Unpacking the RFID Investment Decision

Valerie Baker, Tim Coltman, Samuel Fosso Wamba and Byron Keating

Abstract— **Mandates aside, there are many reasons why firms decide to move forward with or delay investment in RFID technology. In this paper we use a theoretically based, easy to implement methodology to empirically derive a relative importance scale of those factors that influence the decision to invest in RFID technology. More specifically, we compare the factors that matter most and least to a sample of firms that have adopted RFID technology with a sample of firms that have yet to embrace RFID technology. The theoretical and practical implications are that both RFID adopters and non adopters are driven by the promise of greater data accuracy, improved information visibility, service quality, process innovation, and track and trace capabilities. What separates the adopters from the non adopters is an opportunity to derive strategic benefits from RFID through improved decision making. Not surprisingly, the non adopting firms are primarily concerned with the high acquisition and other ongoing costs associated with RFID technology.**

Index Terms—**Radio frequency identification, technology adoption, information technology, innovation.**

I. INTRODUCTION

Technology innovation is widely recognized as an important driver of business transformation and economic growth [1], [2]. The most radical examples are found in situations where the creation and application of information technologies provide open and ubiquitous connectivity. The personal computer, mobile telephone and internet are examples of information technologies that have become both ubiquitous [3] and disruptive [4]. Radio frequency identification (RFID) represents a new technological innovation that has captured the imagination of the scholarly community and some scholars have gone so far as to suggest that RFID represents a disruptive innovation [5] that will revolutionize the supply chain [6].

History tells us that the path to acceptance within the business community can be long for technological innovations. For example, the Internet has its origins in the late 1960s and 1970s, and did not reach wide acceptance until the late 1990's. The primary catalyst for widespread adoption came with a change in the business perceptions of value based on the advent of fast, reliable and low cost hypertext markup language applications. In other words, the perceived benefits or risks that are held by the users of each technological innovation influence the rate of acceptance [7], [8].

It is critical therefore, that the perceptions of business value—that are held by adopters and non adopters—be identified and brought into the early discussions about RFID innovation. This is necessary to spur a deeper understanding of exactly what factors should be addressed to drive forward the development of RFID. Although pundits have predicted high rates of RFID adoption, the reality is that many firm shave yet to seriously embrace RFID technology. The reluctance by many of WalMart's retail suppliers to comply with its RFID mandate is a high profile example. This implies that not all firms are willing to embrace RFID and the technology may not be as disruptive as some have made it out to be.

II. PROBLEM DEFINITION

This discussion implies that it is important to examine the following three research questions:

1. What factors matter most and least to firms when considering an investment in RFID?
2. How does the importance of these factors vary between adopters and non-adopters?
3. Where should future development effort be directed to accelerate the rate of RFID adoption?

All three questions are of practical and theoretical importance and directly address the call in this special issue for a greater understanding of the business impacts of RFID innovation.

First, a lot has been written about the implications of RFID as an alternative to traditional automatic identification and data capture technologies such as barcode systems for tracking items throughout the supply chain [9]. Anecdotal evidence indicates that RFID has had a relatively slow rate of adoption and that the widespread RFID adoption based on a solid business case is still some years away. The main reason for this is that RFID technology provides a particular challenge when it comes to understanding the way firms assess business value and risk. For example, the benefits of RFID technology are greatest when it is integrated into a wider interorganizational context [10], [11]. This is common to prior work that has found that the diffusion of interorganizationnal innovation is dependent upon network externalities and positive feedback [12], [13].

Second, prior work on RFID diffusion has developed a laundry list of possible factors that contribute to the RFID business case. These include unique item and product level identification, non line of sight requirements, multiple tag and item reading, greater data storage capacity and data read/write capabilities [14], [15], better inventory records [16], improved organization coordination and control [17], real-time data collection and sharing among supply chain stakeholders [18], and business process innovation [19]. However, these benefits come with potential risks such as: high infrastructure and implementation costs [20], [21], switching costs [21], immature standards, and privacy and security concerns [20]. The studies described are common in that they characterize RFID according to discrete benefits and risks. Little work has compared the relative importance of a large number of different benefits and risks or tested

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the moderating effects (individual and organizational) that may influence the relative importance of various factors on the rate of RFID diffusion and adoption.

