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The SME Way of Adopting RFID Technology: Empirical Findings from a German Cross-Sectoral Study

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Abstract

More than 98 per cent of all European companies are small or medium-sized enterprises (SMEs). Even though their structural characteristics are well known, neither academia nor politics have paid much attention to SMEs' experiences in using RFID technology. Consequently, SMEs that deal with an implementation have so far only few guidelines regarding specific opportunities and risks. We try to fill that gap by presenting the findings of a survey among German enterprises which already use RFID. As far as we know, this work constitutes the first attempt to directly address SME specific aspects of RFID adoption based on empirical data from SMEs and large enterprises. We have evidence of the existence of an SME specific way: Across all sectors and different application areas, SMEs differ significantly from large enterprises in performance objectives and assessment of barriers. We can show that structural inertia theory supports our empirical findings, according to which RFID adoption favours SMEs. We conclude by deriving implications for SMEs not using RFID so far.

Keywords: RFID, SMEs, Adoption and Usage, Empirical Study.

1 INTRODUCTION

The announcement of RFID mandates by the retail industry and the US Department of Defense, innumerable reports on RFID applications in several industries and countless forecasts are indications of a considerable medium-term diffusion of RFID technology. However, considering the doubtlessly high economic importance of small and medium-sized enterprises (SMEs), it is astonishing that the question of SME-specific requirements and potentials of RFID technology has not yet received the appropriate attention in academic and political discussions. This contribution presents a cross-sectoral and cross-application survey among German enterprises which already use RFID. By exploring differences based on firm size we aim to derive implications for SMEs for which an introduction of RFID is of potential interest.

Firstly, the research deficit is addressed by highlighting SME-related aspects in *chapter 2*, including structural characteristics and IT usage of SMEs as well as first scientific results concerning RFID usage dependent on firm size. *Chapter 3* provides the methodical foundations for our analysis by characterising the research design (3.1) and data set (3.2) as well as highlighting fundamental deficits regarding IT usage among the SMEs of our data set, therefore showing "typical" characteristics of SMEs regarding IT adoption. *Chapter 4* finally analyses the extent of the differences between SMEs and large enterprises with respect to diffusion, application fields, realisation of performance improvements and success of RFID applications, as well as assessment of barriers. *Chapter 5* proposes *structural inertia* of large enterprises as an explanation of our findings and *chapter 6* closes the analysis with strategic implications and highlights further need for research.

2 SMES AND THE ADOPTION OF RFID TECHNOLOGY

2.1 Introduction of New Technology: Size Matters

With regard to the number of employees, 99.8% of all European (EU 2006) and 98.7% of all German (Günterberg and Kayser 2006) enterprises could be classed as SMEs in 2003.[1] SMEs typically exhibit lower financial resources and a *lower number of cooperating suppliers and customers* compared to large enterprises (Hall et al. 2004, EC 2003). On a qualitative level, SMEs are characterised by a concentration of capital, management and control of corporate activities in the hands of the owner(s) (Stonehouse and Pemberton 2002). The central position of the owner(s) in many cases facilitates a distinctive *decision flexibility*, while a lack of mechanisms and systems of planning and controlling is also apparent in many cases (Margi, Powell 1998).

The structural characteristics of SMEs explicitly affect their usage of information technology (IT). Empirical studies document a lower usage of business information systems (IS) as well as in-house and cross-company networking among SMEs (e-Business Watch 2005). As an implication of the structural and IT usage characteristics observed, it can be expected that RFID usage among SMEs and large enterprises will differ with regard to application fields, performance objectives and success. The limited amount of work concerning RFID and SMEs presented in the following section tries to draw direct or indirect conclusions from SME's characteristics in order to make assessments regarding SME-specific RFID usage. Major shortcomings of these approaches are highlighted.

2.2 Related Work: Dependence of Firm Size and Use of RFID

Only a small amount of theoretical and empirical analyses have so far dealt with firm size and RFID usage. In one of the first research works on the issue, (Byrnes 2003) emphasizes the *disadvantages* of

[1] Our separation of SMEs and large enterprises relates to the formal thresholds provided by the EU that came into effect on 2005-01-01 (European Union 2006). Accordingly, SMEs are categorized as employing less than 250 workers and either turning over less than € 50 million annually or exhibiting annual total assets of less than € 43 million.

