Determinants of RFID adoption intention by SMEs: an empirical investigation

Article *in* Production Planning and Control · April 2016

Impact Factor: 1.47 · DOI: 10.1080/09537287.2016.1167981

4 authors, including:

Samuel Fosso Wamba

NEOMA Business School

91 PUBLICATIONS **798** CITATIONS

SEE PROFILE

Angappa Gunasekaran

University of Massachusetts Dartmouth

417 PUBLICATIONS **10,899** CITATIONS

SEE PROFILE

Mithu Bhattacharya

University of Detroit Mercy

9 PUBLICATIONS **110** CITATIONS

SEE PROFILE

Determinants of RFID Adoption Intention by SMEs: An Empirical Investigation

Samuel Fosso Wamba (First Author & Corresponding author)
Department of Information Systems, Supply Chain and Decisions
NEOMA Business School, Rouen, France
1 Rue du Maréchal Juin, BP 215
76825 Mont Saint Aignan Cedex
E-mail: samuel.fosso.wamba@neoma-bs.fr

Angappa Gunasekaran (Second Author)
Charlton College of Business
University of Massachusetts Dartmouth
North Dartmouth, MA 02747-2300
USA
E-mail: agunasekaran@umassd.edu

Mithu Bhattacharya (Third Author)
College of Business Administration
University of Detroit Mercy
4001 W McNichols Rd, Detroit, MI 48221
Email : bhattami@udmercy.edu

Rameshwar Dubey (Fourth Author)
Symbiosis Institute of Operations Management
(Constituent of Symbiosis International University)
Plot No. A-23, Shravan Sector
CIDCO
New Nashik-422008
India
Cell. No. +918600417738
Tel. No. +91-253-2379960 Ext. No.39
E-mail: rameshwardubey@gmail.com

To cite this article: Samuel Fosso Wamba, Angappa Gunasekaran, Mithu Bhattacharya & Rameshwar Dubey (2016): Determinants of RFID adoption intention by SMEs: an empirical investigation, Production Planning & Control

To link to this article: http://dx.doi.org/10.1080/09537287.2016.1167981

Determinants of RFID Adoption Intention by SMEs: An Empirical Investigation

Radio frequency technology (RFID) has been considered as one of the ten technologies that will transform firm across industries. However, the adoption and use of the technology has been slower than predicted, mainly because of technological, organization and environment factors related to RFID. This study develops a conceptual model that explores the role that technological, organizational, environmental, and managerial characteristics of small and mid-sized enterprises (SMEs) play in their intention to adopt radio frequency identification (RFID) technology. To test the model, a web-based survey was administered to 453 SME managers from the U.S.A., the U.K., Australia and India. Logistic hierarchical regression is used to test the proposed model. Implications for RFID technology research, theory and practice are discussed.

Keywords: RFID technology; adoption intention; determinants; SMEs

Introduction

In 2003, Walmart, the world retail giant, issued a mandate that required all its top suppliers to adopt RFID, "a wireless automatic identification and data capture (AIDC) technology" (Fosso Wamba et al., 2008, p. 615) to track and trace their pallets and cases, by the end of 2006 (Violino, 2003). This decision undoubtedly rekindled firms' interest in RFID technology (Holmqvist and Stefansson, 2006). Since the first industrial application of RFID technology during World War II to identify aircraft, the technology has gone through multiple transformations in the form of product and process innovations (Fosso Wamba, 2011), increasing the number of potential applications within different industries. While the emerging literature on RFID adoption and use has demonstrated the high operational and strategic value of this technology (Fosso Wamba and Chatfield, 2009; Ngai et al., 2014), the implementation challenges, including infrastructure costs, environmental upheaval, top management leadership, second-order organizational learning, resource commitment, and organizational transformation (Fosso Wamba and Chatfield, 2009), have caused many potential adopters to back away from RFID. For example, the vast majority of the small and midsize enterprises (SMEs) serving Walmart—representing a significant portion of all of its suppliers—are believed to have spent between $15,000 and $20,000 each on RFID infrastructure alone (e.g., RFID tags, readers and middleware) (Gaudin, 2008). The high cost of infrastructure represents a significant expense for SMEs (Gaudin, 2008). Moreover, most of these suppliers struggled to adopt and use RFID technology cost-effectively for competitive advantage (Ross et al., 2009). In addition, prior studies on RFID adoption have stressed the importance of adoption mandates, particularly in the early stages of exploring the potential of the technology; the importance of these mandates diminishes over time as

the perceived benefits and risks related to the technology are assessed (Fosso Wamba, 2012).

In actuality, the adoption of RFID technology has been slower than predicted, mainly because the hype associated with any emerging information technology (IT) (Bendavid et al., 2013) gave researchers and practitioners unrealistic expectations. In reality, the widespread adoption of any given technological innovation is facilitated by changes in the "business perceptions of business value—that are held by adopters and non-adopters" (Keating et al., 2010). Therefore, it is critical to deepen our understanding of the various factors determining the adoption of RFID technology by firms, especially SMEs, which are at the core of economic growth in many countries. More explicitly, this research examines the following research question:

What role do the organizational, technological, managerial, and environmental characteristics of SMEs play in their intention to adopt RFID technology?

To address this question, we draw on the emerging literature on RFID technology and on diffusion of innovation theory. The remainder of this paper is structured as follows: First we review the literature on successful RFID adoptions. We then present the conceptual model and the hypotheses. The subsequent sections discuss the research methodology for this study, the results, and the conclusion and implications for research and practice.

Literature review

There has been a significant increase in academic RFID research (Zhu et al., 2012) reporting the benefits obtained from implementing RFID technology for various industries. The promising results from the implementation of RFID technology as

evident from the published academic studies and business case studies served as the motivation to conduct this research. For example, (Zhu et al., 2012) provided an overview of the current state of the applications of RFID technology in different industries and its impact on the business operations. (Ngai et al., 2008) show that RFID-enabled conveyor-belt sushi restaurant could enhance operational efficiency in terms of improved inventory control, responsive replenishment, and improved food safety control, and improved service quality. RFID could improve supply chain coordination (Szmerekovaky and Zhang, 2008), reduce labor costs through improved real time visibility (Bhattacharya et al., 2008; Véronneau and Roy, 2009; De Marco et al., 2012), reduce the lead time variability within supply chain (Chang et al., 2010), facilitate the promotion or the cross-selling of new products more effectively and efficiently (Wong et al., 2012), improve customer satisfaction (Kim et al., 2008; Bhattacharya et al., 2010), and customer loyalty (Lee et al., 2008), improved inventory management (De Marco et al., 2012; Fan et al., 2014; Fan et al., 2015; Reaidy et al., 2015), improved patient care, improved patient security and safety (Reyes et al., 2012), improved warehouse and supply chain traceability and transparency (Reaidy et al., 2015), and thus leading to improved firm revenues (De Marco et al., 2012; Reyes et al., 2012) and overall firm operational and strategic performance (Baars et al., 2009; Reyes et al., 2012; Fan et al., 2015). However, Véronneau and Roy (2009) argue that in the context of warehousing for example, "the visibility and tracking benefits from RFID technology remains marginal if a warehouse is efficiently managed with a good bar code system supported by a good warehouse management system" (p. 701).

