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RFID as enabler for the boundless real-time organisation: empirical insights from Germany

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Abstract: Radio Frequency Identification (RFID) is currently considered a hot topic in the IT arena. It is described as a major enabling technology for automated contactless wireless data collection, and as an enabler for the real-time enterprise, a future vision for enterprise information systems. Little is known, however, about the perceived strategic importance of RFID among IT decision makers, current RFID usage and areas of application, or companies' intentions to invest in RFID. In this paper we intend to fill this gap. We convey a quantitative survey among CIOs in Germany across various industries. We present empirical insights on CIOs' perceptions of the strategic importance of RFID, its relevance compared to other IT topics, and their RFID visions for the future of their company.

Keywords: Radio Frequency Identification; RFID; real-time enterprise; IT strategy; IT investments; diffusion; RFID vision; Chief Information Officers; CIO; competitive advantage; survey.

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1 Towards the boundless real-time enterprise

The vision of the Real-Time Enterprise (RTE) is simple: Use real-time information as a basis for business decisions. Managers should be provided with an environment that allows them to make quicker, more informed business decisions to achieve their objectives (Rabin, 2003). The promises of RTE, as promoted by consultancies from early 2000, are that it could generate new sources of revenue, avoid unnecessary business expenses and significantly improve business processes. By ensuring that the right information flows to the right people at the right time, RTE shall allow companies superior efficiency and quicker response time to both problems and opportunities (Chorafas, 2005). Most importantly, operating in real-time could provide early warning signals for changing business conditions so that enterprises can quickly adapt and avoid the disastrous and sometimes fatal mistakes they have made in the past few years (Kuhlin, 2005). The RTE is said to enable process automation in bridging distinct enterprise boundaries, media, and IS and to foster the real-time provision and exchange of information with customers, employees, partners and suppliers (Fingar and Bellini, 2004). RTE thus refers to the seamless fusion of IT and business operations to foster event-driven marketing, process automation, just-in-time provisioning, and readily available business intelligence (Tabrizi, 2006). However, few enterprises can implement RTE techniques and approaches without a major overhaul of their infrastructure (Neil and Clark, 2003). In order to be able to have information in real-time in IS, it is necessary to have a mapping of real-time events with events represented in the IS. One technology that can automatically enable this mapping of real-world events to events in the IS is Radio Frequency Identification (RFID).

RFID is currently widely discussed throughout scientific and non-scientific 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 owing to factors, including the need for more efficiency and security in supply

chains, enhanced technologies, cost pressure, standardisation initiatives, and prominent promoters such as Wal-Mart, Metro, and Tesco. When the Society of Information Management (SIM) conducted its last survey of IT executives, RFID was rated among the top 20 developments in application and technology (Luftman, 2005).

The aim of this study was to explore Chief Information Officers' (CIOs) perspective on RFID technology. Using CIOs as sources of information, we investigated the strategic importance RFID, RFID as an enabler for RTE, and how CIOs plan to act in regard to this issue. The research was conducted using an independent, non-profit German CIO network organisation to obtain interviewees.

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, 2003). 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 the 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
Tags operating on radio frequency are not completely unaffected by materials in their close vicinity. Signals can be attenuated or detuned by metals or liquids.
- Multiple standards
In the past, several different frequencies and standards have been used for RFID solutions. Although the standardisation organisation 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. A common approach is to endorse ERP systems with RFID middleware. 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 are empirical (Loebbecke and Palmer, 2006; Karkkainen, 2003), conceptual (Asif and Mandviwalla, 2005) and simulational (Lee *et al.*, 2004) evidences 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 and Hodges, 2002). 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, 2004b).¹ Other examples highlight the potential for completely new services, such as enriched museum tours (Hsi and Fait, 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 the market. The US Food and Drug Administration (2004) rates RFID as the most promising technology to achieve these goals.

- 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.

- Retail

The intelligent shopping cart. Without spending a considerable amount of time inquiring, consumers often cannot be sure about characteristics and ingredients of the products they are buying, although this information can be highly relevant if the consumer suffers from allergies or other diseases. Doubts could be removed if the shopping cart could read the information stored on the RFID tag on the respective product and display it to the shopper, possibly along with allergy warnings or preparation suggestions. The Metro Group already experiments with smart shopping carts in their RFID pilot store.

- 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 and providing both logistician and client with accurate information.

RFID can enable enterprises to bridge the gap between the real world and its representation in information systems (Haller and Hodges, 2002; Fleisch and Tellkamp, 2005), thus paving the road towards the ‘real-time enterprise’, promising optimised processes over organisational boundaries, improving decisions through higher data quality, and improving integration of supply chain partners.