small actors in retail supply chains compared to their top-selling competitors, regardless of whether a manufacturer, distributor or retailer. In this model, only large retail companies and manufacturers of electronics can realise a positive net present value (NPV) by deploying RFID technology. While this result is accomplished by the deployment of simulation analyses, the basic assumptions of the model remain rather obscure (Byrnes 2003). In contrast, other studies highlight the special *business opportunities* of RFID adoption for SMEs, including inventory reductions via affordable tracking and tracing of logistical objects, a feature previously reserved for large companies (BITKOM 2005). Another argument predominant in existing work is *competitiveness*. According to the strategic implications drawn by a study released by the German Information Forum on RFID, SMEs should keep up with large companies in adopting RFID technology in order to realize potentials of cost savings (Informationsforum RFID 2006). While competitiveness is one of the major arguments regarding RFID as a potential future infrastructure technology[2], some of the cases included in the study indicate that RFID-deploying SMEs, especially the ones that are facing RFID mandates by retail companies, only fulfil their customers' minimum requirements by shipping RFID-equipped pallets without exploiting the possible increases in logistic visibility in order to optimize their own in-house processes ("slap & ship"). It can be argued that fulfilling customers' requirements is a *necessary* part of sustaining competitiveness (especially if the customer is relatively large), while it is surely not *sufficient* given the multiple opportunities for optimizing in-house processes. Straube et al. 2007 emphasize the danger of "betting on the wrong horse" especially for SMEs, given RFID as a future infrastructure technology that is connected with high costs while major aspects of standardisation still have to be conducted.

The amount of *empirical* work with respect to RFID and SMEs is manageable. Smith et al. 2004 found a high perceived business value of RFID compared to other eBusiness instruments such as electronic proof of delivery and electronic reports among Australian SMEs. Nevertheless, the small size of their interview sample has to be taken into consideration, making any assertion about the general importance of RFID for SMEs highly insignificant. Besides, the inclusion of solely SMEs does not allow for any conclusions regarding systematic differences between SMEs and large enterprises. In contrast, the empirical study "eBusiness Barometer 2006/2007" included SMEs as well as large enterprises. The authors identify a higher percentage of large enterprises using and projecting RFID. They conclude that large enterprises either use RFID mainly for internal closed loop applications (which have no impact on partner SMEs) or have not yet communicated their RFID plans to their partner SMEs in an appropriate way (Fricke et al. 2006).

2.3 Unclear Implications of SME-specific Factors of RFID Adoption

In summary, it can be stated that the first studies and analyses dealing with business opportunities and risks of RFID technology for SMEs suggest that firm size is an important factor. However, the wide variety of (partially contradictory) results makes it difficult to derive valid and significant conclusions regarding whether and how RFID technology can contribute to SMEs' business success. Furthermore, the empirical results of previous studies provide first insights, while they are lacking either the *direct comparison* of SMEs and large enterprises or the inclusion of companies with *actual experiences* regarding RFID or the elimination of the possibility of random results by the deployment of *significance tests*. This shortage will be overcome in the following sections by delivering empirical results on the *systematic* (that is, statistically significant) *differences* regarding the application of RFID by *comparing* SMEs and large enterprises with *actual RFID experiences*.

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[2] See (Carr 2004) for a discussion of the impact of IT turning into a commodity on shifting opportunities from competitive advantages towards the retention of competitiveness.

3 RFID USE IN GERMANY: A CROSS-SECTORAL STUDY

3.1 Research Design

The focus of the study was on systematic differences between SMEs and large enterprises regarding the application of RFID. The questionnaire was evaluated and improved based on several external pre-tests with CEOs of German SMEs (see Table 1 for basic parameters of the study).

Research Approach	Explorative Study Quantitative Survey
Method of Collecting Data	Online Questionnaire
Period	April 1st - June 15th 2007
Sample Type	Combination of random and selected
Target Group	CEOs, CIOs, Heads of Logistics
Sample Number	N = 153

Table 1: Basic Parameters of the Study

The selection of participants was carried out in three steps. Firstly, enterprises with realised or planned RFID applications were contacted specifically via e-mail. Additionally, calls for participation were placed in numerous German industrial-related printed and online publications (e.g., impulse newsletter, RFID im Blick etc.) as well as printed publications such as "VDI nachrichten". Furthermore, based on a representative selection of companies from the German "Hoppenstedt"-databases for SMEs and large enterprises, calls for participation were sent via e-mail.