Also, Hassan et al. (2015) conducted a Delphi study to investigate the auto-ID technology-selection process in order to determine the critical factors that influence this decision in warehouse management. The consolidated results from this study suggest

that there are 54 key factors under six major categories that influence the selection decisions in warehouse management. These categories of the factors are organizational, operational, structural, resources, external environmental and technological factors in the order of importance. Similarly, Fosso Wamba and Ngai (2013) conducted a Delphi study to identify and rank a comprehensive list of technological, data management, security and privacy, and organizational and financing issues related to RFID-enabled healthcare transformation projects. The top three technological issues identified were: Integrating RFID infrastructure with current intra- and inter-healthcare information systems, Effective use of common standards to disseminate RFID-enabled healthcare applications, and Lack of comprehensive RFID-enabled solutions. The top three data management, security and privacy issues identified were: Preserving data integrity and reliability, Managing integration of RFID-generated data, and Identifying and addressing privacy concerns. And the top three organizational and financing issues that were identified are: Designing and implementing RFID-enabled healthcare processes, Financial analysis of all types of healthcare costs that can be reduced using RFID technology, and Determining the return on investment by correctly identifying costs and including non-monetary benefits.

Pero and Rossi (2013) conducted a case study to present the application of an innovative system to increase visibility along engineer-to-order supply chain of a leading Italian company that manufactures vessels and tube heat exchangers. The company uses the innovative system for information sharing with different players of its supply chain. The results from this study suggest that companies that had visibility on the suppliers' production process actually interact more with suppliers for problem solving. Such collaboration results in trusting relationships among the supply chain partners. Pfahl and Moxham (2012) developed a conceptual framework using a

systematic review of relevant literature. They made six propositions which propose that the integration of ECR (efficient consumer response), RFID and supply chain visibility may be considered as a strategic capability within retail supply networks. In practice, it is proposed that integration must be considered at the supply network design stage and implemented across the entire supply network for the advantages to be actually realized. Laosirihongthon et al. (2011) conducted a study using an AHP (Analytical Hierarchical Process) to identify and prioritize enabling factors that determine the implementation of radio frequency identification (RFID) in Thailand. The results show that softer and less tangible factors are more important than the harder' and more tangible factors when cost competitiveness is the key objective of RFID implementation. Quetti et al. (2012) conducted a case study of seven small and medium sized companies of the Italian silk industry involved in RFID traceability system and their results suggest that competitive pressure strongly influences managers' adoption decisions while lack of organizational readiness negatively affects adoption decisions. They also found out that the presence of a supervisor and the availability of financial incentives acted as strong facilitators of RFID adoption.

In addition, Yazici (2014) conducted a study to understand how RFID Technology can meet hospital real time asset and information management requirements. Fosso Wamba et al. (2013) performed a systematic review of publications to identify key RFID applications and issues in the healthcare industry. Fosso-Wamba and Ngai (2015) conducted a four round Delphi study to identify and rate the key technological, data management, security and privacy, organizational, and financing issues related to RFID-enabled healthcare transformation projects.

Visich et al. (2009) conducted a review of existing quantitative empirical evidence of RFID on supply chain performance and found that the major benefits of

RFID implementation is automational effects on operational processes such as inventory control and efficiency improvements and informational effects on managerial processes such as improved decision quality, production control and the effectiveness of retail sales and promotions coordination. Tajima (2007) provided insights into the strategic values of RFID by conducting a systematic review to develop propositions theorizing how RFID may create and sustain competitive advantage. Cao et al. (2014) conducted and reported a RFID pilot case project for patient tracking in a large healthcare organization. Reyes et al. (2012) conducted a research of antecedents and outcomes of RFID technology in healthcare sector by surveying 88 healthcare organizations. Lee and Lee (2010) developed a supply chain RFID investment evaluation model providing a basis for enhancing the understanding of RFID value creation, measurement, and ways to maximize the value of RFID technology. Ferrer et al. (2010) studied key variables through which RFID technology benefits service operations after exploring 21 different RFID applications across a wide variety of industries. (Dominguez-Péry et al. (2013) performed an in-depth case study showing different stages of RFID implementation in the jewellery supply chain of a retailer including all stakeholders. (Dwivedi et al. (2013) researched factors affecting the use of RFID systems and user satisfaction in a library. Becker et al. (2010) proposed a model based approach for calculating the process driven business value of RFID investments. (Chang et al. (2010) proposed a novel approach to analyze the potential benefits of RFID system by suggesting various deployment strategies that determine an optimal location of RFID within a supply chain network. (Ngai et al. (2014) explored the value of RFID technology in aircraft parts supply chain by eliminating inventory inaccuracies. (Hermann et al. (2015) conducted a case study to investigate the capability of RFID-based information system in the international distribution process of a car manufacturer.

The results from this case study suggest that RFID technology is matured to be used in a manufacturing industry setting and generated benefits for the entire distribution supply chain. Hardgrave and Miller (2006) provided a realistic view of RFID technology by providing the top ten myths and realities about the technology. Similarly, Lee and Ozer (2007) reviewed some of the ongoing research efforts on RFID in an attempt to close the credibility gap around the technology.

A search within the RFID Journal, the leading journal focusing on RFID adoption and use showed that over 240 RFID case studies across various industries and countries were reported as successful implementations projects, and thus, suggesting that there is an empirical case to be made for RFID technology adoption and for its immense potential (Table 1). Table 1 provides a sample of successful implementation projects where RFID is used by small businesses for business benefits.

While all prior studies on RFID technology help to improve our understanding of RFID technology, they focus mostly on large organizations (Baars et al. 2009; Yee-Loong Chong et al. 2015). Although RFID technology is considered as a disruptive technology (Fosso Wamba, 2011), the widespread adoption of the technology has been slow than projected by many consulting organizations adoption mainly because of the hype surrounding any given IT innovation (Bendavid et al., 2013). The adoption is even slower for small businesses even if RFID is considered to be among IT that will facilitate the evolution of operations management in the incoming years (Gunasekaran and Ngai, 2012).

INSERT Table 1.

Conceptual model development

In this study, we develop a conceptual model of the role that the technological, organizational, environmental and managerial characteristics of SMEs play in the adoption of RFID technology (Figure 1). We endorse the classification of SMEs recommended by the European Commission, which proposed that a micro-firm is an organization that has 1 to 10 employees, a small firm is an organization that has between 11 and 50 employees, and a medium-size firm is an organization that has between 51 and 250 employees (European Commission 2013). Consistent with prior studies on RFID technology, we considered that RFID technology is a technological innovation (Tsai et al., 2010; Fosso Wamba, 2012). In addition, we used diffusion of innovation (DoI) theory (Rogers, 2003) and the technology-organization-environment (TOE) framework (Tornatzky and Fleischer, 1990) as theoretical foundations for the study. Both the DoI and TOE provide a set of technological, organizational and environmental factors that influence the decision to adopt or reject a given IT innovation.

Technological innovation characteristics

In his seminal work, (Rogers, 1995), who is considered as one of the fathers of the DoI, identifies five factors that may influence the decision to adopt or reject an IT innovation. They are "relative advantage," or the degree to which an innovation can provide benefits for an organization; "compatibility," or the degree to which an innovation is consistent with existing business processes, practices and value systems; "complexity," or the degree to which an innovation is difficult to use; "observability," or the degree to which the results of an innovation are visible to others; and "trialability," or the degree to which an innovation may be experimented with. In their review and meta-analysis, Tornatzky and Klein (1982) found that relative advantage,

compatibility, and complexity "had the most consistent significant relationships to innovation adoption" (p. 28).

