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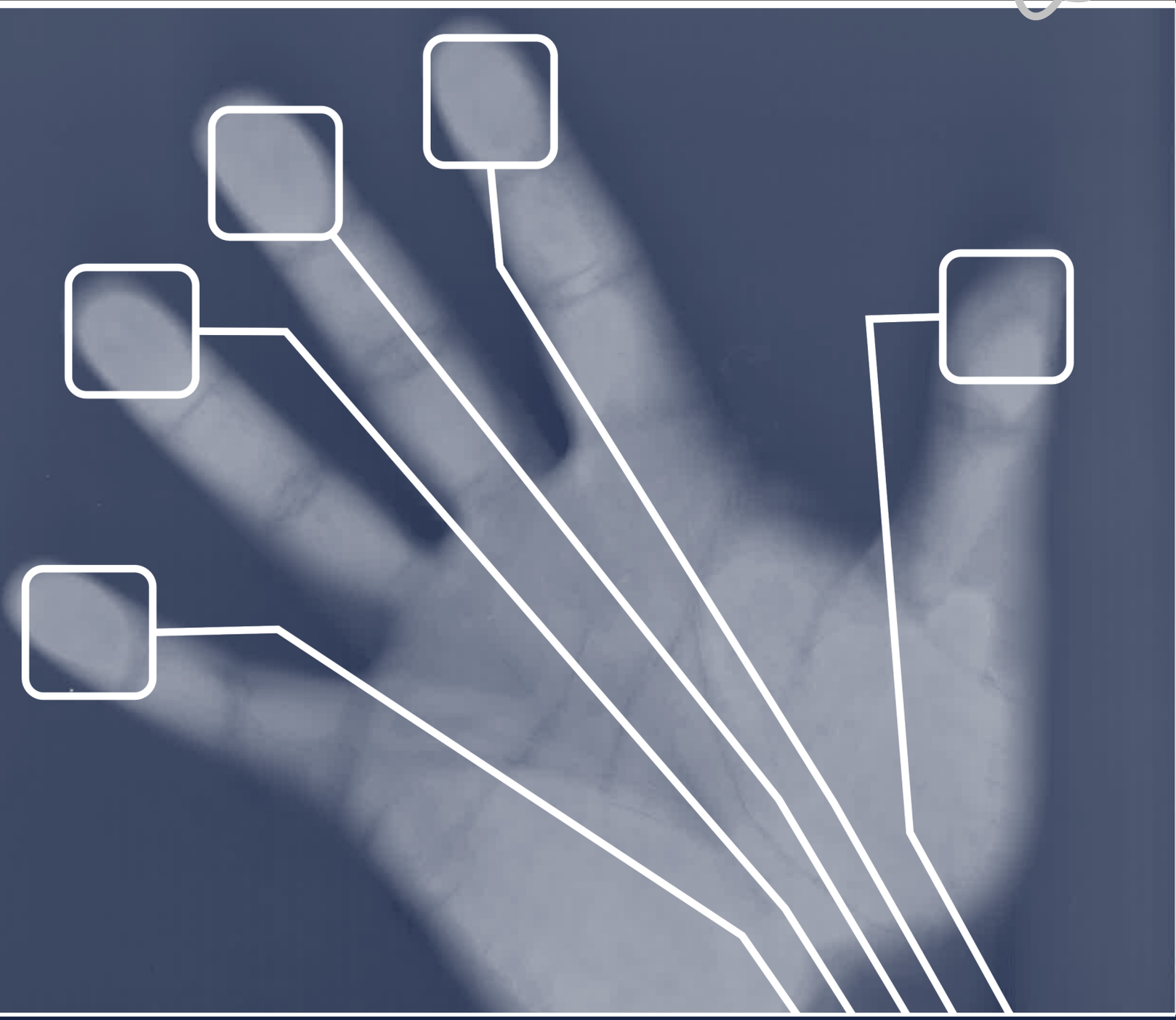

RFID Adoption Issues

Analysis of Organizational Benefits & Risks

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Contents

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Executive Summary

What makes companies such as Wal-Mart in the U.S., Metro Group in Germany and Tesco in the United Kingdom, so willing to adopt RFID technology? More precisely, what are the factors that matter most and least to firms when considering an investment in RFID? And how does the importance of such factors vary between adopters and non-adopters?