3.2 Characterisation of Data Sample

The online questionnaire containing 201 individual questions was completed by a total of 153 CEOs, CIOs and Heads of Logistics. Consistent with the SME definition by the European Union, 53.5% of all respondents represented companies with less than 250 employees and less than € 50 mio. worth of annual sales were therefore categorised as SMEs. In contrast, the other 46.5% of the respondents lacked one or both of the two aforementioned criteria and were therefore categorised as large enterprises. Even though contributing the minority of data sets, large enterprises are highly overrepresented in the sample. However, a representation of firm size according to German population would imply in the best case one large enterprise for our analysis (given the number of 81 SMEs). The overrepresentation is therefore justified in order to enable comparison between the two groups. With the industrial sector, logistics and other services as well as retail being derived as the main application sectors for RFID technology from the review of current literature and case studies,[3] these findings are well reflected by the respondents' sectoral distribution. The majority of firms belong to the industrial (42%) and logistics/services sector (34%), while 9% of all companies represent retailers and their suppliers. Only about 15% could not be assigned to one of the three aforementioned sectors (n = 151).

3.3 SMEs and Large Enterprises: Differences concerning IT Usage and Networking

With the current usage of IS and networking technologies being an important precondition for the introduction of RFID technology, it has to be shown that the SMEs of the sample feature similar characteristics to SMEs in general with regard to these issues. In order to facilitate a meaningful evaluation of RFID applications, it has to be ensured that the SMEs of the data sample do not feature a higher usage of information systems and networking technologies than those in general, therefore distorting the results by being exceptionally "IT-affine" with significantly better basic requirements for RFID adoption than the majority of SMEs. For this reason, the differences between SMEs and large compa-

[3] For literature on RFID pilot projects and case studies in different sectors, see for example (Laubacher et al 2006, Hardgrave et al. 2005, Dighero et al. 2005, Holmqvist and Stefansson 2006).

nies regarding IS and networking usage are analysed with regard to the following characteristics by applying non-parametric tests: [4]

- Use of tactical and operative IS *(Indicators: Use of Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), Supply Chain Management (SCM) and Data Warehouse Systems)*
- Use of strategic IS *(Indicators: Use of Business Intelligence (BI) and Knowledge Management Systems)*
- In-house networking *(Indicator: Use of Enterprise Application Integration (EAI))*
- Cross-company networking *(Indicator: Use of Electronic Data Interchange (EDI))*

Characteristic	Indicator	SME	LE	Trend	Significance (χ^2 (C))
Use of tactical and operative IS	*Use of CRM Systems*	**38%**	**56%**	**-**	C = 1.34 *(p = 0.25)*
	Use of ERP Systems	**52%**	**78%**	**-**	C = 4.04 ***(p = 0.04*)***
	Use of SCM Systems	**8%**	**53%**	**-**	C = 12.59 ***(p = 0.00*)***
	Use of Data Warehouse Systems	**25%**	**63%**	**-**	C = 7.05 ***(p = 0.01*)***
Use of strategic IS	***Use of BI Systems***	**6%**	**30%**	**-**	C = 4.74 ***(p = 0.03*)***
	Use of Knowledge Management Systems	**14%**	**29%**	**-**	C = 1.45 *(p = 0.23)*
In-house networking	***Use of EAI***	**6%**	**28%**	**-**	C = 3.75 ***(p = 0.05*)***
Cross-company networking	***Use of EDI***	**31%**	**67%**	**-**	C = 6.83 ***(p = 0.01*)***

Legend: + Higher usage among SMEs - Lower usage among SMEs (*) Trend is significant ($\alpha = 0.10$)

Table 2: Differences regarding use of IS and networking; basis 142 (66 large enterprises, 76 SMEs)

As can be seen from Table 2, SMEs exhibit lower quantities regarding the usage of all indicators. With the exception of CRM and Knowledge Management Systems, the differences observed are significant with a probability value of below 0.10. Thus, it can be stated that the SMEs included in this study show substantially "worse" basic requirements for an adoption of RFID technology in terms of IS and networking usage than large enterprises. This holds true especially regarding the requirements for *cross-company cooperation* (indicators: SCM Systems and EDI technology), but also for the in-house use of RFID (indicators: ERP, Data Warehouse, BI Systems and EAI). As a result of this analysis, the possibility of a distorted sample due to an "IT-affine" set of SMEs can be eliminated.

4 RFID USE IN GERMANY: SYSTEMATIC DIFFERENCES IN THE APPLICATION OF RFID BASED ON FIRM SIZE

In the next iteration, the question is addressed of whether and to what extent these observed differences between SMEs and large enterprises regarding IS and networking usage translate into systematic differences concerning the application of RFID. In order to operationalise this question, it is divided into sub-categories, including (1) diffusion of applications, (2) application fields (3) realisation of performance improvements, (4) assessment of barriers and (5) success of adoption.

