics, and retail are more ready for RFID than for instance manufacturing, and should be addressed first. Big companies are probably easier to win for the technology than smaller ones.

7 OUTLOOK

This research is a first step towards theoretical concepts and models that help understand, identify, design, deliver and exploit potentially disruptive IT-dependent strategic initiatives that deliver sustainable competitive advantages. Future research should analyse the diffusion of RFID and the corresponding strategic paradigm shifts towards RTE on a longitudinal level and contrast it to the diffusion of other complex IT concepts such as ERP or EDI. There is need for theoretical concepts and models that help understand, identify, design, deliver and exploit potentially disruptive IT-dependent strategic initiatives that deliver sustainable competitive advantages. Especially in the context of multi-national enterprises analyses of the role of different cultural backgrounds of decision makers and corporate cultures might provide fruitful insights.

Further work should also attempt to determine strategic importance as a construct of different aspects instead of asking for it directly. Moreover, it should examine further factors that may take influence on the perceived strategic importance of RFID and intermediating variables as well as causal relationships. Additionally more in-depth insights on risks and success factors of how to systematically leverage the potentials of RFID and consequently the RTE are needed.

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