2 Theoretical background

2.1 The strategic importance of RFID

Porter (1996) describes strategy as “performing different activities from rivals” or “performing similar activities in different ways” and emphasises that although operational effectiveness is crucial for profitability, it is not strategy. Metro’s success in improving operations and cutting cost through RFID (Collins, 2005) and the automotive industry’s report about positive return on investments of RFID solutions (Kraft and Schauler, 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 revolutionise the way items are tagged and traced through distribution channels (Roussel *et al.*, 2005), but also hold “great potential for reshaping business strategies” (Woods *et al.*, 2003). But beyond consultants, vendors and analysts, what do (future) users think? 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 of perceived strategic importance*

The first sector to use RFID technology was the military (Schmid, 2004), but bit by bit, RFID made its way into other industries and institutions. Companies are optimistic about RFID's potential to optimise and rationalise 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?

The diffusion of the 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 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 the 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 (1989) in his Technology Acceptance Model (TAM), describing perceived usefulness as a determinant for adoption. Perceived benefits have also proved relevant in Iacovou and Benbasat's (1995) study about the adoption of EDI and were also considered in the research conducted by Sharma and Citurs (2005) on the adoption of RFID. In this study, relative advantage describes potential benefits and improvement resulting from RFID in comparison to barcode technology. Hence, Research Question 4 addresses the 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 Defense, have declared RFID as a key technology, market forecasts have outbid one another (Lange, 2004). Frost and Sullivan (2004) research predicts a growth in the RFID marketplace of over 30% by 2010

as compared to 2003. Accenture (2005) estimates the growth will be 40%. 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.*, 2006) 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?