Third, known theoretical and methodological biases have impeded progress. These biases include the pro innovation bias (all adoption is good), rational bias (adopters make rational decisions) [22] and pro-adopter bias (non adopters are understudied) [8]. What we require is a method that allows us to capture the relative importance of different RFID benefits and risks in a realistic way. To achieve this we utilize a novel method based on maximum difference scaling or best-worst scaling to identify the organizational factors considered to be most important and least important to the RFID investment decision. The method has been successfully applied to many different organizational contexts in order to identify the efficacy of managerial decision making, and to identify the preference structures for products and services [23].

The remaining sections of this paper are organized as follows. The next section develops the theoretical background as it applies to the IT innovation literature and the specific benefits and risks associated with RFID technology. We then describe the methodology and present the results from our survey of 133 firms. Finally we conclude with a discussion on the implications of this work for academics and practitioners.

III. BACKGROUND THEORY

A. *The IT innovation literature*

Although the IT innovation literature is both voluminous and diverse, researchers have characterized the literature according to two broad streams of work: (1) structural characteristics of industrial innovation and (2) the nature of innovation demand. The first stream deals with the different types of innovation and has examined the structural characteristics of an industry, product (architecture), market or firm. The primary focus is to seek answers to why and how IT artifacts emerge and what impact they have on the business. The second stream has focused on modeling the demand for innovation and has primarily applied diffusion of innovation theory to discern patterns of adoption for new artifacts [8]. In this stream of research scholars have sought to identify adopter attitudes and their innovation-related behavior [24]. This has lead to the identification of various innovation characteristics, technologies, organizational and environmental factors that affect the IT adoption decision [25].

For example, the seminal work by [8], has proposed that the following characteristics explain a firm's usage of particular innovations: (1) the degree to which an innovation can bring benefits to an organization; (2) the degree to which an innovation is consistent with existing business processes, practices and value systems; (3) the degree to which an innovation is difficult to use; and (4) the degree to which the results of an innovation are visible to others. Understanding the impact of each of these characteristics is the key to IT innovation success.

Despite increased awareness of the characteristics that underpin IT innovation, many organizations still report an inability to justify their investment decisions in new IT. This is a demand side problem that arises due to a lack of understanding about the nature of the costs and benefits associated with the adoption and use of IT [26 p. 38]. In other words, widespread adoption of RFID will continue to stall until managers with responsibility for adoption decisions can articulate the real business value of RFID within their organization. This requires a sound understanding of the various drivers and impediments (benefits, risks, challenges, costs) to RFID and should precede the commitment of large amounts of money, time and resources towards RFID technology.

The strategic management literature suggests that the categories of opportunity (benefit) and threat (risk) are relevant and consequential for decision processes [27]. In the specific case of RFID technology, we can derive that the organizational benefits achievable through RFID adoption present as opportunities and the potential adoption risks are categorized as threats [28]. The literature on managerial decision making identifies opportunities as a positive situation in which gain is likely, alternatively, threats are seen as a negative situation in which loss is likely [29].

B. *Specific factors influencing adoption of RFID*

Radio frequency identification technology offers a vast range of benefits. For example, RFID technology can help all stakeholders to reduce shrinkage, reduce material handling costs, increase data accuracy, enabler supply chain business process innovation and improved information sharing [19], [30], [31], [32].

An important part of the strategic decision-making process is to weigh up the benefits of adopting RFID against the risks. The relatively low rates of adoption imply that within the minds of managers, the risks of RFID adoption may outweigh the benefits. The risks associated with RFID range from organizational factors, such as adequate infrastructure, resources and skill [33] to technical factors, that are centered around systems integration [34]. The high costs of purchasing tags and supporting infrastructure is thought to be a prominent adoption barrier. [35 p. 24], in her study on the RFID implementation issues, practices, and benefits within the foodservice sector, found that the two most important issues that needed to be addressed before committing to RFID were: (1) the RFID cost-benefit analysis; and (2) the better way to integrate RFID system with existing business models, business strategies, staff operations, and technology infrastructure". On the other hand, [36], in an RFID trial at IKEA found that the cost of introducing RFID technology is not generally a barrier. This implies that capital costs are not the only risk to be considered to RFID adoption. Many technical challenges arise such as the integration of RFID tags and readers with supporting software and existing IT infrastructure.