With regard to the diffusion of *realised applications*, it is analysed whether the amount of RFID-experienced enterprises differs substantially between SMEs and large enterprises. Furthermore, a more differentiated perspective on characteristic *application fields* will be introduced without giving up the initial cross-sectoral view. To serve this purpose, a distinction between *open* and *closed loop* as well as *in-house* and *cross-company applications* is made. As an indicator for *performance improvements*, the increase in efficiency and effectiveness of business processes will be examined by analysing the realisation of generic performance objectives that are applicable regardless of specific applications. Finally, systematic differences regarding *barriers* and *the success of RFID adoption* will be revealed. All analyses will be conducted by applying non-parametric tests for two independent samples (see footnote 4). The higher-level hypothesis of all forthcoming significance tests can be formulated as follows: SMEs and large enterprises exhibit systematic differences regarding the application of RFID.

[4] In the case of nominal scales, the χ^2-test (chi-square) of homogeneity of one characteristic in two samples will be applied. In the case of ordinal data, the Mann-Whitney-U test is applied.

4.1 Diffusion of RFID Applications

The current frequency of RFID usage exhibits a slight prevalence of realised and planned RFID applications among large enterprises (see Figure 1). Consequently, the group of SMEs shows a higher share of companies with no RFID application.

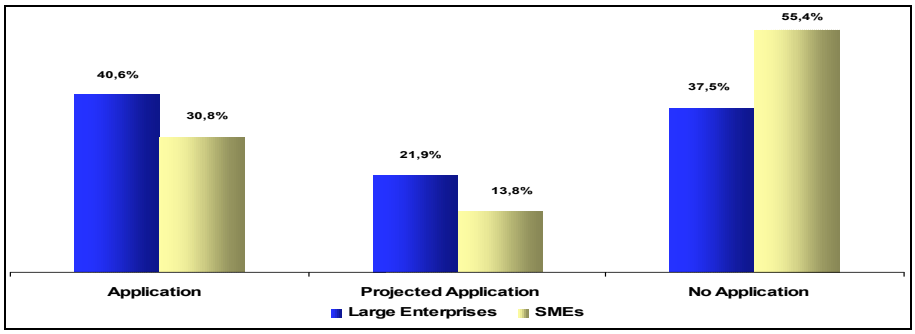

Figure 1: Current RFID usage in the entire data set and among SMEs (Basis 136 (Data Set) / 65 (SMEs))

However, applying the χ^2 test of homogeneity of one characteristic in two samples reveals that these differences are negligible, provided a maximum probability value of 0.1.[5] As a result, despite the observable trend of large enterprises in our data set using RFID more frequently than SMEs, the null hypothesis has to be accepted.

4.2 Application Fields of RFID

As a result of the evaluation of numerous case studies from different sectors[6], it can be argued from an economic perspective that most of the current RFID solutions show considerable similarities regarding underlying technology (protocols, frequencies, tag standards etc.) and supported business processes (tracking & tracing, production scheduling etc.). However, even though enterprises from different sectors face similar challenges when it comes to RFID, a fundamental difference regarding costs and benefits of the solution (and therefore, business opportunities and risks) is linked to the question of whether one or several enterprises participate in RFID-supported processes (in-house vs. cross-company use). With respect to *in-house applications*, higher degrees of freedom regarding the choice of the most suited standard can be expected as well as lower complexity of distribution of RFID data among partners and less complex allocation of costs and benefits. On the other hand, *cross-company applications* promise further benefits (e.g. reduction of out-of-stocks etc.) and raise the expandability of the system (by lowering the possibility of "betting on the wrong horse"). Another strong impact on costs and benefits of a solution can be expected from the decision between non-returnable and reusable transponders (e.g. non-returnable bottle vs. reusable transport items). While *closed loop applications* are characterised by the repeated use of circulating tags which can therefore be interpreted as a part of the initial investment, *open loop applications* require a constant new acquisition of transponders, therefore increasing unit costs.

Our empirical findings in Table 3 show the current trend towards *internal* and *closed-loop* solutions among large enterprises.[7] Furthermore, Table 4 reveals that *only slight differences* can be observed with respect to the subset of SMEs. Applying the χ^2 test supports the presumption that the observed differences are not systematic (see Table 5).

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5 This non-significance holds true for the differences regarding "application" ($p = 0.45$) as well as "projected application" ($p = 0.34$) and "no application" ($p = 0.14$).

6 For a selection of case studies, see footnote 3.

7 Note: The RFID users of the survey could classify themselves under the criteria open loop, closed loop, in-house and cross- company. Several examples were given. Percentages do not add up to 100% due to incomplete answers.