Relative advantage has consistently been identified as a predictor of adoption intent in innovation diffusion literature (Premkumar and Roberts, 1999). It has also been considered as the most frequently cited facilitator of RFID adoption (Sharma and Citurs, 2005).

Compatibility has been suggested to be used as a predictor of RFID adoption in several studies (Sharma and Citurs, 2005; Brown and Russell, 2007; Wang et al., 2010).

Since complexity can be a deterrent to successful implementation followed by use of an innovation, it is usually negatively associated with adoption (Premkumar et al., 1994; Premkumar and Roberts, 1999). Although RFID provides several organizational benefits, the perceived characteristics of the technology is still complex. This is one of the major inhibitors of RFID adoption and has been proposed in several RFID adoption studies (Sharma and Citurs, 2005; Brown and Russell, 2007).

Therefore, we advance the following hypotheses:

H1: *RFID relative advantage will have a significant positive effect on RFID adoption intention.*

H2: *RFID compatibility will have a significant positive effect on RFID adoption intention.*

H3: *RFID complexity will have a significant negative effect on RFID adoption intention.*

Organizational factors

Prior studies on IT adoption identified the professionalism of the information systems (IS) unit, firm size, firm innovativeness, firm readiness, top management support, employees' technical expertise and organizational structure as being among the best

predictors of IT adoption (Jeyaraj et al., 2006). For example, in their review of the predictors, linkages, and biases in IT innovation adoption research, (Jeyaraj et al., 2006) found the best predictors of IT adoption by organizations to include top management support and professionalism of the IS unit. Among these factors, firm size is unquestionably the most studied within the literature (Masters et al., 1992). Firm size encompasses various dimensions including the organization's slack resources and organizational structure (Zhu, 2006). Large organizations have more resources than SMEs. On the basis of this discussion, we formulate the following hypothesis:

H4: *Firm size will have a significant positive effect on RFID adoption intention*.

Environmental factors

The following environmental factors have been found to be among the key predictors of IT adoption: competitive pressure, competitive environment, standards and regulations, and the firm's geographic location (e.g., non-metropolitan area vs. metropolitan area; (Fichman, 2000; Rogers, 2003; Zhu et al., 2003; Zhu, 2006). In their review, (Jeyaraj et al., 2006) found that competitive pressure is one of the best predictors of IT adoption by organizations. Competitive pressure is suggested to be used as a predictor of RFID adoption in several studies (Brown and Russell, 2007; Sharma et al., 2008; Wang et al., 2010). Coronado et al. (2008), in their study of firms' attitudes towards *i*nnovation in peripheral economic regions, concluded that "technological opportunities and location exert positive effects on attitudes towards innovation" (p. 1009). Pontikakis and Collins (2010) argued that the irregular geographic dissemination of broadband network delivery is closely related to the characteristics of each geographic location. In their view, "a critical mass of human presence, economic activity and infrastructure appear to

be good predictors of where broadband will be offered first" (p. 146). Based on this discussion, we set out the following hypotheses:

H5: *Competitive pressure will have a significant positive effect on RFID adoption intention.*

H6: *Firms' geographic location (metropolitan) will have a significant positive effect on RFID adoption intention.*

Manager characteristics

Managers' characteristics play an important role in the adoption of any IT innovation in SMEs (Marcati et al., 2008). For example, age has been shown to be significant in the adoption and use of technologies (Venkatesh et al., 2014). Earlier studies have shown that as people age their ability to handle complex information processing tasks declines, and thus they resist adopting new technologies that alter their working or personal environment and require them to learn new ways of performing their tasks (Venkatesh et al., 2014). Younger managers have greater learning capabilities and more recent education and are therefore likely to be more flexible and open to risk than older managers when it comes to adopting a new technology (Kitchell, 1997). Therefore, we hypothesize:

H7: *Managers' age (older) will be negatively related to RFID adoption intention.*

Another important manager characteristic affecting IT adoption and use is gender, which has been shown to play a major role in the adoption and use of technologies (Venkatesh and Morris, 2000; Venkatesh; Sykes et al., 2014). For example, it has been suggested that men learn to use technology faster than women do and this can inhibit women from adopting and continuing to use technology (Gefen and

Straub, 1997; Venkatesh and Morris, 2000). A study on gender differences in perceptions of web-based shopping shows that gender is a significant predictor of online buying intention (Slyke et al., 2002): men are more likely to buy products or services online than women. Thus, we can say that gender plays an important role in technology adoption and usage decisions (Venkatesh and Morris, 2000). Consequently, we hypothesize:

H8: *Managers' gender (male) will be positively related to RFID adoption intention*.

Past studies on the digital divide have also shown that education is an important prerequisite for access and use of information technologies (Venkatesh et al., 2014). Managers' education level is considered to be an enabler of their intention to adopt an innovation. Educated managers are more likely to use different approaches using innovations and technologies for problem solving (Damanpour and Schneider, 2009; Venkatesh et al., 2014). Thus, we hypothesize:

H9: *Managers' education level (higher) will be positively related to RFID adoption intention.*

Control variable: Industry sector and country

The industry sector and the country where a firm is operating may influence its decision to adopt or reject a given innovation. For example, previous studies on e-business adoption and use have identified a link between the commitment of SMEs to adopt and use e-business tools and applications and the adopting firm's industry sector (Harland et al., 2007; Tiago and Martins, 2009 / Jan 2010). Similarly, prior studies have consistently shown that the country's structure (e.g., legal system, infrastructure, education system) will influence a firm's decision to invest in R&D and IT innovation technologies (Coe et al., 2009). We therefore hypothesize that:

H10: *Industry sector (manufacturing) will be positively related to RFID adoption intention.*

H11: *Country (developed) will be positively related to RFID adoption intention*.

Insert Figure 1

Methodology

The research model developed on the basis of the hypotheses presented above was validated empirically using a cross-sectional study. A web-based questionnaire was used to collect data from SME managers from Australia, India, the U.K., and the U.S. These managers are members of a small business business-to-business (B2B) panel that is managed by Research Now, a leading market research firm. The data collection started on April 4, 2011, when an invitation was sent to a random sample of 13,314 members of the small business B2B panel to participate in the study. As an incentive, $2 was offered to respondents who completed the survey. In response to our initial invitation, 1,997 B2B panel members agreed to participate in the study. A reminder was sent to participants on April 7, 2011, and the web-based questionnaire was closed on April 18, 2011. After a careful analysis of all responses, 453 valid questionnaires were considered to have been correctly filled out and appropriate for further analysis. Thus, for this study, we had a response rate of 29.39%. In the sample, 24.1% of firms were from developing countries and 75.5% from developed countries, with 0.4% marked as unknown. The sample is dominated by firms in the service sector (94%), with only 6% in manufacturing. The average age of the respondents was 47.99 years old (SD = 11.931); 70.9% of the sample was male and 29.1% female, and 70.8% of the managers had attended university. The questionnaire is presented in Appendix 1.

