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# Factors Inhibiting the Adoption of RFID Technology: Results and Implications from an Empirical Study of SMEs in Spain

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## ABSTRACT

This study investigates factors inhibiting the adoption of Radio Frequency Identification (RFID) by SMEs in the retail, transport and logistical (RTL) sector. A predictive model for the adoption of RFID is also proposed for SMEs in Spain. Data from the e-Business Watch was used with a sample of 252 Spanish SMEs. Five of the seven hypotheses were significantly supported: Perceived benefits, Suppliers' non-compatibility, Perceived Security risks, Process/Performance Improvements (internal processes innovation activity), and firm size. It is anticipated that the findings will provide useful guidelines for promoting the adoption of new identification technologies by SMEs.

## Keywords

RFID, identification technologies, adoption, inhibiting factors, SMEs

## INTRODUCTION

The European Commission (EC) frequently advocates the importance of Micro Small and Medium-sized Enterprises (SMEs) to the social and economic fabric of the European Union. SMEs represent 99% of all enterprises in the EU, provide approximately 65 million jobs and contribute to entrepreneurship and innovation (European Commission, 2010). Interestingly, 9 out of 10 SMEs are actually micro enterprises with less than 10 employees hence, the mainstays of Europe's economy are micro firms each providing, on average, work for two persons. The use of Information and Communications Technologies (ICT) in SMEs has the propensity to increase market reach, enhance customer service, and reduce marketing and distribution cost. However, there is a tendency for SMES to adopt new ICTs at a slower rate than their larger counterparts (OECD 2004).

An emerging technology with promise for transforming SMEs in the supply chain is Radio Frequency Identification (RFID). RFID is a wireless technology with capabilities to identify, track, and trace a person or an object. Benefits of RFID in supply chain include: improved stock management, reduction in labor costs and enhanced visibility along the value chain. The EC has invested heavily in RFID projects to promote commercial RFID deployments as they fear that "Europe may be falling behind in a pivotal technology" (Edwards, 2007). However, investment in RFID is only one factor to drive adoption. The IS community has called for a development of a research agenda on RFID adoption in supply chain due to the paucity of empirical research (Matta and Moberg, 2007). In particular, to advance the drive towards adoption of RFID, it is imperative to investigate potential antecedents. SMEs specific requirements are different than larger businesses as they have limited resources for managing IT adoption, hence studies on SMEs warrants its own investigation.

The objective of this study is to investigate factors inhibiting the adoption of RFID Technology in SMES (using Spain as the selected country) and to propose a predictive model. Secondary data was obtained from the 'Sectoral e-Business Survey 2007'. The global survey is part of the "e-Business Watch, provided by empirical GmbH to the European Commission (EC), Enterprise and Industry Directorate General, in co-operation with international partners (European Commission and the

Sectoral e-Business Watch, 2007). The key objective of the e-Business Watch is to gather information on the usage of ICT and their application to the electronic business in companies.

We anticipate that the findings of this paper will provide practitioners, academics, and government/policy makers with empirical insights on salient factors that may affect adoption in SMEs and provide a model/framework that can be applied to future studies. The remainder of the paper will flow as follows: literature review and hypotheses development, methodology, results, discussion and then the conclusion, implications and future research.

## LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The process by which a firm adopts and implements technological innovations is influenced by the technological context (internal and external technologies), the organizational context (characteristics and resources of the organization) and the environmental context (the arena in which the firm conducts its business) (Tornatzky and Fleischer, 1990). These three contexts play a role in SMEs and contribute to the “evaluative structure to determine the propensity of innovation adoption specific to the firm” (Allan et al, 2003). Seven variables were selected to investigate factors inhibiting RFID diffusion in SME’s in Spain: perceived benefits, perceived acquisition cost, perceived security risk, firm size, technical knowledge of employees, process improvements and compatibility with suppliers. These variables were selected based on the stage model of diffusion and traditional IS literature.

### Technological Factors

With reference to previous research (Rashid & Al-Qirim, 2001; Lippert & Govindarajulu, 2003), we recognize the following variables under technological factors: *Perceived Benefits and Perceived Acquisition Cost*, and *Perceived security risk*.

#### *Perceived Benefits*

We define perceived benefits as the firm’s evaluation of the potential gains associated with ICT adoption. E-Business Watch Report (2008) highlighted that firms mainly use ICT and RFID for three main purposes: (i) Cost Reduction (ii) To serve customers in a more efficient and effective manner and (iii) to support business growth (e.g. growth in market share and reach). The literature has purported many benefits of RFID that encapsulate the aforementioned. In particular, Curtin et al (2006) noted that RFID provides the opportunity to redesign traditional warehouse packaging and shipping activities for a business-business vendor managed inventory system cost effectively to combat global competition. Perceived benefits have been found as a significant adoption factor for RFID (Bhattacharya et al, 2007; Madlberger, 2009). Conversely, Schmitt & Michahelles (2009) found no significant relationship between perceived benefits and adoption of RFID, and argued that this may be the case especially for organizations that are mandated to adopt.