The answers to these questions are important because they indicate where future development effort should be directed to increase the rate of RFID adoption. To begin, we conducted a large survey of 133 RFID Journal readers. The industries represented in the sample include: wholesale trade, retail trade, transportation, business services, communication services, manufacturing, finance, insurance, mining, government administration and defence. Firm size was well distributed, with 39% of the sample from small sized firms (less than 20 employees), 21% from medium sized firms (20 to 200 employees) and 40% from large firms (more than 200 employees).

The methodology used to conduct this study allowed us to calculate the relative importance of 21 attributes that influence the decision to invest in RFID. The results indicate that those factors that matter "most" during the RFID investment decision are: (1) the benefits that RFID offers in terms of improved data quality, reliability and timeliness, (2) the amount of top management commitment by senior managers to provide resources that will support investment in RFID, and (3) improved alignment of information between suppliers and customers.

One of the most interesting aspects of the study is that it shows quite clearly which attributes respondents are willing to abandon first. In other words, the factors that matter "least" to the RFID investment decision are: (1) privacy threats, (2) security threats and (3) standards ambiguity. Finally, the results reveal important differences between RFID adopters and non adopters. In the case of adopters, the perceived opportunity to derive strategic benefits from RFID through improved decision making is critical. Not surprisingly, the non adopting firms are primarily concerned with the high acquisition and other ongoing costs associated with RFID technology.

Section 1: Introduction

Technological innovation is widely recognized as an important driver of business transformation and economic growth[1]. The most radical examples of innovation are found in situations where the creation and application of information technologies provide open and ubiquitous connectivity. The personal computer, mobile telephone and the Internet are examples of information technologies that have become ubiquitous[2]. Radio frequency identification (RFID) represents an emerging technological innovation that has captured the imagination of the academic and practitioner communities. Some have even gone so far as to suggest that RFID represents an innovation that will revolutionize the supply chain[3].

History tells us that the path toward acceptance of a new technology within the business community can be quite long. For example, the Internet had its origins in the late 1960s and 1970s, but did not attain widespread acceptance until the late 1990's. The primary catalyst for widespread adoption came with a change in the business perceptions of value, and with the advent of fast, reliable and low cost hypertext markup language applications. In other words, the rate of acceptance of a particular technology is influenced by perceptions of benefits and risks by users, or potential users[4].

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 firms have yet to seriously embrace RFID. The reluctance by many of Wal-Mart'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 that the technology may not be as revolutionary as some have predicted.

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 of RFID?
(3) Where should future development efforts be directed to increase the rate of RFID adoption?

Prior work on RFID diffusion has identified an assortment 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[5], better inventory records[6], improved organization coordination and control[7], real-time data collection and sharing among supply chain stakeholders[8], and business process innovation[9]. However, these benefits come with potential risks such as: high infrastructure and implementation costs[10], switching costs [11], immature standards, and privacy and security concerns[12]. As yet, however, no-one has compared the relative importance of the different benefits and risks, or tested the moderating effects (individual and organizational) that may influence the relative importance of various factors on the rate of RFID diffusion and adoption.

Anecdotal evidence indicates that RFID has had a relatively slow rate of adoption, and that a solid business case to support the widespread RFID adoption may still be some years away. The main reason for this is that current research approaches provide a particular challenge when it comes to understanding the way firms assess business value and risk of RFID technology.

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, our study utilized best-worst scaling, a novel approach that is used to identify the organizational factors considered to be the most important and the 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[13].

What has driven IT innovation adoption?

Researchers have identified various innovation characteristics, technologies, organizational and environmental factors that affect the IT adoption decision[14]. For example, the seminal work by Rogers[15] 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 extent to which an innovation is difficult to use;
(4) The degree to which the results of an innovation are visible to others.

Understanding the impact of each of these characteristics is considered to be the key to IT innovation success. However, despite increased awareness of the characteristics that underpin IT innovation, many organizations still report an inability to justify their investment in new IT. This is a demand side problem that arises due to a lack of understanding about the *true* costs and benefits associated with the adoption and use of a particular technology[16]. In other words, the widespread adoption of RFID will continue to stall until managers with responsibility for adoption decisions articulate the real business value of RFID within their organization. This requires a sound understanding of the various drivers and impediments (i.e., benefits, risks, challenges, costs) to RFID. Ideally, this understanding should precede the commitment of large amounts of money, time and resources in the area of RFID.