Reliability and validity analysis of the questionnaire

The constructs of the questionnaire were tested for two psychometric properties, validity and reliability, to ensure that the measurement is accurate. Validity assesses the degree to which the items measure the construct, whereas reliability assesses the stability of the scale based on the assessment of the internal consistency of the items measuring the construct (Churchill, 1979). The reliability of the constructs was assessed using Cronbach's alpha. Cronbach's alpha coefficient of internal consistency is determined to ensure that the items comprising the factors produce a reliable scale. A higher score indicates greater reliability, with a range from 0 to 1. The agreed-upon acceptable lower limit for Cronbach's alpha is 0.7 (Nunnally and Bernstein, 1994).

The reliability properties of the measurement constructs with multiple items are presented in Table 2. The results in Table 2 indicate that all multi-item constructs have adequate alpha values (> 0.7).

INSERT Table 2.

In this study, validity was assessed first through content validity, which evaluates whether the measurement covers the complete domain of the construct. Content validity was established through an extensive literature search, which led to further refinement, followed by strict scrutiny for appropriate mapping of the constructs by a team of researchers.

Construct validity is evaluated in this study using convergent validity and discriminant validity obtained from confirmatory factor analysis results. Factor analysis examines the interrelationships among a large number of variables and explains these variables in terms of their common underlying dimension (Zhang et al., 2000). The main purpose is to summarize the information into a smaller set of new dimensions without losing the majority of the information (Hair et al., 1983),. In this study, construct validity was examined through confirmatory factor analysis using principal

component analysis (PCA) with promax rotation. Principal component analysis is used to determine whether the selected items cluster on one or more than one factor, which is important if there are three or more items measuring a single construct (Zhang et al., 2000). According to Hair et al. (1983), factor loadings greater than 0.3 are considered as significant; factor loadings greater than 0.4 are considered to be moderately significant; and factor loadings greater than 0.5 are considered to be very significant. The standard criteria of factor loadings greater than 0.5 and an adequately explained factor structure were used in the analysis (Zeller and Carmines, 1980).

We performed confirmatory factor analysis on the multi-item constructs in this study forcing for four factors. The items loaded on the four factors that directly mapped on the theorized constructs. There were no cross-loadings of items on other factors. Table 3 shows the results of the confirmatory factor analysis.

INSERT Table 3.

From table 3, the average loadings of the four constructs are 0.837, 0.891, 0.948, and 0.932 which are greater than 0.5 thus suggesting convergent validity of the three constructs. Average variance extracted between the four constructs is 0.902 (Average of 0.837, 0.891, 0.948, and 0.932). From the component correlation matrix we observed that the correlation between constructs 1 and 2 was 0.671; the correlation between constructs 1 and 3 was -0.409; the correlation between constructs 1 and 4 was 0.106; the correlation between constructs 2 and 3 was -0.484; the correlation between constructs 2 and 4 was 0.157 and the correlation between constructs 3 and 4 was 0.001. When we square these correlations between constructs we get 0.450, 0.167, 0.011, 0.234, 0.024, and 0.000001. As average variance extracted between the four constructs 0.902 > squared correlations, thus suggesting discriminant validity of the constructs.

Results and discussion

The constructs used in this study were adapted from prior studies (see Appendix 1). The dependent variable, RFID adoption intention, was measured as a dichotomous variable (adoption intent vs. no adoption intent). Therefore, the data analysis was conducted using hierarchical logistic regression. Logistic regressions are considered to be easier to interpret and more robust than discriminant analysis. Additionally, they are more common and appropriate when there is a dichotomous dependent variable and multiple independent variables (Patrick and Kar Yan, 1997; McDonald, 2008). We used SPSS to perform the data analysis for the hypotheses tests in this study. Constructs with items using yes/no questions have been used in other related studies (Teo et al., 2009).

For the country coding of developed vs. developing used in our analysis, we coded Australia, New Zealand, North America, and the U.K. as developed; "other Europe" (one entry) was coded as unknown. Africa, East Asia, Middle East, South America, South Asia were coded as developing. We coded "Elsewhere" as developed or developing by evaluating each country that was named. If no country was named, we coded "Elsewhere" as unknown. Therefore, we have three categories for country: 1-developing, 2-developed, 0-unknown. Standardized residuals were also examined to identify potential outliers before we analyzed the data. Some outliers were in fact detected. Thus, we ran hierarchical logistic regressions after removing all the outliers.

Prior to the removal of outliers, the accuracy rate of the logistic regression model was 93%. After outliers were removed, the accuracy rate rose to 95.4%. Since the logistic regression omitting outliers was more than 2% more accurate in classifying cases than the logistic regression with all cases, the model excluding the outliers is interpreted here. Table 4 shows the results of the logistic regression analysis for our hypotheses regarding RFID adoption intention. The test result is significant (chi-square = 161.589, df = 9, p-value = 0.000), indicating an adequate fit of the data to our model.

The Nagelkerke R2 indicates that 84.8% of the variance is explained by the independent variables. The Hosmer and Lemeshow Goodness-of-Fit Test provides an overall test of the fit of the data to the model and is more robust than the general chi-square model; the statistical significance of this test is 0.770. Thus, we do not reject the null hypothesis and conclude that there is no difference between the data and our model. The chi-square value for the Hosmer and Lemeshow Goodness-of-Fit Test is 4.814, indicating a good fit of the data to the model.

In Table 4, the Wald Statistic and the corresponding level of significance test the effect of each independent variable in the model; it is the ratio of the logistic coefficient β to its standard error (SE) squared. If the Wald statistic is significant (< 0.05), then the parameter is significant in the model. The Exp (β) column indicates the odds ratios, that is, the predicted change in odds for a unit increase in the corresponding independent variable. Odds ratios of less than 1 correspond to a decrease and odds ratios of more than 1 to an increase in odds, while odds ratios close to 1 indicate that the unit change in the independent variable does not affect the dependent variable.

As expected, we found that RFID relative advantage and RFID compatibility are significant at the 95% confidence level, and thus **supporting H1 and H2 respectively (Table 5)**. Surprisingly, contrary to early studies on IT adoption (Jeyaraj et al., 2006) and the emerging literature on RFID adoption and use (Tsai et al., 2010; Tsai et al., 2013), we found that RFID complexity, firm size and the competitive environment were not significant, therefore **H3, H4 and H5 were not supported** (Table 5). However, at the 90% confidence level, firm size (organizational characteristic) was found to be significant. But, at the 95% confidence level, firm size is no longer significant. This is probably due to the fact that almost all our responding firms are the same size: micro firms. These unanticipated results are interesting and can be explained by the

uniqueness of RFID technology's complexity. There are so many different aspects of the adoption of the technology that set it apart and these require more maturity to realize the technology's full potential and make an adoption decision. These results may be explained by the fact that the importance of the competitive pressure related to RFID adoption and use diminishes over time to give way to the technology's significant benefits (Ferrer et al., 2011; Dai and Tseng, 2012; Nativi and Lee, 2012; Dominguez-Péry et al., 2013; Fan et al., 2014; Ngai et al., 2014; Tang et al., 2015), including supply chain visibility, better inventory management (Fang et al., 2014), customer service and asset management (Aberdeen Group, 2007), enhance value creation in service innovation projects (Dominguez-Péry et al., 2013), real-time data collection and sharing (Dai and Tseng, 2012; Tang et al., 2015), and smart processes (Fosso Wamba, 2012) and products (Holmqvist and Stefansson, 2006).