	Closed Loop	*Open Loop*
In-House	*27.5%*	*7.5%*
Cross-Company	*12.5%*	*7.5%*

Table 3: RFID application areas among large enterprises (Basis 40 - RFID users only)

	Closed Loop	*Open Loop*
In-House	*34.5%*	*10.3%*
Cross-Company	*13.8%*	*6.9%*

Table 4: RFID application areas among SMEs (Basis 29 - RFID users only)

This is a remarkable result, considering the significantly lower endowment of SMEs with information systems and networking technologies for an application of RFID (see 3.3). If SMEs and large enterprises exhibit no differences regarding application fields, it seems necessary to extend the analysis. Consequently, we will next observe factors effecting the realisation of performance improvements that might compensate the IT shortcomings on the SME side.

Application Area	**Trend**	**Significance** (χ^2 (C))
In-House, Closed Loop	+	C = 1.526 *(p = 0.22)*
In-House, Open Loop	+	C = 0.413 *(p = 0.52)*
Cross-Company, Closed Loop	+	C = 0.706 *(p = 0.40)*
Cross-Company, Open Loop	-	C = 0.049 *(p = 0.83)*

Legend: + SMEs exhibit higher proportion - SMEs exhibit lower proportion (*) Trend is significant ($\alpha = 0.10$)

Table 5: Significance of differences regarding application fields of SMEs and large enterprises (Basis: 73 RFID users (29 SMEs & 44 large enterprises))

4.3 Realisation of Performance Improvements

In order to evaluate realised performance improvements it is firstly necessary to determine how RFID can affect monetary and non-monetary performance characteristics of business processes. Mooney et al. (1996) proposes three bottom-up and non-exclusive effects. Following Tellkamp (2006), these can be categorised for our purposes as *automation* of formerly manual acquisition of information, increased *information quality* and *new or re-engineered business processes*:

1.) Automated acquisition of information (cheaper information): Former manual activities of data acquisition and transmission can be automated via the deployment of RFID technology. For example, RFID readers at a company's goods receipt area can eliminate the need for employees to capture data of incoming pallets manually by applying mobile barcode scanners. Potential economic benefits are gained in terms of decreasing labour costs. The extent of savings is dependent on the data capturing activity's frequency of usage (Laubacher et al. 2006).

2.) Increased information quality (better information): The deployment of RFID enables the collection of additional and higher-quality data in terms of more *accurate, objective, timely* and *complete* information about tagged objects (Tellkamp 2006) and therefore facilitates an improvement of *operative coordination decisions*. For example, picking processes can be improved by automated real-time comparison of to-be-picked and actually picked positions, enabling better decisions, such as the initiation of a rework in the case of detected picking errors. The resulting performance improvement is quantifiable in non-monetary process-based performance indicators such as *delivery accuracy* or *out-of-stock ratio* (Hardgrave 2005), enabling monetary benefits in terms of decreasing internal and external failure costs as well as sales increases due to increased customer satisfaction.

3.) Re-engineered and new business processes: The improved information situation enables a re-engineering of *existing business processes* which in turn realise further performance improvements. In many cases, process adjustments in terms of modified workflows and job specifications will be indispensable in order to avoid a degradation compared to the status quo (process adjustments as complementary investments of technology deployment (Tellkamp 2006)). For example, conventional picking processes in retail distribution centres can be partially replaced by the provision and reallocation of pre-picked, store-level pallets at the loading bay (*cross-docking* (Fricke et al. 2006)). As a result, non-monetary performance improvements can be realised (e.g. inventory reductions) which become manifest in monetary benefits, such as the release of fixed capital as well as permanent savings of cost of

capital. First studies suggest that in many cases the full benefits and thus the generation of a positive net present value (NPV) of RFID investments will be achieved not solely on the basis of automation. In fact, many cases will require additional process re-engineering (Dighero et al. 2005). As a final consequence, increased information quality due to RFID enables the provision of *new services and products* (e.g., tracking and tracing services for customers).