In particular, the strategic management literature suggests that the categories of opportunity (benefit) and threat (risk) are especially relevant for understanding the investment decision-making process. In the specific case of RFID technology, this necessitates that we not only focus on the strengths and weaknesses of the technology *per se*, but that we also consider the organizational opportunities (benefits) and potential threats (risks) that can result from RFID adoption.

What specific factors influence the adoption of RFID?

RFID technology offers a vast range of benefits. For example, it can help stakeholders to reduce shrinkage, reduce material handling costs, increase data accuracy, enable supply chain business process innovation and improve information sharing[17].

An important part of the strategic decision-making process is to weigh up the advantages of adopting RFID against the disadvantages. The relatively low rates of adoption imply that, at least 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 skills[18] to technical factors that are centered on systems integration[19]. The high costs of purchasing tags and supporting infrastructure is also thought to be a prominent adoption barrier.

Sigala in her study on the RFID implementation issues, practices, and benefits within the food service sector[20], found that the two most important issues that need to be addressed before committing to RFID were: (1) the RFID cost-benefit analysis; and (2) the better way to integrate the RFID system with the existing business models, business strategies, staff operations, and technology infrastructure. On the other hand,

Figure 1:

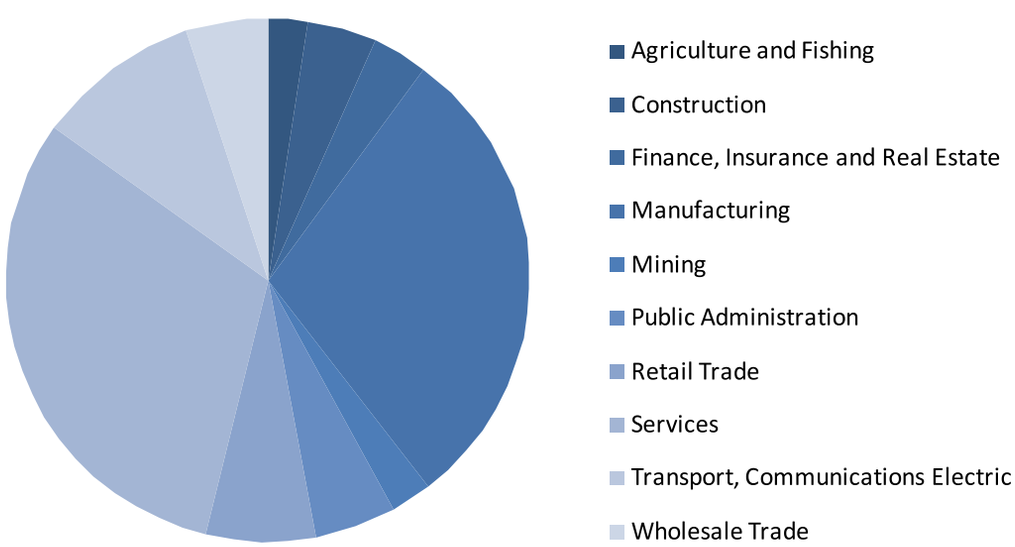
Strategic decision making factors*

Resource issues	Technology issues	Automation issues	Supply chain issues
- Acquisition costs - Ongoing costs - Top management commit - Operational level expertise - Replacement costs - Integration complexity	- Standards ambiguity - Security threats - Technology maturity - Privacy threats	- Inventory management - Data capacity - Track and trace - Compliance - Process innovation	- Information visibility - Data accuracy - Service quality - Decision making - Competitive differentiation - Technology leadership

* Factor definitions are available upon request.