The standardization of data across the supply chain, such as data related to products, vendors and shippers, as well as the data on the RFID tags themselves is critical in order to realize real business value from RFID [37]. In fact, [34] empirically determined that a lack of industry RFID standards negatively affected adoption of the technology. Their research results suggested that standards ambiguity may limit the expectation of ROI because of the inability of firms to deploy RFID across supply chain partners.

Part of the attractiveness of RFID is the ability to create more transparent information sharing across the supply chain. However, for firms to achieve any real planning benefits from RFID adoption they need to deal with the complexity of information sharing across multiple partners. [38] suggest that the biggest advantages in this area will be for those firms operating in complex manufacturing industries that receive a widespread variety of goods on a frequent basis. For firms operating within commodity markets, RFID is likely to provide less of an advantage. The implications that can be drawn are that the strategic benefits from RFID are context dependent and may differ between various firms based on individual and organizational factors.

IV. DESCRIPTION OF THE METHOD

A. *Experimental research design*

An effective method for evaluating the relative importance of the benefits and risks involved in an RFID investment, is to model the actual trade-off that managers are willing to make. We utilize a reduced form of discrete choice analysis referred to as best-worst scaling. The method is based on an ordering task that requires respondents to make a selection from a group of factors by choosing the "best" (most preferred) and "worst" (least preferred) factor from a series of blocks that contain three or more factors. The factors could be attributes of a product, options in a decision, or bundles of

services and products. Specifically, best-worst estimation assumes that there is some underlying subjective dimension, such as "degree of importance", "extent of preference", "degree of concern", etc., and that the researcher wishes to measure the location or position of some set of factors on that dimension. The approach is particularly effective in ordering preferences when the number of factors is large; as individuals are better able to determine which two factors from a smaller group of items are "best" and "worst" than they are at providing the specific ordering of 1, 2, 3,…, N. Best-worst scaling has the added benefit that it is quick and simple to execute, provides results that are empirically consistent with more complex ordering tasks and is theoretically in line with the precepts of random utility theory.

The statistical model that is used for estimation is the conditional logit model. This model extends the multinomial logit model to allow for the inclusion of explanatory variables related to the choice set options. The composition of the choice sets is consequently determined according to some underlying experimental design. In the case of best-worst choice models, this is achieved using a balanced and incomplete block design. This type of design aims to minimize the resulting number of choices, whilst ensuring balance between the total number of times an factor appears in the experiment, and the number of times each factor appears alongside every other factor in the design [39].

Table 1. Firm characteristics

	Aggregate (N=133)	*Adopter (N=57)*	*Non-adopter (N=76)*
Industry			
Agriculture and Fishing	2.5	5.9	0.1
Construction	4.2	3.9	4.4
Finance, Insurance and Real Estate	3.4	0.1	5.9
Manufacturing	29.4	25.4	32.3
Mining	2.5	5.9	0.1
Public Administration	5.0	3.9	5.9
Retail Trade	6.7	7.8	5.9
Services	31.1	31.4	30.8
Transport, Communications Electric	10.1	11.8	8.8
Wholesale Trade	5.0	3.9	5.9
Firm size			
Small business (less than 20 staff)	39.3	30.1	47.2
Medium (20 to 200 staff)	21.2	30.0	13.2
Large (more than 200 staff)	39.5	39.0	39.6
Mean	53188	83950	3780
Financial position			
Revenue (Average $US,000)	2,614,463	4,519,776	928,993
Profit margin (average)	17.5	15.1	19.6
Existing infrastructure			
Enterprise resource planning	53.9	46.4	59.5
Supply chain management	57.7	55.4	59.5
Customer relationship management	84.6	89.3	81.1
Internal Database	62.3	57.1	66.2
Business intelligence/Data warehouse	68.5	67.9	68.9
Internet applications/Web services	70.0	69.6	70.3
Product lifecycle management	69.2	76.8	63.5