We also found some results that contradicted our hypotheses. At the 95% confidence level, we found a negative relationship between RFID adoption and firms' geographic location. We expected that firms located in metropolitan areas would be more likely to adopt RFID technology. However, we actually found that firms located in non-metropolitan areas were more likely to adopt RFID technology, which is consistent with recent findings related to the adoption and use of emerging tools and technologies including social media by SMEs (Fosso Wamba and Carter, 2014). Therefore, **H6 was not supported (Table 5).**

Furthermore, at the 90% confidence level, we also found a negative relationship between RFID adoption intention and managers' age, managers' gender and managers' education. Indeed, we expected that younger managers, male with high education would be more likely to adopt RFID technology, but we found instead that older managers were more likely to do so. Therefore, **H7, H8 and H9 were not supported (Table 5).**

These results contradict prior finding on IT adoption and use, where age, gender and education were found to be strong predictors of IT adoption and use (Venkatesh et al. 2014; Yee-Loong Chong et al., 2015). These conflicting results highlighting the importance of more studies on these predictors.

Moreover, while the industry sector was found not to be significant (**H10 not supported**), the country (control) was found to be significant, and thus **supporting H11 (Table 5)**. All our results for each of our hypotheses are highlighted in Table 5. These conflicting but interesting results should be further investigated in a follow-up study to delve deeper into the issue.

INSERT Table 4

INSERT Table 5

Conclusion and implications for research and practice

In this study, we have explored the role that SMEs' technological, organizational, environmental and managerial characteristics play in the adoption of RFID technology. Our study was designed to offer a deeper understanding of certain key factors that may drive the adoption of RFID technology by SMEs. The proposed model was tested using logistic hierarchical regression since our dependent variable was dichotomous (intention to adopt vs. no intention to adopt) (Patrick and Kar Yan, 1997; McDonald, 2008). Prior to discussing the implications of our study in terms of research and practice, it is important to outline some of its limitations. First, this study used a survey-based approach. This may introduce the so-called "self-report bias," whereby respondents tend to provide responses that they believe are desirable or ideal instead of reporting their actual behavior. Second, we were interested in adoption intention. Future studies should

look more at the actual use of RFID technology as well as the real business value generated by the adoption of the technology at the firm and inter-firm levels.

The results of the study indicate that the intention to adopt RFID technology is mainly related to RFID's relative advantage and compatibility, the firm's size, and the country where the adopting organization is located. The study also found that RFID complexity, the competitive environment, manager characteristics (e.g., age, education and gender), and industry sector were not significant factors driving RFID adoption among SMEs. Therefore, this study identified and validated some salient predictors of RFID adoption for SMEs, contributing to the emerging literature on RFID adoption and use. Indeed, while there are a growing number of articles on RFID technology adoption and use by large organizations, very few of them have focused on its adoption and use by SMEs. Thus, our study extends prior studies on RFID technology. In addition, very few studies have been published on the innovative capacity of SMEs outside the industrial sector (Forsman, 2011). In this study, we focused on SMEs' RFID adoption intentions thus bridging the knowledge gap by identifying the determinants that significantly impact on RFID technology adoption among SMEs and advancing our understanding of the issues affecting these firms. The results of our survey administered to SME managers helped to create some guidelines for managers, who are eager to make evidence-based decisions, notably on the key characteristics on which they should focus before committing their scarce resources and efforts to the implementation of RFID technology projects. Future research may build on the proposed model and explore the inter-organizational determinants of RFID adoption. Finally, lessons learned from the responding firms could help other SMEs use RFID technology effectively. The present study can be further examined using institutional theory and contingent resource based theory.

References

Aberdeen Group. 2007. "RFID: Roadmap for Retail-Visibility Beyond the Supply Chain." Accessed 12 August 2009 http://www.aberdeen.com/summary/report/benchmark/3949_RA_RFIDRetail.asp.

Baars, H., D. Gille, J. Struker. 2009. "Evaluation of RFID Applications for Logistics: A Framework for Identifying, Forecasting and Assessing Benefits." *European Journal of Information Systems* 18 (6): 578-591.

Becker, J., L. Vilkov, B. Wei, and A. Winkelmann. 2010. "A Model Based Approach for Calculating the Process Driven Business Value of RFID Investments." *International Journal of Production Economics* 127 (2): 358-371.

Belfiore, M. 2014. "RFID Helps Maintain Shuttle Buses." Accessed 21 January 2015 https://www.rfidjournal.com/purchaseaccess?type=Article&id=12288&r=%2Farticles%2Fview%3F12288.

Bendavid, Y., S. Fosso Wamba, and J. Barjis. 2013. "The Emerging Research Field of Internet of Things " *Journal of Theoretical and Applied Electronic Commerce Research* 8 (2): 3-11.

Bhattacharya, M., C.H. Chu, and T. Mullen. 2008. "A Comparative Analysis of RFID Adoption in Retail and Manufacturing Sectors." IEEE International Conference on RFID, April 242-249.

Bhattacharya, M., C. H. Chu, T. Mullen, and J. Hayya. 2010. "An Exploratory Study of RFID Adoption in the Retail Sector." *Operations Management Research* 3 (1-2): 80-89.

Brown, I., and J. Russell. 2007. "Radio Frequency Identification Technology: An Exploratory Study on Adoption in the South African Retail Sector." *International Journal of Information Management* 27 (4): 250–265.

Cao, Q., D. R. Jones, and H. Sheng. 2014. "Contained Nomadic Information Environments: Technology, Organization, and Environment Influences on Adoption of Hospital RFID Patient Tracking." *Information & Management* **5**1 (2): 225-239.

Chang, S., D. Klabjan, and T. Vossen. 2010. "Optimal Radio Frequency Identification Deployment in a Supply Chain Network." *International Journal of Production Economics* 125 (1): 71-83.

Churchill, G. A., Jr. 1979. "A Paradigm for Developing Better Measures of Marketing Constructs." *Journal of Marketing Research* 16 (1): 64-73.

Coe, D., E. Helpman, and A. Hoffmaister. 2009. "International R&D Spillovers and Institutions." *European Economic Review* 53: 723-741.

Coronado, D., M. Acosta, and A. Fernández. 2008. "Attitudes to Innovation in Peripheral Economic Regions." *Research Policy* 37 (6): 1009-1021.

Dai, H., and M. M. Tseng. 2012. "The Impacts of RFID Implementation on Reducing Inventory Inaccuracy in a Multi-Stage Supply Chain." *International Journal of Production Economics* 139 (2): 634-641.

Damanpour, F. and M. Schneider. 2009. "Characteristics of Innovation and Innovation Adoption in Public Organizations: Assessing the Role of Managers." *Journal of Public Administration Research & Theory* 19 (3): 495-522.

De Marco, A., A. C. Cagliano, M. L. Nervo, and C. Rafele. 2012. "Using System Dynamics to assess the impact of RFID technology on retail operations." *International Journal of Production Economics* 135 (1): 333-344.

Dominguez-Péry, C., B. Ageron, and G. Neubert. 2013. "A Service Science Framework to Enhance Value Creation in Service Innovation Projects. An RFID Case Study." *International Journal of Production Economics* 141 (2): 440-451.

Dwivedi, Y. K., K. K. Kapoor, M. D. Williams, and J. Williams. 2013. "RFID Systems in Libraries: An Empirical Examination of Factors Affecting System Use and User Satisfaction." *International Journal of Information Management* 33 (2): 367-377.