Figure 2:

Respondent profile



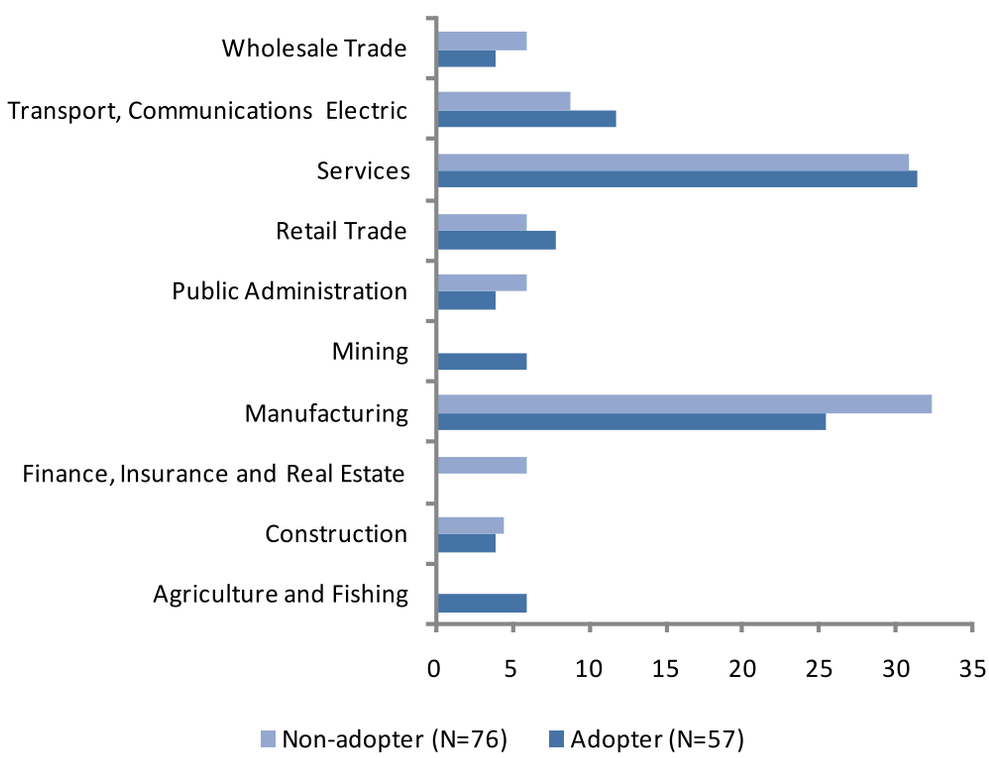
a RFID trial at IKEA, found that the cost of introducing RFID technology is not generally a barrier[21]. This implies that capital costs are not the only risk that should be considered in RFID adoption. Many technical challenges also arise from the integration of RFID software and hardware within the existing IT infrastructure, and these need to be investigated.

For instance, the standardization of data across the supply chain, such as the data related to products, vendors and shippers, as well as the data on the RFID tags themselves, is critical for the realization of a real business value from RFID[22]. In fact, Whitaker & Krishnan[23] empirically determined that a lack of industry RFID standards continues to negatively affect adoption. In particular, their research suggested that standards ambiguity may limit the expectation of ROI because of the inability of firms to deploy RFID across the supply chain.

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. Chopra & Manmohan[24] highlight that the greatest advantages in this area will accrue to firms that are part of complex supply chains who deal with a large volume of goods, and rely on accurate and timely information on the movement of these products. 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.

Figure 3:

Breakdown by adoption



Section 2: Methodology

An effective method for evaluating the relative importance of the benefits and risks involved in RFID is to model the actual trade-off that managers are willing to make. Various models termed discrete choice analysis, stated preference models, and choice-based conjoint models exist that enable researchers to predict the marginal utilities that are associated with various choices from experimentally designed sets of alternatives. The regression model that is being used for this purpose is the conditional logit model developed by the 2000 Nobel Laureate, Daniel McFadden. This model is an extension to the multinomial logit model that allows for the inclusion of explanatory variables related to the choice set options. In this study, we use a reduced form of discrete choice analysis referred to as best-worst scaling.

The composition of the choice sets is determined according to an underlying experimental design. In the case of best-worst choice models, this is achieved using a balanced and incomplete block design (BIBD). This type of design aims to minimize the resulting number of choices, whilst ensuring balance between the total number of times a factor appears in the experiment, and the number of times each factor appears alongside every other factor in the design[25]. The number of factors in each choice set, and the total number of choice sets is ultimately a factor of the number of factors in the design.