In this study we utilized a 21-factor design, resulting in 21 choice sets of 5 factors. A detailed pre-testing procedure was employed to capture the full range of factors that are potentially important in the RFID investment decision. This list was sourced from extensive rounds of exploratory work that included reviewing the academic literature, industry reports and websites, along with insight gained from numerous discussions with experienced academics, customers and practitioners. This work identified 21 factors in four general categories that reflect the common themes in the literature related to the evaluation and decision to invest in RFID. These were: (a) resource issues: acquisition costs, ongoing costs, top management commitment, operational level expertise, replacement costs and integration complexity; (b) technology issues: standards ambiguity, security threats, technology maturity and privacy threats; (c) automation issues: inventory management, data capacity, track and trace, compliance and process innovation; (d) supply chain issues: information visibility, data accuracy, service quality, decision making, competitive differentiation and technology leadership. Operational definitions were developed to capture the domain for each of the 21 factors and to ensure that each responding decision-maker understood the meaning of these factors in exactly the same way. The definitions of these factors are available upon request.

Pilot testing conducted during a recent research forum on RFID held by the Wireless Internet for Mobile Enterprise Consortium at UCLA confirmed the validity of the list along with their definitions. While we are confident that this list represents a comprehensive list of factors influencing the RFID adoption decision, we acknowledge that it is not exhaustive, and that there may be other factors influencing the decision to invest in RFID that have not been included in our study.

In addition to the experimental best-worst task, respondents were also asked questions about their risk orientation, and the dependence of the firm on technology. The specific questions along with the psychometric properties of the associated measurement scales are available upon request.

B. Data collection procedures

Responses were sampled randomly from the readership of the RFID Journal. One hundred and thirty three customers completed an online version of the questionnaire. The distribution of respondents covers most of the main segments of business activity: wholesale trade (5%), retail trade (7%), transportation and communications (10%), business services (31%), communication services (6%), manufacturing (29%), finance and insurance (3%), mining (3%), government administration and defense (5%). Firm size was also well distributed, with 39 percent of the sample from small sized firms (less than 20 employees), 21 percent from medium sized firms (20 to 200 employees) and 40 percent large firms (more than 200 employees). The mean number of employees for the entire sample was 53,188. The results indicate that our sample is skewed towards larger firms. A review of the sample indicates the majority of these firms are subsidiaries of multinational companies. Key descriptive sample data are provided in Table 1.

V. EVALUATING THE TRADEOFFS BETWEEN FACTORS

A. Aggregate model

In this section we show how this approach can be used to identify what influences firms when considering an RFID investment decision. For the purpose of this analysis, we used a variant on best-worst that focused on most-least. That is, we asked respondents to

Table 2. Best-worst results for aggregate model

	Best	*Worst*	*B-W*	β	$\exp(\beta)$	*Share*
Data accuracy	248	32	216	0.98***	2.66	0.11
Top management commitment	245	89	156	0.68***	1.97	0.08
Information visibility	199	61	138	0.63***	1.87	0.08
Inventory management	214	79	135	0.62***	1.85	0.08
Track & trace	193	70	123	0.56***	1.74	0.07
Service quality	135	51	84	0.41***	1.50	0.06
Process innovation	163	81	82	0.37***	1.45	0.06
Acquisition costs	174	98	76	0.33***	1.39	0.06
Ongoing costs	168	101	67	0.29***	1.34	0.05
Decision making	123	80	43	0.21***	1.24	0.05
Integration complexity	121	105	16	0.08	1.08	0.04
Operational level expertise	122	113	9	0.05	1.05	0.04
Technological maturity	115	119	-4	-0.03	0.97	0.04
Competitive differentiation	153	174	-21	-0.15	0.86	0.03
Technology leadership	100	154	-54	-0.26	0.77	0.03
Replacement costs	78	160	-82	-0.34	0.71	0.03
Compliance	61	183	-122	-0.52	0.59	0.02
Data capacity	46	201	-155	-0.67	0.51	0.02
Standards ambiguity	39	228	-189	-0.85	0.43	0.02
Security threats	56	254	-198	-0.92	0.40	0.02
Privacy threats	40	360	-320	-1.47	0.23	0.01

Note: *** p<0.001 ** p<0.01 * p<0.05.

identify from the set of possible alternatives, which factor mattered "most" and "least" in terms of the RFID investment decision.