European Commission. (2013). "Small and medium-sized enterprises (SMEs): What is an SME?" Accessed 13 May 2013 http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/.

Fan, T.-J., X.-Y. Chang, C. -H. Gu, J., -J. Yi, and S. Deng. 2014. "Benefits of RFID Technology for Reducing Inventory Shrinkage." *International Journal of Production Economics* 147 C(0): 659-665.

Fan, T., F. Tao, S. Deng, and S. Li. 2015. "Impact of RFID Technology on Supply Chain Decisions with Inventory Inaccuracies." *International Journal of Production Economics* 159 (0): 117-125.

Ferrer, G., N. Dew, and U. Apte. 2010. "When is RFID Right for Your Service?" *International Journal of Production Economics* 124 (2): 414-425.

Ferrer, G., S. K. Heath, and N. Dew. 2011. "An RFID Application in Large Job Shop Remanufacturing Operations." *International Journal of Production Economics* 133 (2): 612-621.

Fichman, R. G. 2000. "The Diffusion and Assimilation of Information Technology Innovations. Framing the Domains of IT Management: Projecting the Future through the Past." R. W. Zmud. (ed.), Cincinnati, OH: Pinnaflex Educational Resources: 105-127.

Forsman, H. 2011. "Innovation Capacity and Innovation Development in Small Enterprises. A Comparison Between the Manufacturing and Service Sectors." *Research Policy* 40 (5): 739-750.

Fosso Wamba, S. 2011. "Positioning RFID Technology into the Innovation Theory Landscape: A Multidimensional Perspective Integrating Case Study Approach." The 15th Pacific Asia Conference on Information systems (PACIS), July, Brisbane, Australia.

Fosso Wamba, S. 2012. "Achieving Supply Chain Integration Using RFID Technology: the Case of Emerging Intelligent B-to-B e-Commerce Processes in a Living Laboratory." *Business Process Management Journal* 18 (1): 58-81.

Fosso Wamba, S., A. Anand, and L. Carter. 2013. "A Literature Review of RFID-Enabled Healthcare Applications and Issues." *International Journal of Information Management* 33 (5): 875-891.

Fosso Wamba, S., and L. Carter. 2014. "Social Media Tools Adoption and Use by Smes: An Empirical Study." *Journal of End User and Organizational Computing* 26 (2): 1-17.

Fosso Wamba, S., and A. T. Chatfield. 2009. "A Contingency Model for Creating Value From RFID Supply Chain Network Projects in Logistics and Manufacturing Environments." *European Journal of Information Systems* 18 (6): 615-636.

Fosso Wamba, S., L.-A. Lefebvre , Y. Bendavid, and E. Lefebvre. 2008. "Exploring the Impact of RFID Technology and the EPC Network on Mobile B2B Ecommerce: A Case Study in the Retail Industry." *International Journal of Production Economics* 112 (2): 614-629.

Fosso Wamba, S., and E. W. Ngai. 2015. "Importance of Issues Related to RFID-Enabled Healthcare Transformation Projects: Results from a Delphi Study." *Production Planning & Control* 26 (1), 19-33.

Gambon, J. 2011. "RFID Journal Award Winner: Best Use of RFID to Enhance a Product or Service—RFID Delivers a Royal Payback." Accessed 17 January, 2015 https://www.rfidjournal.com/purchase-access?type=Article&id=8579&r=%2Farticles%2Fview%3F8579.

Gambon, J. 2013. "Argentine Winery Harvests Crops With RFID " RFIDJournal Accessed 15 January 2015 https://www.rfidjournal.com/purchase-access?type=Article&id=10425&r=%2Farticles%2Fview%3F10425.

Gaudin, S. 2008. "Some Suppliers Gain from Failed Wal-Mart RFID Edict." Accessed 4 March 2016 http://www.computerworld.com/article/2551910/mobile-wireless/some-suppliers-gain-from-failed-wal-mart-rfid-edict.html.

Gefen, D. and D. W. Straub. 1997. "Gender Differences in the Perception and Use of E-Mail: An Extension to the Technology Acceptance Model." *MIS Quarterly* 21 (4): 389-400.

Greengard, S. 2014. "Custom Door Maker Turns to RFID to Better Manage Business. " Accessed 23 January 2015 https://www.rfidjournal.com/purchaseaccess?type=Article&id=11412&r=%2Farticles%2Fview%3F11412.

Greengard, S. 2014. "Swiss Manufacturer Adopts RFID to Stay Competitive." Accessed 22 January 2015 https://www.rfidjournal.com/purchaseaccess?type=Article&id=12270&r=%2Farticles%2Fview%3F12270.

Gunasekaran, A., and E. W. T. Ngai. 2012. "The Future of Operations Management: An Outlook and Analysis." *International Journal of Production Economics* 135 (2): 687-701.

Hair, J. F., R. E. Anderson, R. L. Tathum, and W. C. Black. 1983. *Multivariate Data Analysis.* Tulsa, OK: PPC Books.

Hardgrave, B. and R. Miller. 2006. "The Myths and Realities of RFID." *International Journal of Global Logistics & Supply Chain Management* 1 (1): 1-16.

Harland, C., N. Caldwell, P. Powell, and J. Zheng. 2007. "Barriers to Supply Chain Information Integration: SMEs Adrift of Elands." *Journal of Operations Management* 25 (6): 1234-1254.

Hassan, M., M. Ali, E. Aktas, and K. Alkayid. 2015. "Factors Affecting Selection Decision of Auto-Identification Technology in Warehouse Management: An International Delphi Study." *Production Planning & Control* 26 (12): 1025-1049.

Herrmann, S., H. Rogers, M. Gebhard, and E. Hartmann. 2015. "Co-Creating Value in the Automotive Supply Chain: An RFID Application for Processing Finished Vehicles." *Production Planning & Control* 26 (12): 981-993.

Holmqvist, M., and G. Stefansson. 2006. "Smart Goods' and Mobile RFID: A Case with Innovation from Volvo." *Journal of Business Logistics* 27 (2): 251-272.

Jeyaraj, A., J. W. Rottman, and M. C. Lacity. 2006. "A Review of the Predictors, Linkages, and Biases in IT Innovation Adoption Research." *Journal of Information Technology* 21 (1): 1-23.

Keating, B. W., T. R. Coltman, S., Fosso Wamba, and V. Baker. 2010. "Unpacking the RFID Investment Decision." Proceedings of the IEEE: 98 (9), 1672-1680.