In our 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. The final list was based on extensive exploratory work that included reviewing the academic literature, industry reports and websites, along with insight gained from numerous discussions with key informants (for example 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 (see Figure 1). 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 (WINMEC) at the University of California (Los Angeles) confirmed the validity of this list and the associated 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, the dependence of the firm and industry on technology, and the turbulence of the market in which the firm competes. The specific questions along with the psychometric properties of the associated measurement scales are available upon request.

Who was studied?

The industries in this study represented most of the main segments of business activity (see Figure 2 and 3): 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%). The firm size was also well distributed (Figure 4), 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 from large firms (more than 200 employees). The mean number of employees for the entire sample was around 53,000. 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 MNCs.

What is the level of RFID adoption?

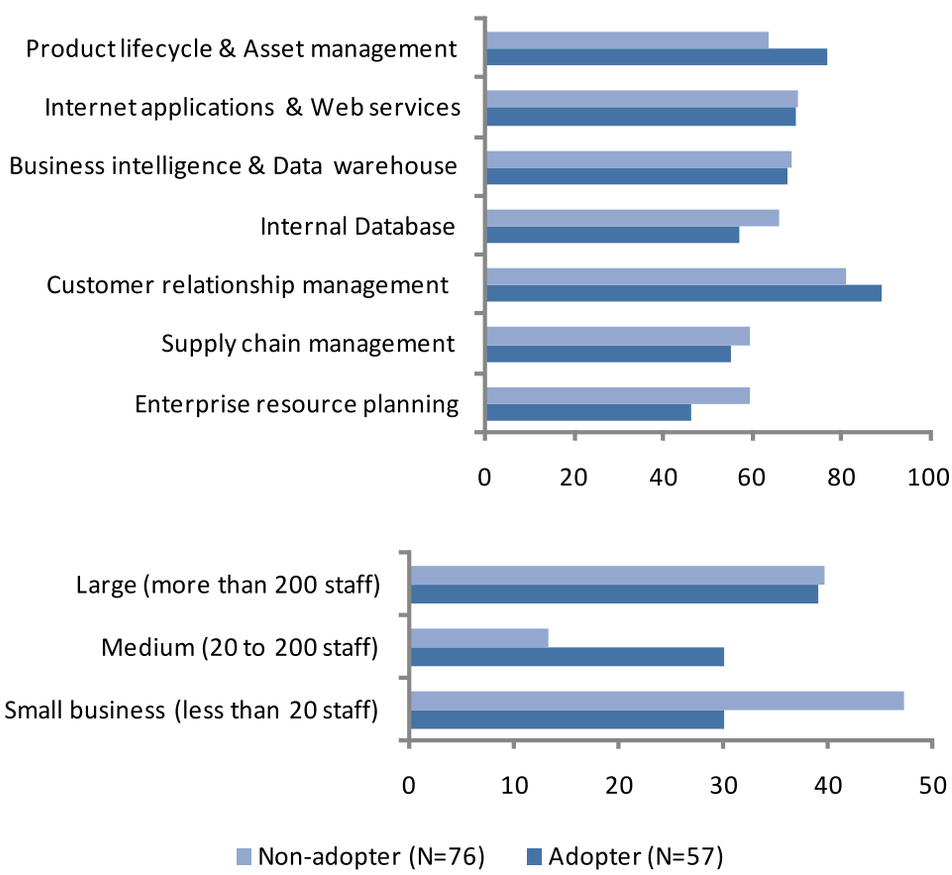
Concerning the breakdown of RFID adopter and non-adopter by firm size (see Figure 4), the study shows that even if large firms are those with the high level of RFID adoption (39%), they also have a high level of non-adoption (39.6%), which is also the case for small firms. Medium firms are the only segment with a level of adopters (30%) much higher than the level of non-adopters (13.2%).

When conducting a breakdown of RFID adopters and non-adopters by their current IT infrastructure (bottom Figure 4), we observe that the highest level of RFID adoption is among firms using Customer Relationship Management. Moreover, for firms using Product Lifecycle & Asset Management and CRM, the level of adoption is higher than the level of non-adoption, which is not the case for firms using Internet applications & Web services, Business Intelligence & Data Warehouse, Internal Database, Supply Chain Management or Enterprise Resource Planning.