Table 2 provides a summary of the key data from this analysis. The "most" and "least" columns indicate the number of times that a particular factor was selected by all respondents across all choice sets. The column labeled "β" provides the corresponding marginal utilities from the conditional logit model. For ease of interpretation, we rescale these values in the "share" column according to the underlying logit model such that they sum to 1. We can see that the factor with the greatest influence on RFID investment is "data accuracy" which accounts for 11 percent of preferences, followed by "top management commitment" and "information visibility" which account for 8 percent each. Conversely, the factors with the least impact on the RFID investment decision are "privacy threats" followed by "security threats" and "standards ambiguity" which account for 1, 2 and 2 percent respectively.

A valuable byproduct of the relative nature of choice-based modeling is that the resulting factor effects, are captured on a relative scale. In other words, "top management commitment" with a relative share of 0.08 is actually twice as important as "integration complexity" with a relative share of 0.04, and eight times as important as "privacy threats".

B. Distinguishing between adopters and non-adopters

While the data presented above provides an interesting snapshot of what influences RFID investment at the aggregate level, it is also interesting to understand how these preferences vary when we control for adopters vis-à-vis non-adopters. Because of scale factor issues, it is not possible to make a direct comparison between factor effects in nested samples without first isolating the scale factor effect. To correct this situation, we determined an appropriate multiplier for the non-adopter model relative to the adopter model using the procedure suggested by [40].

Figure 2 provides a comparison of the preference shares for adopter and non-adopter samples. From this we can see that adopters identify with what they believe are potential strategic advantages from investment in RFID. For example, those firms that have currently adopted RFID are more concerned with "information visibility" and "competitive differentiation" and less concerned with the costs. On the other hand, those firms that have not yet adopted RFID are more concerned with acquisition, replacement and ongoing costs. Interestingly, both groups are interested in benefits such as greater data accuracy, better track and trace capabilities and improved inventory management. This implies that future work should be directed towards these three common operational factors.

C. Impact of risk aversion and experience with IT

It was also hypothesized that a firm's risk orientation, and the level of prior experience with IT, will impact on the preference for RFID investment. To investigate these hypotheses we introduced two additional predictor variables to the original conditional logit model; (1) risk orientation, and (2) firm reliance on technology.

Table 4 provides an overview of how these variables impacted on the factor effects. From this table we can see that the level of risk aversion has a different impact on those firms that have adopted RFID technology and those firms that have yet to adopt RFID technology. In the case of the RFID adopters that consider themselves to be risk averse, two factors stand out as important: (1) integration complexity, and (2) operational level expertise. In the case of adopters that do not have a lot of experience with IT, two factors were found to be stand out; competitive differentiation and technological maturity. Risk aversion and technological adoption do not materially affect the non-adopter sample. In other