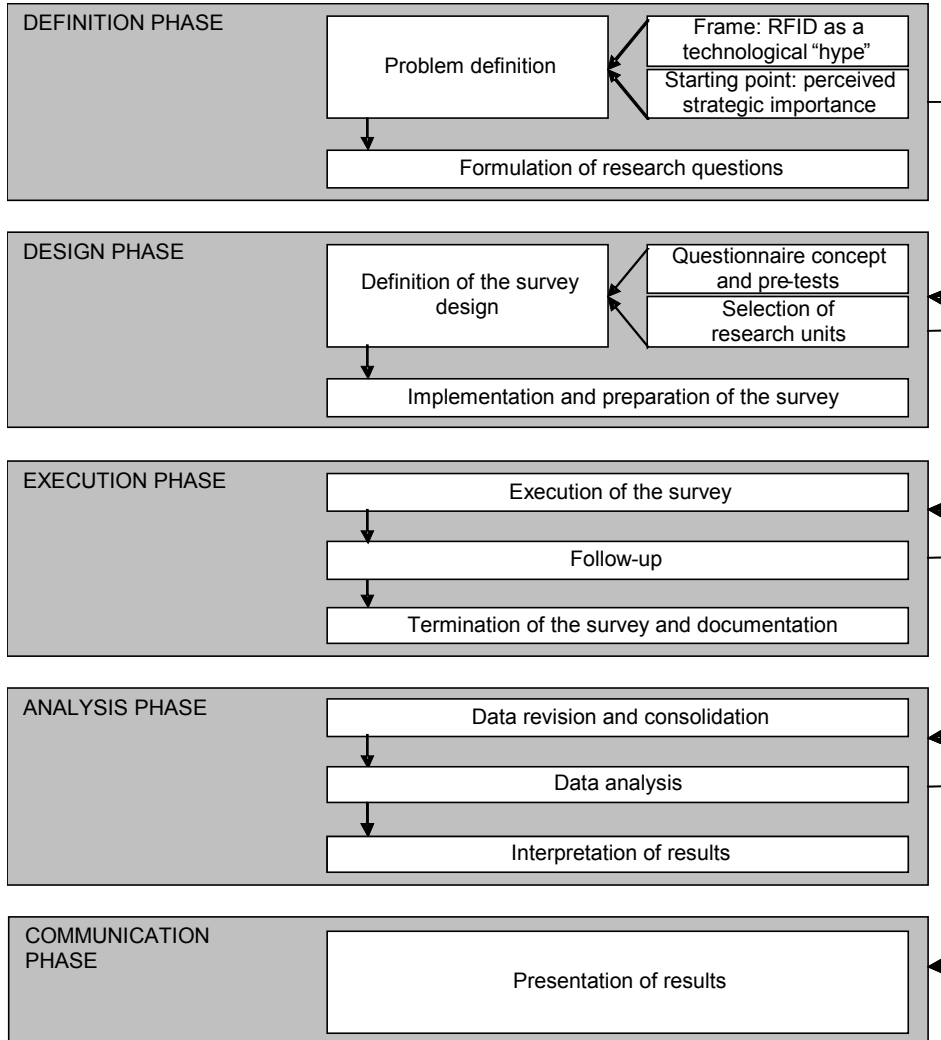
3 Research design

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 were based upon the model describing the phases to gain information by Nieschlag *et al.* (2002), an established model in German social sciences. The model was applied and customised to fit the research questions addressed in this study. The study was conducted in a non-commercial German CIO network, the 'CIO Circle'. All 450 members who represent virtually all areas of industry were sent a personal invitation to take part in the survey. Table 1 summarises the important design parameters of the study and Figure 1 illustrates the survey execution.

Table 1 Study design parameters

<i>Research framework</i>	<i>Explorative study</i>
Research method	Online survey
Period	11 November 2005 – 2 January 2006
Universe	Members of the 'CIO Circle', a non-profit CIO networking organisation (approximate 450 members) in Germany
Sample type	Census
Approach to contact potential participants	Personal e-mail invitation containing personal unique access code for survey website
Rate of return	Approximate 25% (114 data sets)

Figure 1 Survey execution and process



Source: Adapted from Nieschlag *et al.* (2002)

The respondents were asked to give free statements in reply to questions on their strategic visions for RFID. The data analysis procedures included horizontalisation, delimiting to invariant horizons or meaning units and clustering the invariant constituents into themes. For identifying meaning units, a code book approach was used (Neuendorf, 2002) and then the identified clusters are described. Two coders worked independently and the results were consolidated. The calculated intercoder reliability measure for Cohen's Kappa (Lombard *et al.*, 2002) was 0,91 and can be considered satisfactory based on social science research practice (Bakeman, 2000).

4 Empirical findings

4.1 Characteristics of participants

In total, 114 members of the CIO Circle participated in the survey, of which all but one was male. The age group 41–50 years had the highest representation (57.9%), followed by the group 31–40 (28.9%). Asked for the main business activities of their companies,² participants indicated manufacturing (28.1%), service (19.3%), transport/logistics (17.5%), automotive (16.7%), retail (14.0%), consumer goods (11.4%), consulting (9.6%), IT (8.8%), pharmaceuticals/healthcare (8.8%), others (18.4%). Company sizes measured in number of employees varied; the majority (61.4%) had less than 2500 employees, 17.5% exceeded 10 000 employees. Most respondents were CIOs (77.2%).

4.2 RFID diffusion

Concerning their knowledge of potential applications of RFID, most of the participants described it as good or very good (42.1%), 36.0% as average and the remainder as poor or very poor (13.2%).

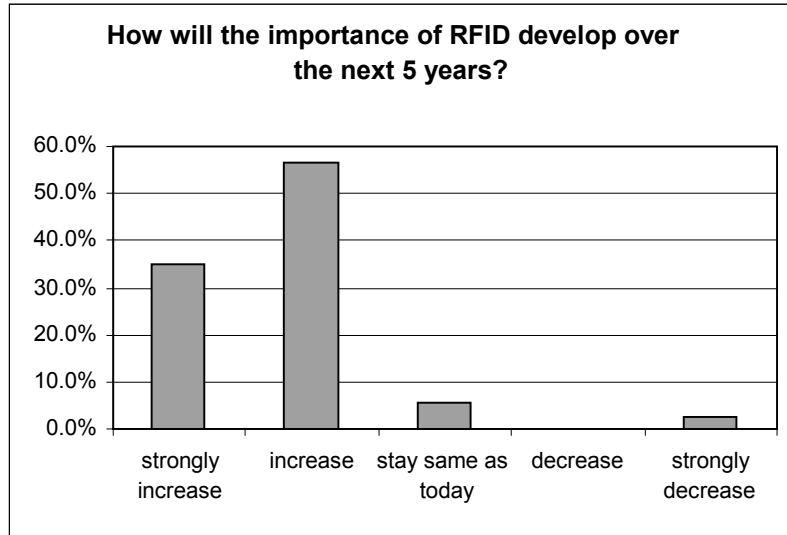
The experience with RFID systems among the respondents was low. Only a small number had implemented RFID systems in their companies (7.0%) and others were planning (10.5%) or building (6.1%) an RFID application. About a third were conducting tests (33.3%) and another third had not yet thought about the topic (33.3%). The remainder had conducted tests, but then decided to reject the technology (9.6%).