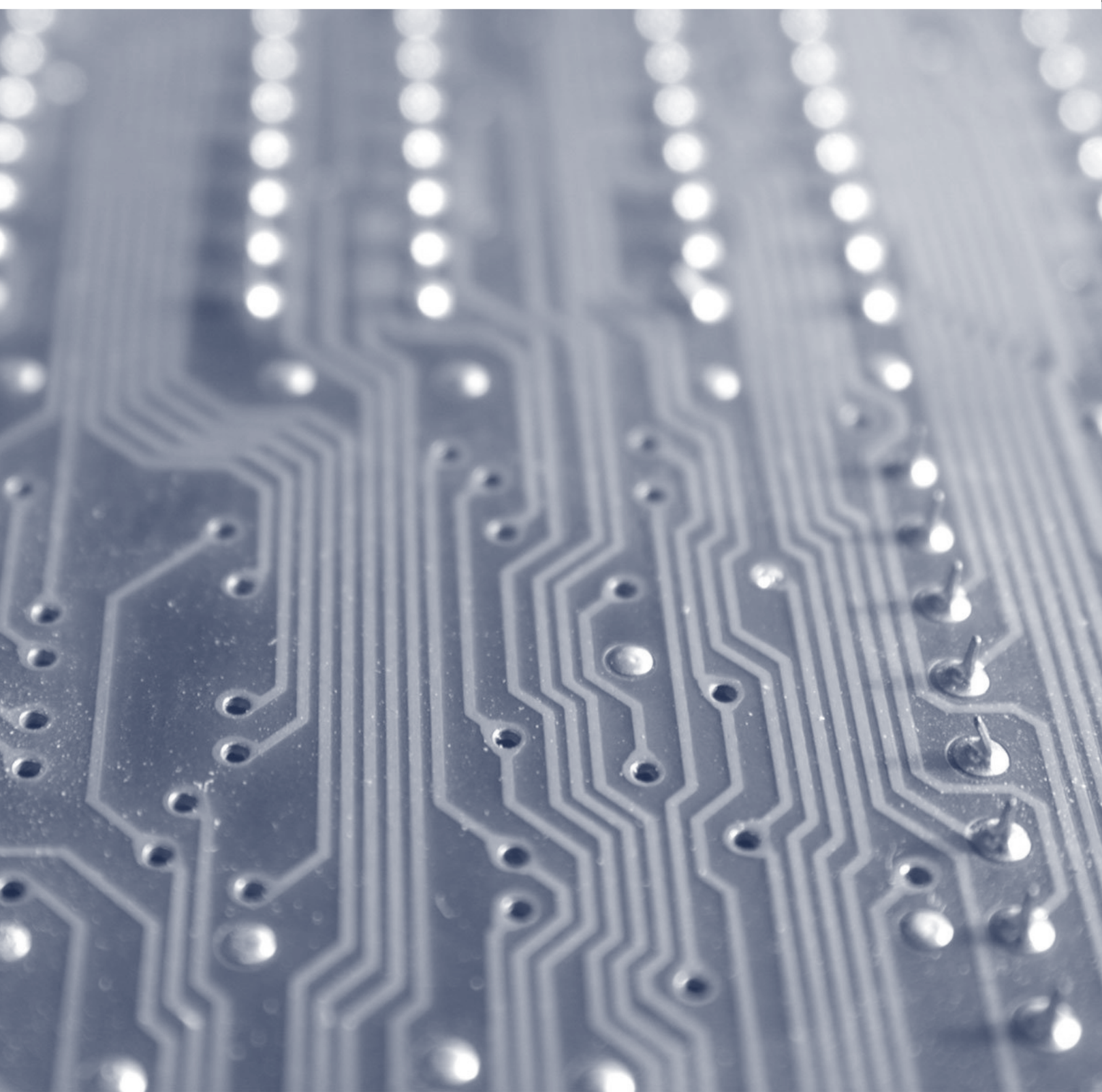
Further analysis of RFID adopter and non-adopter by industry (not shown) indicates that most RFID technology adopters are in the Services sector followed by Manufacturing, Transport, Communications Electric and Retail Trade. However, it is in the Agriculture & Fishing and Mining where the level of adoption is by far higher than the level of non-adopters.