We seek to determine whether a lowered perception of ICT benefits is likely to negative influence adoption of RFID by SMEs. Therefore:

*H<sub>1</sub>: The lower the perceived benefits of ICT, the less likely RFID will be adopted by SMEs*

#### *Perceived Acquisition Cost*

SMEs often have difficulty in obtaining financial resources to invest in technologies. In a study on ICT adoption by Wymer & Regan (2005), they highlighted that cost was the single consistent factor found across all organizational types (Wymer & Regan, 2005). Similarly, Harindranath et al (2008) reported cost as the greatest inhibitor to future ICT investments. RFID is a costly ICT investment, although the cost of tags and readers are decreasing, other associated costs such as software development, integration and implementation, and supporting infrastructure are very high (Liu et al, 2009). The literature has indicated that one of the most cited issues among retailers is the justification of additional costs and the anticipated ROI frame (Reyes, 2007). Based on the cautious nature of SMEs in approaching ICT investments in general, we would expect that the greater acquisition cost, the less likely SMEs will be willing to invest in the implementation of RFID. Hence, we posit:

*H<sub>2</sub>: The greater the perceived acquisition costs of ICT, the less likely RFID will be adopted by SMEs*

#### *Perceived Security Risk*

The perceived security risk associated with ICT is a major issue to managers/owners of SMEs (Allan et al, 2003), and continues to be a barrier to adoption (Tan and Eze, 2008). Furthermore, RFID security concerns have been acknowledged as a factor that may affect widespread adoption of technology (OECD, 2008), with concerns such as susceptibility of data to unauthorized parties. We anticipate that the greater the concern with regards to ICT security, the less likely SMEs will be willing to adopt RFID. Therefore:

*H<sub>3</sub>: The greater the perceived potential security risks of ICT, the less likely RFID will be adopted by SMEs.*

### **Organizational Factors**

Under organizational factors, we examine *firm size, internal technological knowledge and process/performance improvement*.

#### *Firm Size*

Organizational size is labeled one of the best predictors of organizational adoption of IS innovations (Jeyaraj et al., 2006), with larger firms having a greater propensity to adopt ICT. Schmitt and Michahelles (2009) listed organizational size as one of the most mentioned factors affecting the adoption and diffusion of RFID. Lin (2009) found a significant positive association between company size and RFID adoption, and noted that larger companies tend to be more willing to adopt RFID as they have greater resources. In contrast Goode & Stevens (2000) reported that business size, previously the best indicator of technology adoption, was not significantly related to IS innovation adoption. In a RFID specific study, Madlberger (2009) found that size did not have a significant impact on adoption. Hence, we seek to investigate the influence of size, and posit:

*H<sub>4</sub>: The size of the firm influences the non-adoption of RFID by SMEs*

#### *Internal Technological Knowledge/Skills*

With reference to Lippert and Govindarajulu (2003), technological knowledge can be identified under organizational context, as it “represents the totality of institutional technological knowledge resident within an organization”. A lack of IT skills has been reported as a barrier to ICT adoption by SMEs (Taylor and Murphy, 2004; Upfold and Liu, 2010). Irrespective of size, retailers believe that a lack of expert skills could result in high cost and time investment on RFID project and could possibly lead to its failure (Upfold and Liu, 2010). Similarly, Lin (2009) found that the quality of human capital and organizational knowledge accumulation positively influences the firm’s willingness to adopt RFID.

We anticipate that that the lower the skills level of ICT practitioners available in the firm, the more likely it will negatively influence the adoption of RFID by SMEs. Hence:

*H<sub>5</sub>: The greater the absence of ICT practitioners in the firm, the less likely RFID will be adopted by SMEs.*

#### *Process/Performance Improvements (Internal Process Innovation Activity)*

In many instances, the introduction of RFID in an organization can be regarded as an ICT-enabled process innovation (Lui et al, 2009). The authors further emphasized that “understanding one’s business processes, and having a clear vision how they could be improved’ are critical elements in RFID adoption. RFID has the potential to enhance processes in terms of improved workflow and quality and better tracking (Vujayaraman et al, 2008). The literature on process performance improvement of RFID adoption by SMEs is generally mute except for one known study by Strucker & Gille (2008). They found that SME’s deployed RFID for purposes beyond automation and data acquisition although improvements based on re-engineered business processes were harder to obtain. Therefore:

*H<sub>6</sub>: The lower the ability of ICT to improve internal processes of a firm, the less likely RFID will be adopted by SME’s.*

### **Environmental Factors**

#### *Perceived Compatibility with Suppliers*

Although the critical role of suppliers in the adoption process seems evident, there is a dearth of research in adoption literature (Deeter-Schmelz et al, 2001). Roy & Sivakumar (2007) found that compatibility and integration of IT between a company and its long term suppliers is paramount for IT adoption. For SMEs, changes in business process should consider the compatibility with current technologies, so that it does not ‘find itself at odds’ (Chong, 2004). One of the benefits of RFID in the supply chain is the likelihood of increased data/information sharing between members in the value chain. Lack of standardization is a major problem affecting large scale RFID adoption, with issues ranging from different data formats used, to interoperability between RFID readers and tags from different vendors, to interference problems (Gupta, 2003). This raises some reluctance to invest in RFID with fears of constant changes and reinvestment. Notably, manufacturers and their

suppliers' decision to adopt technologies tend to be influenced by network effects (Schmitt et al, 2008). As a result, we argue that the relationship is such that the lower the ICT compatibility with suppliers, the less more likely RFID will be adopted by SMEs. Therefore:

*H<sub>7</sub>: The lower the perceived compatibility of e-technologies with the suppliers, the more likely RFID will not be adopted by SMEs.*

## METHODOLOGY

### Research Design

We used a secondary data source, the 'Sectoral e-Business Survey 2007. The e-Business Survey 2007 had a scope of 5,325 telephone interviews with decision-makers from five industry sectors (3 in manufacturing and 2 retail sectors) in nine EU countries and the USA. In our study, the raw data were gathered from SMEs in Spanish Retail, Transport and Logistics (RTL) sectors and were defined on the basis of the NACE classification (General Industrial Classification of Economic Activities within the European Communities).

The target respondent within each company was a person responsible for or taking part in decisions concerning the use of ICT and e-business. The fieldwork was carried out using computer-aided telephone interview technology. The final questionnaire contained 70 questions, which were structured into major sections: ICT Infrastructure and e-Business Software Systems, Automated Data Exchange, ICT Expenditure and Investments, Innovation Activity of the Company, ICT Skills Requirements and ICT Costs, ICT Impacts, Drivers and Inhibitors and Background Information about the Company

The Spanish RTL sector was selected for analysis because the survey revealed that the RFID-adoption rates are the highest in Spain 10% in relation to other European survey participants e.g. Italy 8%, and the UK 7%.

### Sample and Data Collection

A random sample of companies from the respective sector population in Spain was done. The sampling source was Dun & Bradstreet (D&B). The final sample size of 259 according to industry sector and company size is illustrated in Table 1, however for the purposes of this paper we will not discuss companies with 250 or more employees as they would not satisfy the size criteria for SME's.

		Company size in size-classes					Total
		0-9	10-49	50-249	250+		
Survey Sectors	Retail	Count	41	41	45	4	131
		% within: Survey Sector	31,3%	31,3%	34,4%	3.0%	100%
	Transport & Logistics	Count	35	51	39	3	128
		% within: Survey Sector	27,3%	39,8%	30,5%	2.3%	100%
Total		Count	76	92	84	7	259
		% within: Survey Sector	29,3%	35,5%	32,4%	2.8%	100%

Source: EC Sectoral e-Business Survey 2007

**Table 1: Distribution of Interviews by Firm Size and Industry Sectors.**

### Data Analysis Technique

To test the hypotheses and determine the likelihood of adopting RFID, we used a Binary Logistic Regression model estimated by the maximum likelihood method, along with a dichotomous dependent variable (non-adoption of RFID and adoption of RFID). The raw data were coded and analyzed using the PASW Statistics 18.

**FINDINGS**

**Adoption Rates of RFID**

Prior to testing the hypotheses, a cross-tabulation of company size and RFID use as well as the purposes of using RFID technology was done (Table 2). The adoption of RFID by the SMEs appears particularly low. The use of RFID in micro (0-9 employees) is a mere 4.1%, reaching 7.8% in the small firms (10-49) and 19.6% in the medium-sized firms. In all SMEs categories, the adoption rates of RFID is considered to be low, an observation leading to our further researching the factors inhibiting adoption. Using the chi-square test with *p*-value of 0.021 (less than 0.05), it can be verified that there is a statistically significant association between the size of the firm and usage of RFID. The Chi-square test reveals that there is some departure from statistical independence. Post hoc analyses of the contingency table cells are based on adjusted residuals that are calculated by dividing the residual (the difference between observed and expected cell frequency) into the standard error of the contingency table cell. The adjusted residuals of the categories 0-9 and 50-249 are greater than 1.96 in their absolute magnitude (2.0 and 2.7 respectively), indicating a significant deviation from the independency assumption. In the above test, there is no violation of the basic rule of using chi-square test (the expected values in each cell should be greater than 1 and (that) most cells have expected values greater than 5 (Norusis, 2008).