4.3 Strategic importance of RFID

The participants were asked to assess the strategic importance of RFID for their company on a 5-point scale ('totally agree' = 1 to 'do not agree at all' = 5). Seventy-three people answered the question. No particular tendency was revealed, the answers were evenly distributed across all categories (mean = 3.05). To gain more insights, the respondents were then asked for their opinion on RFID influencing their core competencies. Similar to the assessment of strategic importance, on average, the respondents neither agreed nor disagreed that RFID could influence their core competencies, with a slight positive tendency regarding the better exploitation of existing core competencies (mean = 2.78), and a slight negative tendency regarding the buildup of new core competencies (mean = 3.33). Nevertheless, they tended to agree that through RFID, they could generate competitive advantages (mean = 2.61) (for details about all other statements, see Appendix, Tables 1 and 2). As these results are in line with strategic importance, only strategic importance will be further analysed in the following section.

Looking beyond the present, almost all respondents (91.0%) expected the importance of RFID for their company to increase in the near future (Figure 2). Sixty-eight percent of the 75 persons who answered the following question believed that RFID will become critical for the success of their company in the future. Fifty-five percent even believed this to be the case in less than four years.

Figure 2 Future importance of RFID (n = 74)

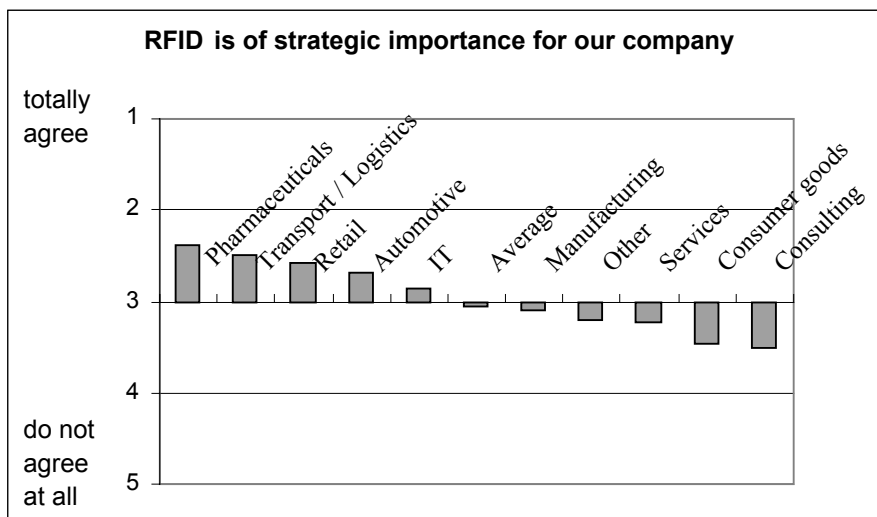


4.4 Determinants of perceived strategic importance

4.4.1 Characteristics of company and respondent

Figure 3 analyses the perceived strategic importance by industry. Although the differences are not drastic, it shows that the perceived strategic importance of RFID indeed does vary among the industries. Pharmaceuticals, logistics, retail, and automotive tend to attribute a positive strategic importance to RFID, while other industries, e.g., manufacturing, assess it more negatively.

Figure 3 Strategic importance of RFID by industries (n = 114)



When analysing the strategic importance by company size, the means suggest it is rated higher, the larger the company size. A correlation analysis using Spearman's rank correlation coefficient confirms this, indicating a modest negative relationship between company size and 'RFID is of strategic importance for our company'³ ($r = -.371$, $p = .001$).

Regarding characteristics of the responding persons, such as age and individual knowledge about RFID, no significant correlations with the perceived strategic importance can be found.

4.4.2 Experience with RFID

When cross-tabulating the RFID experience of the companies with the perceived strategic importance, a comparison of the means reveals different values in all of the categories (see Table 2). Companies with tests in progress on average had a neutral opinion of the strategic importance of RFID. Of those who had already conducted tests, companies who do not intend to apply the technology also did not believe in its strategic importance. In contrast, a positive tendency was noticed for those intending to adopt the application. Those most convinced of RFID's strategic importance were companies currently implementing the system. This group even surpassed those companies already applying it.

Table 2 Cross table of RFID experience and perceived strategic importance

<i>RFID experience</i>	<i>Strategic importance of RFID</i>	
	<i>Mean</i>	<i>Std. dev.</i>
Applies RFID	2.38	1.408
Implementing RFID	1.67	1.033
Conducted tests, intends application	2.42	1.311
Tests in progress	3.19	0.995
Conducted test, does not intend application	4.70	0.675

Note: 5-point scale from 'totally agree' = 1 to 'do not agree at all' = 5; $n = 73$

4.4.3 Perceived potentials of RFID

On average, all participants agreed on the presented potentials of RFID (see Table 3).