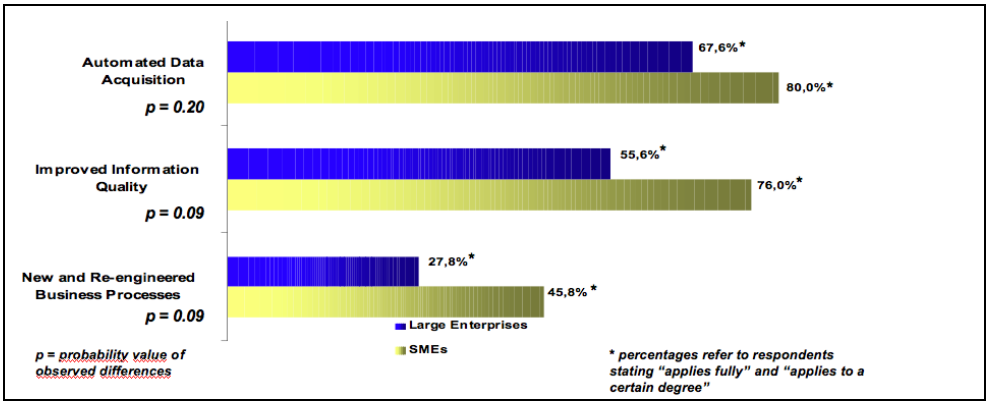

Figure 2: Performance improvements of large enterprises and SMEs with realised or projected RFID applications (Basis: 39 large firms and 27 SMEs)

Figure 2 exhibits that the number of SMEs in our data set that has already realised performance improvements or clearly identified performance objectives is larger than the corresponding number of large enterprises. This holds true for all three aforementioned categories. Furthermore, applying Mann-Whitney U Test confirms a (weak) systematic connection for benefits resulting from improved information quality and new and re-engineered business processes ($\alpha = 0.10$). Thus, it can be stated that SMEs deploy RFID technology more frequently for purposes that exceed pure automation of data acquisition. While the benefits of improved information quality and re-engineered business processes are harder to obtain (Laubacher et al. 2006), observations of the introduction of the EAN code in the 1970s suggest that these areas promise the most substantial economic gains (Garg et al. 1999).

4.4 Assessment of Barriers

Barriers of an RFID application to be evaluated were derived based on an extensive literature review[8] and results of numerous interviews with representatives of firms, both RFID users and companies currently considering RFID investments. Four major areas of obstacles could be derived:

Integration: In order to reap the full benefits of the technology, RFID has to be *integrated* into the company's existing *IT infrastructure*, *in-house business processes* and, in the case of an intercorporate use, into the corresponding *cross-company processes* as well. These activities can prove too costly for companies, especially when there is a shortage of adequately *skilled employees*. Additionally, the *lack of commonly accepted standards* can inhibit firms from using RFID as well as *strong opposition among suppliers and customers* (both of them mainly in the case of cross-company applications).

Costs / Benefits: In current assessments of RFID technology, the fact that benefits of an RFID solution should exceed costs is frequently neglected, concentrating solely on the cost side of an RFID project. If this is the case and the fact is ignored that *costs* of a specific RFID solution *exceed benefits*, RFID projects will probably fail or be aborted. More specifically, especially the SMEs involved in our project perceived the *costs of testing* the technology at their sites as too high. Moreover, while there are approaches for the approximate measurement of the *costs* of an IT solution in place (e.g., Total Cost of Ownership (TCO)), a lack of methods for *forecast/measurement of RFID-related benefits* is seen, making an application of cost/benefit approaches such as *net present value method* problematic.

[8] For a presentation of the main barriers of RFID adoption, see for example (Federal Office for Information Security 2004).

Functionality: Regarding technical functionality of RFID systems, *insufficient quality* in terms of low read rates or inadequate tag features is an important potential barrier. Furthermore, the *management of large data amounts* can impose too high a burden for existing information systems (Wang and Liu 2005).

Security / Privacy: Regarding security, *unresolved questions* like the prevention of unauthorised executions of tag commands (e.g., read, write or kill) or the abuse of sensitive information in the case of a cross-company exchange of RFID data have to be addressed. Besides, *unresolved legal aspects* have to be addressed (e.g. liability in case of unauthorised tag reading). One of the most fundamental hurdles for RFID adoption are *privacy concerns* which may occur on the side of *customers* or *employees* (Sackmann et al. 2006). The consequences of underestimating this potential problem are well documented for the case of METRO Group (cp. Sackmann et al. 2006).

Taking into account the experiences of 42 RFID users, Table 6 (column "overall priority") shows the most important barriers to the realisation of RFID solutions which belong to the categories of "Integration" and "Costs / Benefits". Comparing the average importance of each barrier for SMEs and large firms and testing the significance of these differences reveals specific problems of RFID adoption dependent on firm size. First, it becomes obvious that six barriers are considered more severe by SMEs and nine barriers by large enterprises. Second, out of the nine barriers considered less important by SMEs, six pass the Mann-Whitney U Test of significance ($\alpha = 0.10$). Third, none of the six barriers rated more important by SMEs exhibit considerable differences towards large enterprises' assessment, thus being highly insignificant. As a result, in six cases the hypothesis can be accepted: There are differences regarding specific barriers to RFID adoption between SMEs and large firms. More specifically, SMEs have significantly less problems with the integration of RFID into in-house processes, costs of testing, forecasting and measurement of benefits, negative cost-benefit ratios, quality and functionality of RFID systems and unresolved security issues. In a certain way, this corresponds to the findings of chapter 4.3 which revealed a more sophisticated application of RFID among SMEs.