Kim, J., K. Tang, S. Kumara, S. -T. Yee, and J. Tew. 2008. "Value Analysis of Location-Enabled Radio-Frequency Identification Information on Delivery

Chain Performance." *International Journal of Production Economics* 112 (1): 403-415.
Kitchell, S. 1997. "CEO Characteristics and Technological Innovativeness: A Canadian Perspective." *Canadian Journal of Administrative Sciences / Revue Canadienne des Sciences de l'Administration* 14 (2): 111-121.
Laosirihongthong, T., P. Punnakitikashem, and D. Adebanjo. 2011. "Improving Supply Chain Operations by Adopting RFID Technology: Evaluation and Comparison of Enabling Factors." *Production Planning & Control* 24 (1): 90-109.
Lee, I., and B.-C. Lee. 2010. "An Investment Evaluation of Supply Chain RFID Technologies: A Normative Modeling Approach." *International Journal of Production Economics* 125 (2): 313-323.
Lee, L. S., K. D. Fiedler, and J. S. Smith. 2008. "Radio Frequency Identification (RFID) Implementation in the Service Sector: A Customer-Facing Diffusion Model." *International Journal of Production Economics* 112 (2): 587-600.
Lee, H., and O. Ozer. 2007) "Unlocking the Value of RFID." *Production and Operations Management* 16 (1): 40-64.
Lipton, A. 2013. ".Health Club Saves Money with RFID Laundry Solution " Accessed 23 January 2015 https://www.rfidjournal.com/purchaseaccess?type=Article&id=10736&r=%2Farticles%2Fview%3F10736.
Lipton, A. 2013. "Hospital Deploys RFID to Boost Hand-Washing Compliance " Accessed 23 January 2015 https://www.rfidjournal.com/purchaseaccess?type=Article&id=11121&r=%2Farticles%2Fview%3F11121.
Marcati, A., G. Guido, and A. Peluso. 2008. "The Role of SME Entrepreneurs' Innovativeness and Personality in the Adoption Of Innovations." *Research Policy* **37** (9): 1579-1590.
Masters, J. M., G. M. Allenby, B. J. La Londe, and A. Maltz. 1992. "On the Adoption of DRP." *Journal of Business Logistics*, 13: 47-68.
McCartney, L. 2012. "RFID for Small Ski Resorts." Accessed 17 January 2015 https://www.rfidjournal.com/purchase-access?type=Article&id=9399&r=%2Farticles%2Fview%3F9399.
McDonald, J. H. 2008. *Hanbook of Biological Statistics*. Baltimore, Maryland Sparky House Publishing.
Nativi, J. J., and S. Lee. 2012. "Impact of RFID Information-Sharing Strategies on a Decentralized Supply Chain with Reverse Logistics Operations." *International Journal of Production Economics* 136 (2): 366-377.
Ngai, E. W. T., B. K. S. Cheung, S. S. Lam, and C. T. Ng. 2014. "RFID Value in Aircraft Parts Supply Chains: A Case Study." *International Journal of Production Economics* 147 (PB): 330-339.
Ngai, E. W. T., F. F. C. Suk, and S. S. Lo. 2008. "Development of an RFID-Based Sushi Management System: The Case of a Conveyor-Belt Sushi Restaurant." *International Journal of Production Economics* 112 (2): 630-645.
Nunnally, J. C., and I. H. Bernstein. 1994. Psychometric Theory: New York, McGraw-Hill.
Patrick, Y. K. C., and T. Kar Yan. 1997. "Factors Affecting the Adoption of Open Systems: An Exploratory Study." *MIS Quarterly* 21 (1): 1-24.
Pero, M. and T. Rossi. 2013. "RFID Technology for Increasing Visibility in ETO Supply Chains: A Case Study." *Production Planning & Control* 25 (11): 892-901.

Pfahl, L., and C. Moxham. 2012. "Achieving Sustained Competitive Advantage by Integrating ECR, RFID and Visibility in Retail Supply Chains: A Conceptual Framework." *Production Planning & Control* 25 (7): 548-571.
Pontikakis, D., and P. Collins. 2010. "Exploring Geographic Variation in Corporate Broadband Adoption; Evidence from Irish Small- and Medium-Sized Enterprises (SMEs)." *Telecommunications Policy* 34 (3): 144-161.
Premkumar, G., K. Ramamurthy, and S. Nilakanta. 1994. "Implementation of Electronic Data Interchange: An Innovation Diffusion Perspective." *Journal of Management Information Systems* 11 (2): 157–186.
Premkumar, G., and M. Roberts. 1999. "Adoption of New Information Technologies In Rural Small Businesses." *Omega International Journal of Management Science, 27* (4): 467– 484.
Quetti, C., F. Pigni, A. Clerici. 2012. "Factors Affecting RFID Adoption in a Vertical Supply Chain: The Case of the Silk Industry in Italy." *Production Planning & Control* 23 (4): 315-331.
Reaidy, P., A. Gunasekaran, and A. Spalanzani. 2015. "Bottom-Up Approach Based on Internet of Things for Order Fulfillment in A Collaborative Warehousing Environment." *International Journal of Production Economics* 159: 29-40.
Reyes, P. M., S. Li, and J. K. Visich. 2012. "Accessing Antecedents and Outcomes of RFID Implementation in Health Care." *International Journal of Production Economics* 136 (1): 137-150.
Rogers, E. M. 1995. *Diffusion of Innovations*. New York, Free Press.
Rogers, E. M. 2003. *Diffusion of Innovation*. New York, Free Press.
Ross, A. D., D. Twede, R. H. Clarke, and M. Ryan. 2009. "A Framework for Developing Implementation Strategies for a Radio Frequency Identification (RFID) System in a Distribution Center Environment." *Journal of Business Logistics* 30 (1): 157-183.
Sharma, A., and A. Citurs. 2005. "Radio Frequency Identification (RFID) Adoption Drivers: A Radical Innovation Adoption Perspective." *Proceedings of the eleventh American conference on information systems*, August, Omaha, USA, 1213–1218.
Sharma, A., D. Thomas, and B. R. Konsynski. 2008. "Strategic and Institutional Perspectives in the Evaluation, Adoption and Early Integration of Radio Frequency Identification (RFID): An Empirical Investigation of Current and Potential Adopters." *Proceedings of the 41st Annual Hawaii International Conference on System Sciences*, January, Waikoloa, Big Island of Hawaii, HI, 1–10.
Slyke, C. V., C. L. Comunale, and F. Belanger. 2002. "Gender Differences in Perceptions of Web-Based Shopping." Communications of the ACM - Evolving Data Mining into Solutions for Insights 45 (8): 82-86.
Szmerekovaky, J. G., and J. Zhang. 2008. "Coordination and Adoption of Item-Level RFID with Vendor Managed Inventory." *International Journal of Production Economics* 114: 388-398.
Tajima, M. 2007. "Strategic Value Of RFID in Supply Chain Management." *Journal of Purchasing & Supply Management* 13 (4): 261-273.
Tang, L., H. Cao, L. Zheng, and N. Huang. 2015. "Value-Driven Uncertainty-Aware Data Processing for an RFID-Enabled Mixed-Model Assembly Line." *International Journal of Production Economics* 165: 273-281.
Teo, T.S.H, S. Lin, and K-H. Lai. 2009. "Adopters and Non-Adopters of E-Procurement in Singapore: An Empirical Study." *Omega* 37: 972-987.