A correlation analysis using Spearman's rank correlation coefficient was conducted to measure whether perceived potentials influence the perceived strategic importance. A highly significant positive relationship can be found between 'improve quality' ($r = 0.379$; $p = 0.001$), 'accelerate the flow of goods' ($r = 0.336$; $p = 0.004$), 'optimise stock keeping' ($r = 0.436$; $p < 0.001$) and the perceived strategic importance. The results also indicate a significant positive relationship involving 'automate' ($r = 0.284$; $p = 0.016$), 'reduce errors' ($r = 0.278$; $p = 0.018$) and 'improve customer service' ($r = 0.245$; $p = 0.038$). For the other statements, no significant relationships could be found.

Table 3 Perceived potentials of RFID

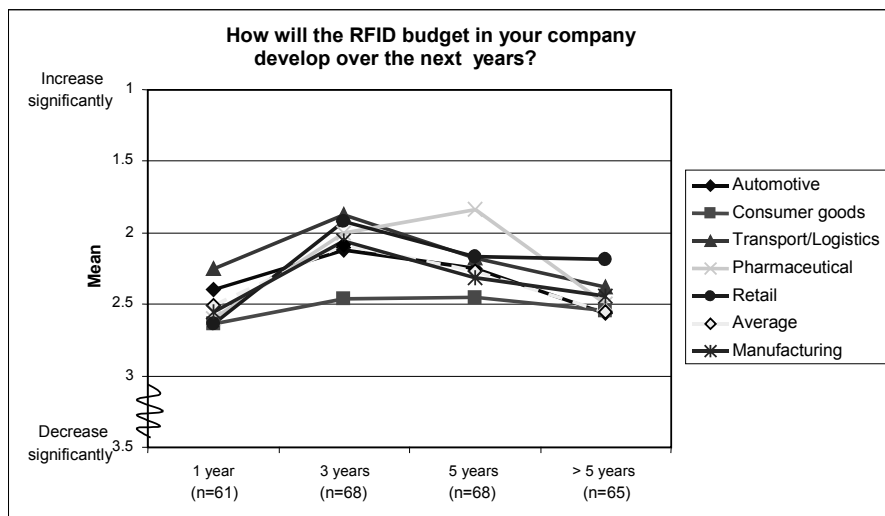
<i>RFID has the potential to...</i>	<i>Mean</i>	<i>Std. dev.</i>
Reduce errors (n = 75)	1.81	0.817
Accelerate the flow of goods (n = 73)	1.88	0.927
Automate/reduce manpower (n = 75)	1.93	0.811
Be consistent in the integration of data across the supply chain (n = 74)	2.15	1.043
Improve quality (n = 75)	2.16	1.027
Improve customer service (n = 75)	2.16	0.959
Reduce inconsistencies in stock (n = 74)	2.2	1.047
Optimise stock keeping (n = 74)	2.38	1.069
Reduce counterfeits (n = 69)	2.59	1.204

Note: 5-point scale from 'totally agree' = 1 to 'do not agree at all' = 5

4.5 Willingness to invest in RFID

On a 5-point scale ('totally agree' = 1 to 'do not agree at all' = 5), the participants were asked to comment on the statement 'we will invest in RFID'. On average, the participants tended to agree to this (mean = 2.41; std. deviation = 1.122). A correlation analysis using Spearman's rank correlation between 'RFID is of strategic importance for our company' and 'we will invest in RFID' showed a significant strong positive correlation ($r = 0.784$; $p < 0.001$).

Asked how they think the RFID budget of their company will develop over the next years, on average all participants expected it to rise, the strongest rise expected in about three years. Then it will go down again, but will nevertheless be higher than today. When analysed separately, with slight variations, this trend is also true for the single industries. Pharmaceuticals is an exception as it does expect the RFID budget to grow more five years from now.

Figure 4 RFID budgets

4.6 RFID and top IT topics

The statement 'RFID is one of our top IT topics' (5-point scale from 'totally agree' = 1 to 'do not agree at all' = 5) was rated on average with 3.69 (std. deviation = 1.115). To put this into perspective, the participants were asked in an open question to specify the three top IT topics their company have dealt with at the moment. A total of 111 participants followed the request, of which 8.1% persons mentioned 'RFID' among the top IT topics. About 17% mentioned 'tracking & tracing' or similar expressions. CRM and IT integration followed.