Figure 1. Share of Preferences for Adopters and Non-adopters

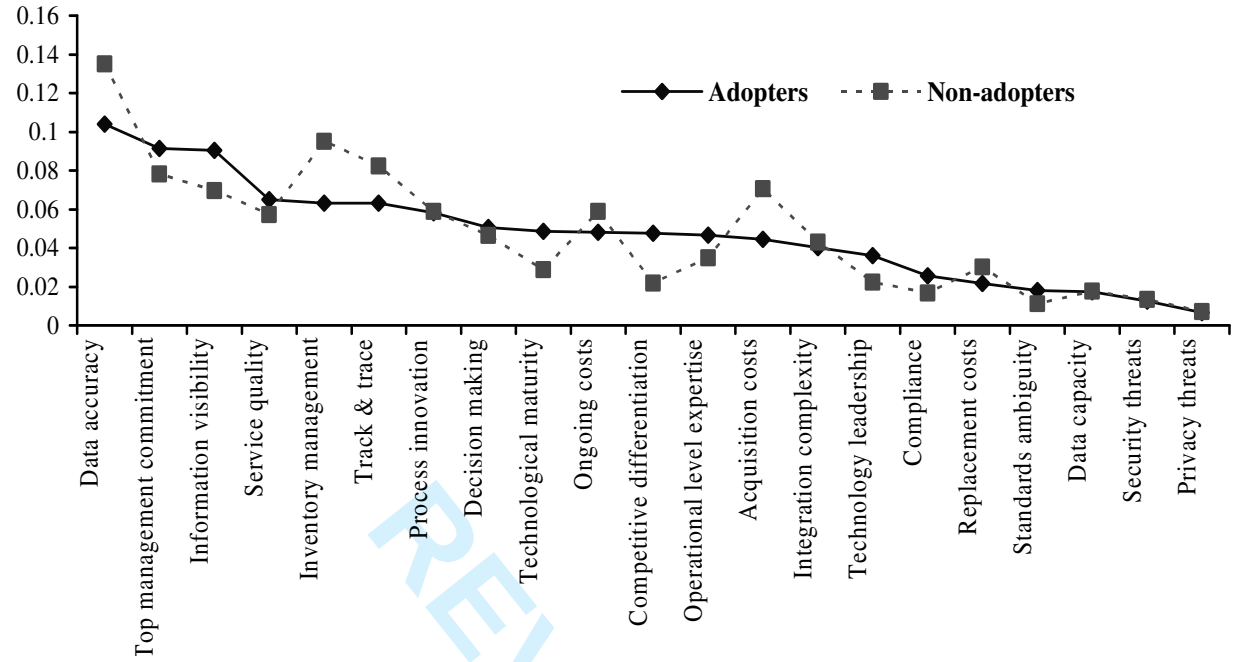

Table 3. Impact of executive judgment on adoption

	β_{adopt}	$\beta_{adopt \bullet risk}$	$\beta_{adopt \bullet tech \mid firm}$	$\beta_{non-adopt}$	$\beta_{non-adopt \bullet risk}$	$\beta_{non-adopt \bullet tech \mid firm}$
Acquisition costs	0.12	0.16	0.13	0.65***	0.39***	0.77***
Competitive differentiation	0.19	0.07	0.25*	-0.52	-0.26	-0.73
Compliance	-0.43	-0.16	-0.60	-0.78	-0.78	-0.86
Data accuracy	0.97***	0.69***	1.01***	1.30***	1.30***	1.25***
Data capacity	-0.82	-0.92	-0.74	-0.73	-0.83	-0.75
Decision making	0.25**	0.02	0.30**	0.23**	0.26	0.25
Information visibility	0.83***	0.69***	0.91***	0.64***	0.87***	0.52***
Integration complexity	0.02	0.32*	-0.07	0.16	0.07	0.22
Inventory management	0.47***	0.27	0.56***	0.95***	0.91***	0.98***
Ongoing costs	0.20	0.29	0.16	0.47***	0.31***	0.59***
Operational level expertise	0.17	0.31*	0.11	-0.05	0.05	0.00
Privacy threats	-1.77	-1.73	-1.89	-1.64	-1.96	-1.65
Process innovation	0.39***	0.69***	0.40***	0.47***	0.53***	0.48***
Replacement costs	-0.60	-0.43	-0.65	-0.20	-0.55	-0.08
Security threats	-1.14	-1.16	-1.21	-1.01	-1.21	-1.07
Service quality	0.50***	0.58***	0.53***	0.44***	0.62***	0.57***
Standards ambiguity	-0.78	-0.60	-0.90	-1.20	-1.26	-1.22
Technological maturity	0.21	0.12	0.36**	-0.25	0.07	-0.20
Technology leadership	-0.09	-0.08	-0.16	-0.49	-0.25	-0.40
Top management commitment	0.84***	0.51***	0.90***	0.75***	0.88***	0.65***
Track & trace	0.47***	0.39**	0.60***	0.81***	0.82***	0.68***
$R(0)^2$	0.07	0.10	0.10	0.07	0.08	0.07
Log-likelihood	-3210.71	-2693.14	-2673.73	-4392.03	-3484.14	-3636.62
BIC	6502.28	5541.95	5503.13	8870.67	7132.72	7438.98
AIC	6461.42	5466.28	5427.46	8824.06	7048.29	7353.25
CAIC	6522.28	5581.95	5543.13	8890.67	7172.72	7478.98

Note: *** p<0.001 ** p<0.01 * p<0.05. The $R(0)^2$ measure is based on Goodman-Kruskal tau-b coefficients and is more conservative than traditional measures. According to [41] a $R(0)^2$ measure of 0.1 equivalent to a traditional R^2 of 0.3

words, acquisition costs, data accuracy, information visibility, inventory management, operational expertise, process innovation, service quality, management commitment and track and trace are robust indicators of importance regardless of the level of risk aversion or technological maturity.