Category	Barrier	Overall Priority (Rank)	Mean SMEs	Mean Large Enterpr.	Trend	Significance (Mann-Whitney-U)
Integration	Integration into existing IT Infrastructure	2	2.94	3.61	-	U = 152.5 *(p = 0.13)*
	Integration into In-House Business Processes	**6**	**2.78**	**3.54**	-	U = 145 ***(p = 0.06*)***
	Integration into Cross-Company Processes	1	3.28	3.75	-	U = 167 *(p = 0.20)*
	Lacking Standard	8	3.19	3.04	+	U = 172.5 *(p = 0.58)*
	Employee Skills	13	2.82	2.79	+	U = 203 *(p = 0.98)*
	Opposition among Suppliers and Customers	9	3.06	2.79	+	U = 180 *(p = 0.51)*
Costs / Benefits	**Costs of Testing**	**5**	**3.06**	**3.61**	-	U = 144.5 ***(p = 0.08*)***
	Forecasting and Measurement of Benefits	**4**	**3.00**	**3.58**	-	U = 151 ***(p = 0.08*)***
	Costs exceed Benefits	**3**	**2.83**	**3.58**	-	U = 144.5 ***(p = 0.06*)***
Functionality	Management of Large Data Amounts	15	2.59	2.67	-	U = 177.5 *(p = 0.46)*
	Quality and Functionality of RFID Systems	**10**	**2.39**	**3.30**	-	U = 116 ***(p = 0.01*)***
Security / Privacy	**Unresolved Security Issues**	**14**	**2.53**	**3.29**	-	U = 129 ***(p = 0.04*)***
	Unresolved Legal Issues	12	2.82	2.75	+	U = 200 *(p = 0.91)*
	Privacy Concerns among Customers	7	3.12	2.88	+	U = 190 *(p = 0.55)*
	Privacy Concerns among Employees	11	3.13	2.88	+	U = 176 *(p = 0.50)*

Legend: Means are based on a 5-stage scale (1="no importance" to 5="high importance")
+ SMEs attach higher importance - Large Enterprises attach higher importance ***(*)*** *Trend is significant ($\alpha = 0.10$)*

Table 6: Differing Assessment of RFID-related barriers among SMEs and large enterprises (Basis: 42 RFID Users (24 Large Enterprises, 28 SMEs))

4.5 Success of RFID Applications

Analysed as an indicator for the success of RFID usage, the number of firms that lower or terminate their RFID engagement exhibit no significant differences as regards their size. Three large enterprises are going to limit their RFID applications, while one SME shows limitations and another one a com-

plete termination (basis 73).[9] Furthermore, the average duration of RFID applications shows no significant deviation.[10] Thus, an overall success can be maintained as there are no signs for major deviations between SMEs and large enterprises.

5 STRUCTURAL INERTIA AS DERTERIMING FACTOR OF THE SME WAY

5.1 Introducing RFID and Firm Size: the Smaller the Better

Our analysis has shown that SMEs using RFID have significantly less extensive IT-equipment than large RFID users. However, the application fields defined by the characteristics of in-house, cross-company, open, and closed loop are widely the same. Both groups' RFID-experiences – measured in years – also exhibit no significant deviation. Likewise, SMEs and large enterprises agree with each other on unlimitedly carrying on their use of RFID technology: Almost no enterprise currently plans to stop RFID activities within the next years. The remarkable thing about these findings is that both groups, at the same time, differ so clearly in their performance objectives. SMEs seek significantly more frequently to optimize the coordination of processes or generate new processes and applications than large enterprises and they make explicit use of the more extensive and more correct information based on new RFID data. The assessment of problems linked with an RFID adoption is a further crucial difference between both groups: SMEs significantly rate crucial barriers lower than large enterprises. In summary, one can conclude that, ceteris paribus, a smaller enterprise size eases RFID adoption and exhaustion of the productivity potential.