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 30%) hope for real-time information and identification throughout the supply chain, creating complete transparency of all processes relevant to the company at anytime. 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 14%) also expect RFID to optimise 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 5%) aims at replacing existing barcode technologies first, maybe later considering enhanced applications of RFID.
- Type 4 No vision. About 25% 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'). Twenty-three percent provide no statement at all. The remaining 3% could not be classified.

5 Conclusion

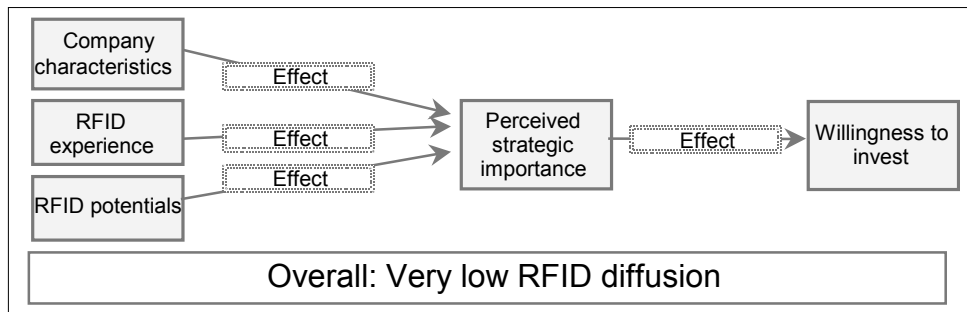
This research presented quantitative data on IT decision makers' views of RFID across industries and companies of varying sizes. The respondents indicated that RFID diffusion is very low. Many IT decision makers have heard about, taken an interest in it, but are still far from implementing it.

The opinion on the strategic importance of RFID is divided. The judgements 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 optimisation of stock were characteristics that most attracted CIOs to RFID.

Across all industries, companies expected their RFID budgets to increase, especially within the next three 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 the companies' IT agenda. The high-level concepts often associated with RFID in the media or in consulting, and 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 did not indicate that it was necessary to define a vision. On the other hand, virtually all participants stated that the importance of tracking and tracing and RFID will rise significantly over the next years. The technology might well turn out to be a sleeping giant. Figure 5 summarises the findings of the study.

Figure 5 Results of the survey



Analysing the innovation leaders in RFID in the German market in follow-up interviews and case studies (Metro and DHL), our findings were in accordance with those of previous research (Loebbecke and Palmer, 2006). For example, if RFID is considered strategically, it can help to increase process efficiencies and provide a significant competitive advantage from the use of RFID data as claimed by consultants in the context of the RTE. Furthermore, responses indicated that companies were very interested in building up and improving technical and management skills to be able to redesign infrastructures, processes and organisational structures in order to leverage the potential of real-time infrastructures. Furthermore, they stated [as reported also in other related research (Khosla and Pal, 2002)] that migration to RTE requires a continuous migration process and they are convinced that these RFID-enabled RTE-Systems have all the necessary attributes of IT-dependent strategic initiatives (Piccoli and Ives, 2005) to be able to deliver a sustainable competitive advantage.

Based on the experiences of these innovation leaders, the following insights can be derived:

- RFID is a logical next step in enterprise computing and extending corporate boundaries.
- There is nothing really new about RFID.
- The barcode will not be replaced by RFID.
- RFID is not yet a plug&play technology; standards are currently being established.
- The public will display an interest in RFID with respect to privacy issues.
- Efficiency of existing processes can be enhanced with RFID.
- RFID allows for the radical redesign of processes, products and services.
- RFID can create a competitive advantage.

Limitations of the study

The explorative research approach of the study is associated with certain limitations. First, because of the self-selection of the participants, the research results are not necessarily representative. Second, the survey recorded individual perceptions that 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

What are potential users and vendors to do about RFID? We will deduce several recommendations for both groups.

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 organisational RFID experience by moving along with:

- isolated, closed loop internal asset management processes on pallet/carton level
- open loop cross-enterprise asset management on pallet level
- item-based solutions as products and services while continuously analysing present and emerging 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 over to the technology than smaller ones.

7 Outlook

Future research should analyse the diffusion of RFID and the corresponding strategical paradigm shifts towards RTE on a longitudinal level and contrast it with 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 multinational 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 the risks and success factors of how to systematically leverage the potentials of RFID and consequently the RTE are needed.