VI. Conclusion

We started this study with a relatively simple objective. First, we sought to identify the factors that are most and least important to the decision to adopt RFID technology. Using an appropriate method we calculated the relative importance of 21 factors on a common scale. Second, we sought to identify the extent to which these factors differ between those firms have and have not adopted RFID technology. The picture presented clearly shows that ten factors are particularly important and statistically significant to both the firms that have adopted RFID and those that have yet to adopt RFID technology. The normative implications are that the uptake of RFID is dependent upon the ability to promote the strategic decision making benefits of improved data accuracy, information visibility, process innovation and service quality. Non adopters are also interested in these benefits but remain concerned with the costs of implementation.

Appendix

Due to space constraints, details on the psychometric properties of the scales and the definitions of the factors used within the study have been omitted. Please email the first named author for this information.

References

[1] M. E. Porter, & V. E. Millar, How information gives you competitive advantage, *Harvard Business Review* (63:4) 1985, pp. 149-160.

[2] A. M. Aizcorbe, C. E. Moylan, & C. A. Robbins, Toward better measurement of innovation and intangibles: survey of current business, *Bureau of Economic Analysis* (89:1) 2009, pp. 10-23.

[3] K. Lyytinen, & G. M. Rose, The disruptive nature of information technology: the case of internet computing in systems development organizations, *MIS Quarterly* (27:4) 2003, pp. 557-586.

[4] C. M. Christensen, *Innovators dilemma* Harvard Business School Press, Boston MA, 1997.

[5] P. J. Vail, & N. Agarwal, Disruptive innovation offers far-reaching solutions, *IEEE Potentials* (26:2) 2007, pp. 25-33.

[6] B. Srivastava, Radio frequency ID technology: the next revolution in SCM, *Business Horizons* (47:6) 2004, pp. 60-68.

[7] V. Venkatesh, M. G. Morris, G. B. Davis, & F. D. Davis, User acceptance of information technology: toward a unified view, *MIS Quarterly* (27:3) 2003, pp. 425-478.

[8] E. M. Rogers, *Diffusion of Innovation*. Free Press, New York, 2003.

[9] Y. Sheffi, RFID and the innovation cycle, *International Journal of Logistics Management* (15:1) 2004, pp. 1-10.

[10] H. Boeck, & S. Fosso Wamba, RFID and buyer-seller relationships in the retail supply chain, *International Journal of Retail & Distribution Management* (36:6) 2008, pp. 433-460.

[11] G. M. Gaukler, & R. W. Seifert, Applications of RFID in supply chains. In *Trends in Supply Chain Design and Management: Technologies and Methodologies*, by Hosang Jung, F. Frank Chen, Bongju Jeong, Springer Series in Advanced Manufacturing, Springer, 1st edition, 2007, pp. 29-48.

[12] R. J. Kauffman, & A. Kumar, Network effects and embedded options: decision-making under uncertainty for network technology investments, *Information Technology and Management* (9:3), 2008, pp. 149-168.

[13] C. Shapiro, & H. R. Varian, Information rules: a strategic guide to the network economy, *Harvard Business School Press*, 1999.

[14] M. Tajima, Strategic value of RFID in supply chain management, *Journal of Purchasing and Supply Management* (13:4) 2007, pp. 261-273.

[15] Z. Asif, & M. Mandviwalla, Integrating the supply chain with RFID: a technical and business analysis, *Communications of the Association for Information Systems* (15) 2005, pp. 393-427.

[16] H. S. Heese, Inventory record inaccuracy, double marginalization, and RFID adoption, *Production and Operations Management* (16:5) 2007, pp. 542-553.

[17] A. R. Cannon, P. M. Reyes, G. V. Frazier, & E. L. Prater, RFID in the contemporary supply chain: multiple perspectives on its benefits and risks, *International Journal of Operations & Production Management* (28:5) 2008, pp. 433-454.

[18] D. Delen, B. C. Hardgrave, & R. Sharda, RFID for better supply chain management through enhanced information visibility, *Production and Operations Management* (16:5) 2007, pp. 613-624.

[19] Fosso Wamba, S., Lefebvre, L. A., Bendavid, Y., & Lefebvre, É. Exploring the impact of RFID and the EPC network on mobile B2B ecommerce: a case study in the retail industry, *International Journal of Production Economics* (112:2) 2008, pp. 614-629.