5.2 Structural Inertia: Coordination and Cooperation Problems due to RFID

Firm size obviously matters for RFID adoption. However, this empirical result is solely a first step. A further step – explanation of the findings – is necessary in order to derive implications for SMEs. Introducing a new technology always requires organisational changes. The bigger the enterprise is, the more the likelihood is that different firm units and therefore more persons are involved (Quinn 1985). There is an extensive body of economic work dealing with the resulting so-called *organisational inertia* (Colombo and Delmastro 2002). This phenomenon hinders firms from adapting their market strategies and organisational boundaries (Hannan and Freeman 1977). Empirical studies show that SMEs differ from large firms in their structural inertia (Sintas and Alvarez 1999): They regularly try organisational change more often (Aldrich et al. 1986) and also show a higher frequency of attempts to adapt to competitive changes than large firms. With regard to RFID adoption, structural inertia approach could therefore explain the SME-way described before: coordination and cooperation problems of an RFID adoption increases with firm size. Next, we employ the structural inertia approach to our empirical findings.

Coordination Problem

RFID applications regularly encompass and affect numerous processes (see footnote 2). Giving a forecast of the potential benefits and costs of an RFID adoption firstly requires their identification. However, since information-gathering costs increase with firm size and complexity of organisation, SMEs receive a clear advantage: At the same costs, SMEs are able to base their decisions in the scope of an RFID-deployment on more and better information than large enterprises. Consequently, SMEs should have fewer difficulties in forecasting and measuring benefits and costs. Our empirical findings perfectly match this theoretic result (see chapter 4). The actual lower information uncertainty of SMEs can also explain why they more frequently conduct ambitious RFID applications: Improvement of op-

[9] Applying Mann-Whitney U Test, this difference turns out to be insignificant ($p = 0.41$).

[10] SMEs exhibit a median of 2 years and large enterprises of 1,5 years, being an insignificant difference with $p = 0.79$.

erative coordination decisions, re-engineering of existing business processes or the provision of new services and products require considerably more coordination effort than automation of formerly manual acquisition of information. In this way, the large enterprises of our sample correspond to a well-documented phenomenon: introducing new information technology regularly leads to an incomplete exhaustion of productivity potential (Martins and Kambil 1999, Pijpers and van Montfort 2006).

Cooperation Problem

An alternative explanation for structural inertia focuses on the organisational changes themselves being necessary in order to introduce a new technology. If a firm is going to change processes and organisational structure, resulting in corresponding distributional implications, individual employees will try to influence the nature of the change so as to protect or augment their own quasirents (Milgrom and Roberts 1990). As such influence activities absorb employees' time and attention, which could otherwise be used in direct productive activities, they engender substantial costs (Sintas and Alvarez 1999). In order to avoid them, a firm may refrain from implementing organisational changes that would improve productivity. According to this approach, RFID adoption can lead to a particular shift in distribution of quasirents among firms' employees: The larger the enterprise, the more persons profiting from an RFID deployment and persons bearing the costs will diverge. In particular, the cooperation problem will occur if firms try to implement RFID applications going beyond simple automatisation. For instance, production and sales departments will profit by improving inventory management through RFID: Decisions about order taking can be based on sounder capacity planning. In consequence, the amount of liquidated damages as well as refused orders due to incorrect inventory data will decrease. Nevertheless, the production manager has to *share the benefit* of RFID introduction but *bear the efforts and costs alone*. Finally, in the case of profit and cost centres, the inventory manager has little incentive to initiate RFID introduction. Similarly, the *organisational conservatism* approach explains the tendency in employees' behaviour to prevent organisational changes (Child et al. 1987). However, according to this approach, employees' risk aversion instead of distributing quasirents is seen as the reason for less radical solutions suggesting more productivity gains.

6 IMPLICATIONS

The findings show that the RFID technology favours SMEs: A smaller enterprise size makes, ceteris paribus, RFID adoption and exhaustion of the productivity potential easier. The result is in accordance with structural inertia approach, suggesting that firm size is positively correlated with coordination and cooperation problems due to technology adoption.

Our insights lead to the following first implication for SMEs contemplating an introduction of RFID. Primarily, there is no evidence at all that a restriction to easy-to-conduct RFID automatisation applications is the rational strategy for SME. In contrast, since more ambitious objectives, such as improvement of operative coordination decisions, lead to more cooperation and coordination problems, they cause more costs and are therefore more difficult for competitors to copy. In consequence, SMEs in retail, automotive and pharmaceutical industry should check thoroughly whether the fulfilment of an RFID mandate without changing any internal processes – so-called "slap & ship" solutions - is appropriate: they might run the risk of missing an opportunity to gain a competitive advantage. Some time ago, a manager of Wal-Mart's RFID strategy claimed that smaller suppliers are more nimble and therefore can make the most of RFID (Knight 2005). Regardless of the clear interests of this manager, it looks as if the stated view proves to be valid. Further research has to show whether the SME way of RFID adoption will be successful and can serve as a model.

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