References

- Accenture (2005) *Pushing the Pace – How Leaders are Putting RFID to Work*, München, Accenture.
- Agarwal, V. (2001) *Assessing the Benefits of Auto-ID Technology in the Consumer Goods Industry*, Cambridge, University of Cambridge.
- Asif, Z. and Mandviwalla, M. (2005) 'Integrating the supply chain with RFID: a technical and business analysis', *Communications of AIS*, Vol. 15, pp.393–427.
- Bakeman, R. (2000) 'Behavioral observation and coding', in T. Reis and E.M. Judge (Eds.) *Handbook of Research Methods in Social and Personality Psychology*, New York: Cambridge University Press.
- Chorafas, D. (2005) *The Real-Time Enterprise*, Boca Raton, Auerbach.
- Collins, J. (2005) 'Metro group reaps gains from RFID', *RFID-Journal*.
- Davis, F.D. (1989) 'Perceived usefulness, perceived ease of use and user acceptance of information technology', *MIS Quarterly*, pp.319–339.
- Fingar, P. and Bellini, J. (2004) *The Real-Time Enterprise: Competing on Time with the Revolutionary Business S-Ex Machine*, Tampa: Meghan Kiffer Press.
- Finkenzeller, K. (2003) *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification*, Chichester: Wiley.
- Fleisch, E. and Tellkamp, C. (2005) 'Inventory inaccuracy and supply chain performance: a simulation study of a retail supply chain', *International Journal of Production Economics*, Vol. 95, No. 3, pp.373–385.
- Frost and Sullivan (2004) *World RFID-based Application Markets*, Palo Alto: Frost & Sullivan.
- Haller, S. and Hodges, S. (2002) *The Need for a Universal SmartSensor Network*, Cambridge, University of Cambridge.
- Hsi, S. and Fait, H. (2005) 'RFID enhances visitors' museum experience at the Exploratorium', *Communications of the ACM*, Vol. 48, pp.60–65.
- Iacovou, C. and Benbasat, I. (1995) 'Electronic data interchange and small organizations: adoption and impact of technology', *MIS Quarterly*, Vol. 19, pp.465–485.
- Karkkainen, M. (2003) 'Increasing efficiency in the supply chain for short shelf life goods using RFID tagging', *International Journal of Retail & Distribution Management*, Vol. 31, p.529.
- Khosla, V. and Pal, M. (2002) 'Real-time enterprises: a continuous migration approach', *Information Knowledge Systems Management*, Vol. 3, p.53.
- Kraft, J. and Schauler, C. (2005) 'RFID setzt sich durch', *Information Week*.
- Kuhlin, B. (Ed.) (2005) *The Practical Real-Time Enterprise*, Berlin: Springer.
- Landt, J. (2005) 'The History of RFID', *IEEE Potentials*, Vol. 24, pp.8–11.
- Lange, V. (2004) 'Perspektiven für die Nutzung der RFID-Technologie in Supply Chain Management und Logistik', *IM*, Vol. 19, pp.20–26.
- Lee, Y.M., Cheng, F. and Leung, Y.T. (2004) 'Exploring the impact of RFID on supply chain dynamics', *Simulations Conference*, IEEE.
- Loebbecke, C. and Palmer, J. (2006) 'RFID in the fashion industry: Kaufhof Department Stores AG and Gerry Weber International AG, Fashion Manufacturer', *MIS Quarterly Executive*, Vol. 5, pp.69–79.
- Lombard, M., Snyder-Duch, J. and Bracken, C.C. (2002) 'Content analysis in mass communication: assessment and reporting of intercoder reliability', *Human Communication Research*, Vol. 28, pp.587–604.
- Luftman, J. (2005) 'Key issues for IT executives 2004', *MIS Quarterly*, Vol. 4, pp.269–285.
- Luftman, J., Kempaiah, R. and Nash, E. (2006) 'Key issues for IT executives 2005', *MIS Quarterly Executive*, Vol. 5, pp.27–45.