SMEs (70.8%) used RFID mainly for in-house managerial activities (such as tracking, transport, logistics, labeling and packing). Approximately 67% of the SMEs use RFID to support ordering of goods, products and services and 65.2% for tracking and for managing the organizational value chain. Finally 58.3% of the SMEs declared that the main reason for adoption was to support customer services.

		Adoption		RFID use							
		RFID (%)		Support ordering of goods and services (%)		Manage goods, products and services in-house (%)		Support customer services (%)		Track and manage the organizational value chain (%)	
		No	Yes	Yes	No	Yes	No	Yes	No	Yes	No
Firm Size	0-9	95.9	4.1	66.7	33.3	33.3	66.7	66.7	33.3	50.0	50.0
	10-49	92.2	7.8	71.4	28.6	42.9	57.1	71.4	28.6	57.1	42.9
	50-249	83.3	16.7	64.3	35.7	92.9	7.1	50.0	50.0	71.4	28.6
	Total	90.3	9.7	66.7	33.3	70.8	29.2	58.3	41.7	65.2	34.8

**Table 2: Use and purpose of use of RFID technology in relation to company size**

**A prediction model for the factors inhibiting the Adoption of RFID technology**

Since the research model uses a dichotomous dependent variable and a mixture of dichotomous and continuous independent variables, the binary logistic regression analysis was used to validate the research model empirically. Logit analysis is a preferred technique as it does not assume equal variance-covariance matrices across groups and multivariate normality of the variables (Hair et al., 1998). The final logit model is specified as follows:

$$Ln (Prob(RFID=No)/ 1- Prob(RFID=No)) = \beta_0 + \beta_1 * PB_i + \beta_2 * AC_i + \beta_3 * SNC_i + \beta_4 * SR_i + \beta_5 * IPIA_i + \beta_6 * ICTP_i + \beta_7 * FS_i + \varepsilon_i$$

*Hypothesis Testing*

Five of the seven hypotheses were supported (Table 3). The remaining, related to *Perceived Acquisition Cost* (H2) and *Internal Technological Knowledge (ICT-practitioners in the firm)* (H6) were insignificant attributes in SMEs' adoption of RFID.

Independent Variables	Hypothesis	Coef ( $\beta$ )	Likelihood Ratio Chi-Square	Sig.	Exp( $\beta$ )
Constant		5.050	22.368	0.000	
Perceived Benefits*	H1	2.107	7.981	0.005	8.223
Perceived Acquisition Costs	H2	-1.059	2.004	0.157	0.347
Security Risks*	H3	2.217	7.978	0.005	9.176
Firm Size*	H4	-0.717	3.941	0.047	0.488
Technological Knowledge (ICT-Practitioners in the firm)	H5	0.590	0.475	0.491	1.804
Process Performance Improvement (Internal Process Innovation Activity)*	H6	2.128	4.736	0.030	8.394
Suppliers non-compatibility*	H7	-2.511	5.772	0.016	0.081

Notes: \* Variables are significant at the 0.05 level of significance.

**Table 3: Logistic Regression Results**

The Likelihood-ratio test is used instead of Wald statistics because the latter has undesirable properties. For large coefficients, the standard error can be too large, resulting in Wald statistics that are too small. That is, we may fail to reject the null hypothesis when it is false (Norusis, 2008). Therefore to eliminate this possibility, the likelihood-ratio test was chosen.

The deviance of the model was equal to 58.860 on 124 degrees of freedom. Thus, the comparison of this number with the 95% point of the chi-square distribution with 49 degrees of freedom produced a p-value equal to 0.999. This means that the fit of the model is not rejected. The comparison with the chi-square distribution is however asymptotic, which means it requires a large sample. The addition of the test statistics for the seven variables is equal to 30.425 which can be used to test the statistical significance of the seven variables together. The comparison is made against the chi-square distribution with 7 degrees of freedom and the associated p-value equal to 0.000. Based on the small observed significance level, we can reject the null hypothesis that the coefficients for all of the variables in the model are zero.