Tiago, O., and M. F. Martins. 2009. "Firms Patterns of E-Business Adoption: Evidence for the European Union-27." *The Electronic Journal of Information Systems Evaluation* 13 (1): 47-56.
Tornatzky, L., and M. Fleischer. 1990. *The Processes of Technological Innovation:* The Free Press, New York.
Tornatzky, L. G., and K. J. Klein. 1982. "Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings." *IEEE Transactions on engineering management* 29 (1): 28-45.
Tsai, M.-C., K.-H. Lai, and W. -C. Hsu. 2013. "A Study of the Institutional Forces Influencing the Adoption Intention of RFID by Suppliers." *Information & Management* 50 (1): 59-65.
Tsai, M.-C., W. Lee, and H. -C. Wu. 2010. "Determinants of RFID Adoption Intention: EvidencefFrom Taiwanese Retail Chains." *Information & Management* 47 (5-6): 255-261.
Venkatesh, V., and M. G. Morris. 2000. "Why Don't Men Ever Stop to Ask for Directions? Gender, Social Influence, and Their Role in Technology Acceptance and Usage Behavior." *MIS Quarterly* 24 (1): 115-139.
Venkatesh, V., T. A. Sykes, and S. Venkatraman. 2014. "Understanding E-Government Portal Use in Rural India: Role of Demographic and Personality Characteristics." *Information Systems Journal* 24 (3): 249-269.
Véronneau, S., and J. Roy. 2009. "RFID Benefits, Costs, and Possibilities: The Economical Analysis af RFID Deployment in a Cruise Corporation Global Service Supply Chain." *International Journal of Production Economics* 122 (2): 692-702.
Violino, B. 2003. "Wal-Mart Expands RFID Mandate." Accessed 4 March 2016 http://www.rfidjournal.com/articles/view?539.
Violino, B. (2013). "Fortis Escorts Heart Institute Manages Outpatients Via RFID." Accessed 15 January, 2015 https://www.rfidjournal.com/purchase-access?type=Article&id=10322&r=%2Farticles%2Fview%3F10322.
Violino, B. (2014). "ROI on Temperature-Monitoring Solution Leads to RFID Asset Tracking." Accessed 5 January 2015 https://www.rfidjournal.com/purchaseaccess?type=Article&id=12515&r=%2Farticles%2Fview%3F12515.
Visich, J. K., S. Li., B. M. Khumawala, and P. M. Reyes. 2009. "Empirical Evidence of RFID Impacts on Supply Chain Performance." *International Journal of Operations & Production Management* 29 (12): 290-1315.
Wang, Y. M., Y. S. Wang, and Y. F. Yang. 2010. "Understanding the Determinants of RFID Adoption in the Manufacturing Industry." *Technological Forecasting and Social Change* 77 (5): 803–815.
Wong, W. K., S.Y.S. Leung, Z.X. Guo, X.H. Zeng, and P.Y. Mok. 2012. "Intelligent Product Cross-Selling System with Radio Frequency Identification Technology for Retailing." *International Journal of Production Economics* 135 (1): 308-319.
Yazici, H. J. 2014. "An Exploratory Analysis of Hospital Perspectives on Real Time Information Requirements and Perceived Benefits of RFID Technology for Future Adoption." *International Journal of Information Management* 34 (5): 603-621.
Yee-Loong Chong, A., M. J. Liu, J. Luo, O. Keng-Boon. 2015. "Predicting RFID Adoption in Healthcare Supply Chain From the Perspectives of Users." *International Journal of Production Economics* 159 (0): 66-75.

Zeller, R. A. and E. G. Carmines. 1980. *Measurement in Social Sciences: The Link Between Theory and Data*. New York, Cambridge University Press.
Zhang, Z., A. Waszink, and J. Wijngaard. 2000. "An Instrument for Measuring TQM Implementation for Chinese Manufacturing Companies." *International Journal of Quality & Reliability Management* 17 (7): 730 - 755.
Zhu, K., Dong, S., Xu, S. X., Kraemer, K. L. 2006. "Innovation Diffusion in Global Contexts: Determinants of Post-Adoption Digital Transformation of European Companies." *European Journal of Information Systems* 15: 601-616.
Zhu, K., K. L. Kraemer, and S. Xu. 2003. "Electronic Business Adoption by European Firms: A Cross-Country Assessment of The Facilitators and Inhibitors." *European Journal of Information Systems* 12 (4): 251-268.
Zhu, X., S. K. Mukhopadhyay, and H. Kurata. 2012. "A Review of RFID Technology and Its Managerial Applications in Different Industries." *Journal of Engineering and Technology Management* 29 (1): 152-167.

Appendix 1: Survey Items

1. Firm size: How many employees do you have?

1) full-time

2) part-time

Personal characteristics of manager

2. What is the gender of the owner / CEO?

☐ 1) Male
☐ 2) Female

3. What is the age of the owner / CEO?

……..Years

4. What is the highest education qualification of the owner / CEO?

- ☐ 1) No formal qualification
- ☐ 2) Primary qualification
- ☐ 3) Secondary qualification
- ☐ 4) College qualification (diploma/certificate)
- ☐ 5) Undergraduate degree
- ☐ 6) Postgraduate degree (Master/Ph.D.)

98) CAN'T SAY

Technological innovation characteristics

5. Relative advantage

1)	My company expects RFID to help lower inventory costs	☐ Yes	☐ No
2)	My company expects RFID to help speed up data capture and analysis	☐ Yes	☐ No
3)	My company expects RFID to help reduce paperwork	☐ Yes	☐ No

6. Complexity

1)	My company believes that RFID is complex to use	☐ Yes	☐ No
2)	My company believes that RFID development is a complex process	☐ Yes	☐ No

7. Compatibility

1)	The changes introduced by RFID are consistent with my firm's existing beliefs/values	☐ Yes	☐ No
2)	RFID is compatible with our firm's existing information infrastructure	☐ Yes	☐ No
3)	The changes introduced by RFID are consistent with our firm's existing practices	☐ Yes	☐ No
4)	RFID development is compatible with my firm's existing experiences with similar systems	☐ Yes	☐ No

Environmental factors

8. Competitive environment

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1)	My company experienced competitive pressure to implement RFID	1	2	3	4	5
2)	My company would have experienced a competitive disadvantage if RFID had not been adopted	1	2	3	4	5

9. Firm's geographic location: Is your business's head office located in a metropolitan or non-metropolitan area?

- ☐ 1) Metropolitan area
- ☐ 2) Non-metropolitan area

10. Industry sector: Which of the following best describes the industry sector you operate in?

- ☐ 1) Accommodation and food service activities
- ☐ 2) Administrative and support service activities
- ☐ 3) Agriculture, forestry and fishing
- ☐ 4) Arts, entertainment and recreation
- ☐ 5) Construction
- ☐ 6) Education
- ☐ 7) Electricity, gas, steam and air conditioning supply
- ☐ 8) Financial and insurance activities
- ☐ 9) Human health and social work activities
- ☐ 10) Information and communication
- ☐ 11) Manufacturing
- ☐ 12) Mining and quarrying
- ☐ 13) Professional, scientific and technical activities
- ☐ 14) Public administration and defense; compulsory social security
- ☐ 15) Real estate activities

☐ 16) Transportation and storage
☐ 17) Water supply; sewerage, waste management
☐ 18) Wholesale and retail trade; repair of motor vehicles and motorcycles
☐ 19) Other service activities

11. Country of ownership of your firm (Please select multiple options if joint ownership)

☐ 1) Africa
☐ 2) Australia
☐ 3) East Asia
☐ 4) Middle East
☐ 5) New Zealand
☐ 6) North America
☐ 7) South America
☐ 8) South Asia
☐ 9) UK
☐ 10) Other Europe
☐ 98) Elsewhere (Please specify)

Adoption intention

12. Is your company planning to purchase an RFID technology solution in the near future?

☐ 1) Yes
☐ 2) No (if not, why? ……..)