[20] N. Huber, K. Michael, & L. McCathie, Barriers to RFID adoption in the supply chain, *IEEE RFID Eurasia*, Istanbul, Turkey, 2007, pp. 1-6.

[21] A. Smart, & R. Bunduchi, Identifying the costs of RFID implementation in supply chains, Working Paper, Supply Chain Management Research Group, Manchester Business School, 2007.

[22] R. G. Fichman, Going beyong the dominant paradigm for information technology innovation research, *Journal of the AIS* (5:8) 2004, pp. 314-355.

[23] P. J. Buckley, T. M. Devinney, & J. J. Louviere, Do managers behave the way theory suggests? *Journal International Business Studies* (38:7) 2007, pp. 1069-1095.

[24] M. J. Gallivan, Organization adoption and assimilation of complex technological innovations: development and application of a new framework, *Database for Advances in Information Systems* (32:3) 2001, pp. 51-85.

[25] L. G. Tornatzky, & K. J. Klein, Innovation characteristics and innovation adoption and implementation: a meta analysis of findings, *IEEE Transactions on Engineering Management* (29:11) 1982, pp. 28-45.

[26] Z. Irani, J. N. Ezingeard, & R. J. Grieve, Costing the true costs of IT/IS investments in manufacturing: a focus during management decision making, *Journal: Logistics Information Management* (11:1) 1998, pp. 38-43.

[27] H. Mintzberg, D. Raisinghani, & A. Theoret, The structure of unstructured decision processes, *Administrative Science Quarterly* (21) 1976, pp. 246-275.

[28] B. Tyler, & K. Steensma, The effects of executives' experiences and perceptions on their assessment of potential technological alliances, *Strategic Management Journal* (19) 1998, pp. 939-965.

[29] J. Dutton, & S. Jackson, Categorising strategic issues: links to organizational action, *The Academy of Management Review* (12:1) 1987, pp. 76-90.

[30] E. Bottani, & A. Rizzi, Economical assessment of the impact of RFID technology and EPC system on the fast-moving consumer goods supply chain, *International Journal of Production Economics* (112:2) 2008, pp. 548-569.

[31] C. Loebbecke, & C. Huyskens, Item-level RFID in the Japanese publishing industry: a case study, *The Communications of the Association for Information Systems* (23:18) 2008, pp. 319-332.

[32] T. Coltman, R. Gadh, & K. Michael, RFID and Supply Chain Management: Introduction to the Special Issue, *Journal of Theoretical and Applied Electronic Commerce Research,* (3:1), 2008, pp. iii-vi.

[33] R. Banker, J. Kalvenes, & R. Patterson, Information technology, contract completeness, and buyer-supplier relationships, Proceedings of the International Conference on Information Systems, Brisbane, Australia, 2000, pp. 218-228.

[34] M. Whitaker, & A. Krishnan, A field study of rfid deployment and return expectations, *Production and Operations Management* (16:5) 2007, pp. 599-612.

[35] M. Sigala, RFID applications for integrating and informationalizing the supply chain of foodservice operators, *Journal of Foodservice Business Research* (10:1) 2007, pp. 7- 29.

[36] D. Hellström, The cost and process of implementing RFID technology to manage and control returnable transport items, *International Journal of Logistics Research and Applications* (12:1) 2009, pp.1-21.

[37] A. Dutta, H. Lee, & S. Whang, RFID and operations management: technology, value and incentives., *Production and Operations Management* (16:5) 2007, pp. 646-655.

[38] S. Chopra, & S. Manmohan, In search of RFID's sweet spot, *Wall Street Journal*, March, 2007.
[39] D. J. Street, & L. Burgess, Optimal and near-optimal pairs for the estimation of effects in 2-level choice experiments, *Journal of Statistical Planning and Inference* (118:1-2) 2004, pp. 185-199.
[40] J. Swait, & J. Louviere, (1993). The role of the scale parameter in the estimation and comparison of multinomial logit models, Journal of Marketing Research, (30:3), 305-314.
[41] D. Hensher, J. Rose, & W. Greene, Applied choice analysis: A primer, Cambridge University Press, United Kingdom, 2005.