Figure 4:

Breakdown by IT infrastructure & firm size



“Why does technology, which is supposed to make life easier, bring us so little happiness? The simple answer... we have not yet learned to make sensible use of it.” *(Albert Einstein)*



Section 3:
Key Findings

This section presents the key findings. Specifically, we reveal the relative importance of 21 factors to the RFID investment decision. The method required respondents to identify from a set of possible alternatives, the factors that mattered most and least to the RFID investment decision.

What are the shares of preferences for Adopters and Non-adopters of RFID technology?

Figure 5 provides an interesting snapshot of what influences RFID investment when we control for adopters vis-à-vis non-adopters. We can see that adopters identify with what they believe are potential strategic advantages from investment in RFID. For example, those firms that presently adopting 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 costs", "replacement costs" and "ongoing costs". More importantly, both groups are interested in benefits such as greater "data accuracy", "track and trace" capabilities and improved inventory management. This implies that future work should be directed towards these three operational factors.

Figures 6 and 7 show the ten factors which matter most and least to the RFID investment decision respectfully at the aggregate level. From Figure 6, we can see that the factors that mattered "most" in the RFID investment decision were "data accuracy" followed by "top management commitment" and "information visibility". Meanwhile, Figure 7 shows that of those factors influencing RFID investment, the "least" important were "Privacy threats" followed by "Security threats" and "Standards ambiguity".

Figure 5:

Relative importance of strategic factors

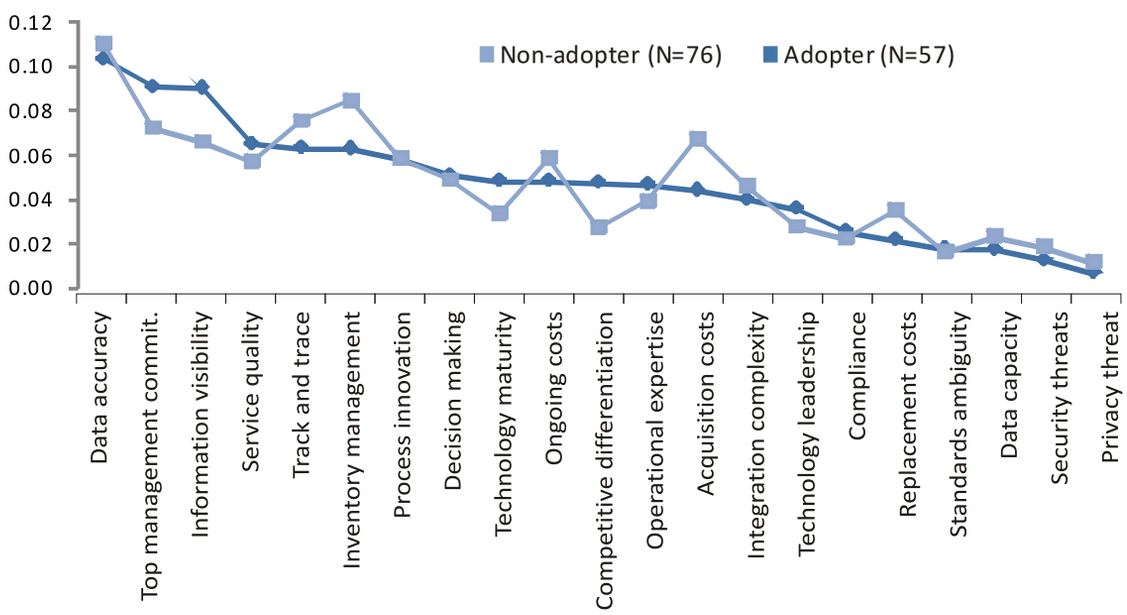


Figure 6:

Ten most important factors

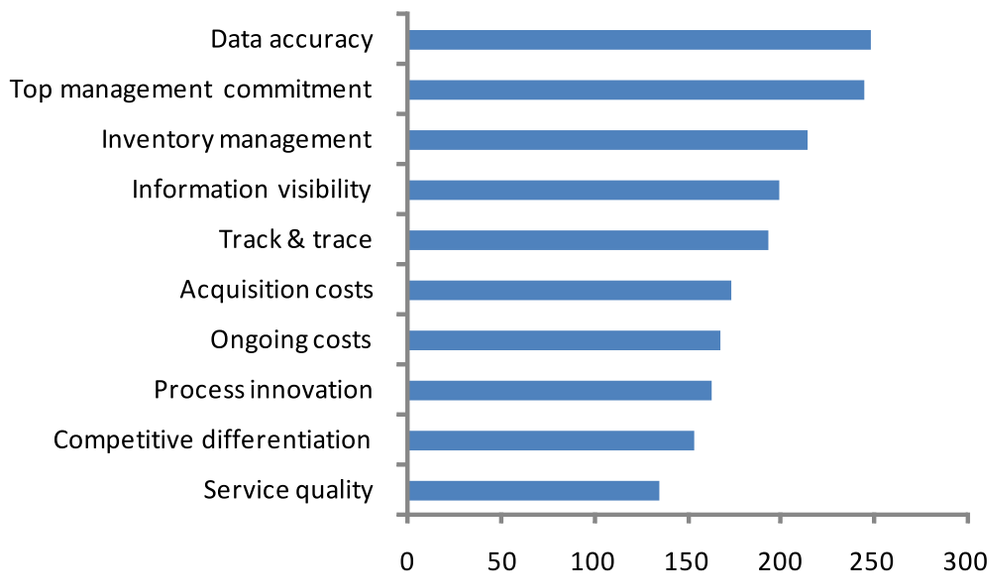
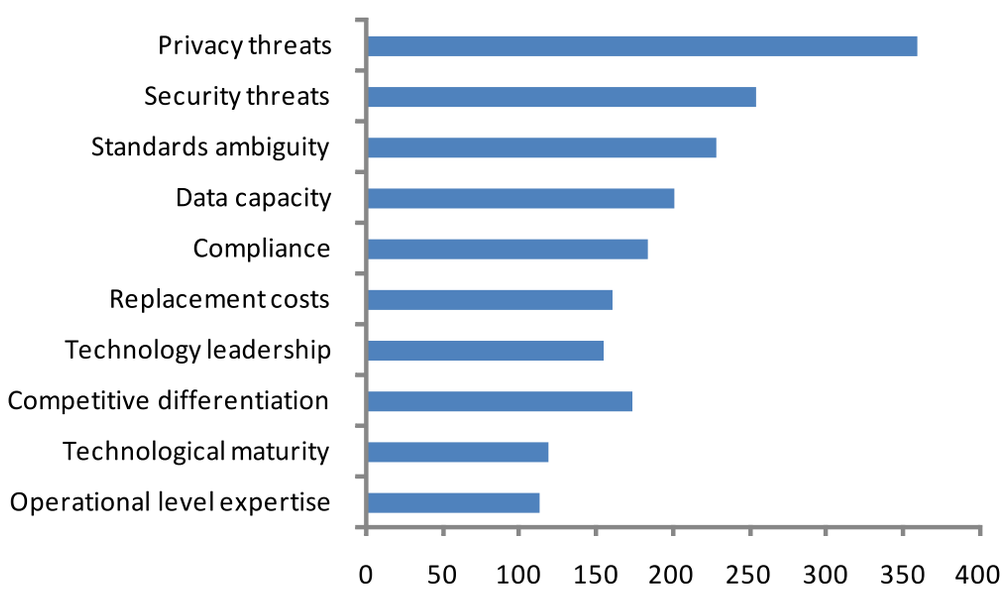


Figure 7:

Ten least important factors



Section 4: Discussion

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.

Future research will build on these findings to explore the impact of firm level issues on the importance of these factors for both adopters and non-adopters of RFID. For instance, we intend to investigate whether RFID investment is influenced by (1) past IT investment experience; (2) the risk orientation of managers; (3) the strategic importance of technology to the firm; and (4) the turbulence of the markets in which the firm competes.

To obtain access to forthcoming publications and industry reports related to this research study, or to access information on the authors and their associated research, please visit the CBSS website (cbss.uow.edu.au). Alternatively, please feel free to email the lead author, Samuel Fosso Wamba, at samuel@uow.edu.au.

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