- Maselli, J. (2003) 'ABI: RFID market poised for growth', *RFID-Journal*.
- Neil, D. and Clark, W. (2003) 'The real-time enterprise and network', *Gartner Research*.
- Neuendorf, K.A. (2002) *The Content Analysis Guidebook*, Thousand Oaks: Sage.
- Nieschlag, R., Dichtl, E. and Hörschgen, H. (2002) *Marketing*, Berlin: Duncker&Humboldt.
- Piccoli, G. and Ives, B. (2005) 'Review: IT-dependent strategic initiatives and sustained competitive advantage: a review and synthesis of the literature', *MIS Quarterly*, Vol. 29, pp.747–776.
- Porter, M.E. (1996) 'What is strategy?', *Harvard Business Review*, Vol. 74, pp.61–78.
- Rabin, S. (2003) 'The real-time enterprise, the real-time supply chain', *Information Systems Management*, Vol. 20, p.58.
- Reilly, K. (2005) 'AMR research survey finds 69% of respondents plan to evaluate, pilot, or implement RFID in 2005', AMR Research, Press release.
- Rogers, E.M. (1995) *Diffusion of Innovations*, New York: The Free Press.
- Roussel, A-M., Fenn, J. and Linden, A. (2005) 'Gartner's radar screen pinpoints hot technologies likely to grab investors' attention', Stanford, Gartner Research.
- Sarma, S. (2004) 'Integrating RFID', *QUEUE*, pp.50–57.
- Schmid, F. (2004) 'Radio frequency identification standards – Produkte – Vorgehen in Projekten', *IM*, Vol. 19, pp.6–11.
- Sharma, A. and Citurs, A. (2005) 'Radio Frequency Identification (RFID) adoption drivers – a radical innovation adoption perspective', *Eleventh Americas Conference on Information Systems*, Omaha, NE, USA.
- Staake, T., Thiesse, F. and Fleisch, E. (2005) 'Extending the EPC network: the potential of RFID in anti-counterfeiting', *ACM Symposium on Applied Computing*, Santa Fe, ACM.
- Tabrizi, B. (2006) *Becoming a Real-Time Enterprise*, New York: McGraw-Hill.
- US Food and Drug Administration (2004) 'Combating counterfeit drugs', *US Food and Drug Administration*.
- Want, R. (2004) 'The Magic of RFID', *QUEUE*, pp.40–48.
- Wilding, R. and Delgado, T. (2004a) 'RFID demystified: company case studies', *Logistics & Transport Focus*, Vol. 6, pp.32–42.
- Wilding, R. and Delgado, T. (2004b) 'RFID demystified: supply-chain applications', *Logistics & Transport Focus*, Vol. 6.
- Woods, J., Peterson, K. and Hirst, C. (2003) 'Maturing open RFID applications will reshape SCM', Stanford, Gartner Research.

Notes

- 1 For an overview of selected case studies, see Wilding, and Delgado (2004a).
- 2 Multiple answers possible, percentages add up to more than 100%.
- 3 5-point scale from 'totally agree' = 1 to 'do not agree at all' = 5.

Appendix

Table 1 Strategic importance of RFID by industry (Mean)

Statistics	Industry										
	All	Autom.	CG	Log.	Pharma.	IT	Manuf.	Retail	Service	Consult.	Other
RFID is of strategic importance to our company.*	3.05	2.69	3.46	2.50	2.38	2.86	3.10	2.58	3.22	3.50	3.20
By using RFID, we can open up competitive advantages.*	2.61	2.25	3.15	2.11	2.13	2.63	2.52	2.42	2.80	3.17	2.82
RFID helps us to build new core competencies.*	3.33	3.19	3.54	2.50	3.38	3.13	3.43	2.83	3.20	3.67	3.18
RFID helps us to better exploit existing core competencies.*	2.78	2.38	3.15	2.33	2.13	2.75	2.90	2.50	2.90	3.50	2.64
How will the importance of RFID develop over the next five years?***	1.78	1.69	1.83	1.67	1.63	1.50	1.70	1.58	2.00	2.83	1.73

Notes: * 5-point scale from 'totally agree' = 1 to 'do not agree at all' = 5

** 5-point scale from 'strongly increase' = 1 to 'strongly decrease' = 5

Table 2 Strategic importance of RFID by industry (Standard Deviation)

Statistics	Industry										
	All	Autom.	CG	Log.	Pharma.	IT	Manuf.	Retail	Service	Constlt.	Other
RFID is of strategic importance to our company.*	1.32	1.08	1.33	1.20	0.92	1.68	1.41	1.44	1.64	1.76	1.55
By using RFID, we can open up competitive advantages.*	0.78	0.48	0.39	1.03	0.52	0.76	0.57	0.67	1.25	1.17	0.65
RFID helps us to build new core competencies.*	1.23	1.13	0.99	0.96	0.83	1.85	1.25	1.51	1.62	1.72	1.33
RFID helps us to better exploit existing core competencies.*	1.28	1.05	1.27	1.29	1.19	1.36	1.36	1.53	1.55	1.51	1.40
How will the importance of RFID develop over the next five years?***	1.31	0.96	1.34	1.28	0.83	1.67	1.26	1.45	1.66	1.64	1.43

Notes: * 5-point scale from 'totally agree' = 1 to 'do not agree at all' = 5

** 5-point scale from 'strongly increase' = 1 to 'strongly decrease' = 5