The regressors are not directly of interest in statistics but the exponent of each term is the odds ratio and thus reveals the contribution of each term in the probability for a SME to not adopt RFID. The term 2.107 when exponentiated gives  $\exp(2.107) = 8.22$ . This means that the odds of not adopting RFID, for a small firm which considers as important the reason that “their company is too small to benefit from e-technologies” are 8.22 times the odds for a company that does not. The coefficient of the variable *SNC* gives an odds ratio equal to 0.08 while the coefficient of the variables Security Risks (SR) and Internal Process Innovation Activity (IPIA) give a significantly higher odds ratio. Firstly, the odds attribute to SR variable are equal to 9.18, which means that the odds of not adopting RFID for a SME that consider as important the reason that “an e-technology has potential security risks” are 9.18 the odds in relation to a SME that has adopted RFID. Moreover, the odds attributes to IPIA variable are equal to 8.39, which means that the odds of not adopting RFID for a SME that has not introduced any new or significantly improved its internal process are 8.39 the odds for a firm that has. Finally, the odds of not adopting RFID are rising according to the employment size of the firms.

## DISCUSSION

An organization uses an innovation essentially to satisfy internal needs and unless the innovation provides the benefits that meet the needs, the likelihood of adoption and use is reduced. We found that SME’s in the RTL sector in Spain saw little perceived benefits by adopting RFID Technology. Previous research (Bhattacharya et al, 2007) found that perceive advantage is the primary reason for encouraging ICT growth and is therefore an important criterion for an organization to use an innovation. This study also found that SME’s did not anticipate any process improvement by adopting RFID. This point is connected to perceived benefits and relative advantage. Although the EC has invested heavily in projects to promote commercial RFID deployment this may yield little results if firms don’t see the benefits of adopting. According to e-Business Watch (2008) the key business drivers for RFID adoption include mainly operational incentives such as the opportunity to

achieve cost reductions and productivity improvements along the supply chain and in production processes. For RFID to be widely used in the supply chain, that is open loop, the technology needs to be standardized. The incompatibility issues with standards will inhibit widespread use of the technology. The findings of this study reflect the issues relating to incompatibility standards. We found that incompatibility of ICT with suppliers to be a strong inhibitor to adoption.

This study found a strong relationship between firm size and RFID adoption, which is consistent with Schmitt & Michahelles (2009) and Ramdani et al (2009). A number of factors are likely contributors. SME consider that there is not enough scale to justify implementation and lack of strong return on investments (ROI) may also be a deterrent. The lack of ROI is a concern for all size firms but more so with SME's. Surprisingly, acquisition costs did not play a significant role on the non-adoption of RFID. Several other studies including OECD (2004) and Tan and Eze (2008), have indicated that cost is considered the most crucial issue for ICT investment by SMEs. Our findings however seem like an aberration and require further investigation.

Lack of technical expertise and skilled workforce in house did not represent a key barrier to RFID adoption. This finding is consistent with e-Business Watch (2008) and inconsistent with other research on e-technology adoption and advanced users of ICTs such as OECD (2004) and Brynjolfsson & Hitt (2000).

Finally we found strong support for the association between firms' perceptions that ICT has potential security risks and non-adoption of RFID. These security issues are likely to be associated with privacy especially for SME's in the health and transport sectors.

## CONCLUSION, IMPLICATIONS AND FUTURE RESEARCH

The purpose of this exploratory study was to investigate the factors that inhibit the adoption of RFID by SMEs in RTL sectors in Spain. We found that perceived benefits, compatibility, security risks, process innovation improvement, and firm size all impacted SME's ability to adopt RFID technology in their operations. The other two factors cost and ICT practitioners/employee skills did not factor in the decision making process.

E-Business Watch (2008) anticipated that by 2011 approximately 44% of European enterprises would have implemented RFID and potentially 50% by 2012. In light of these projections, the findings of H<sub>1</sub> (SME's perception that RFID technology offers limited benefits over existing technologies) is most troubling, based on the fact that 98% of European firms are defined as SMEs and that the data was collected from Spain which has the highest adoption rate. This finding may be peculiar to Spain and therefore further studies in other EU countries should be conducted. At the micro level owner/managers of SMEs should explore the technology as empirical evidence suggests that the implementation of RFID can enable labor and total factor productivity growth as well as innovation in business processes.

This work is not free from limitations. The findings in this study are based on the Spanish RTL small firms, and therefore cannot be generalized to RTL firms in other countries. In terms of future research, it would be interesting to examine factors inhibiting and boosting the adoption of RFID in other countries and sectors, such as manufacturing firms, since other business sectors may exhibit different forms of behavior. It would also be of value to carry out this research in other countries that share similar industry infrastructure. Further comparative research is needed to replicate the results found in this study.

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