RFID Technology Adoption in New Zealand's Supply Chains: A Case Study Approach

Chin-Boo Soon
Department of Information Systems
and Operations Management
The University of Auckland Business School
c.soon@auckland.ac.nz

Jairo A. Gutiérrez
Faculty of Engineering
Universidad Tecnológica de Bolívar
jgutierrezd@unitecnologica.edu.co

Abstract

The reasons for reluctance or hesitation in deploying radio frequency identification for supply chain management (RFID/SC) may rely upon firms' ability to innovate. This paper presents the findings of a study of adoption of RFID in New Zealand's supply chains. Three ability factors were found to be important in the adoption of the technology: Compatibility, Facilitating Condition, and Readiness. This study argues that applying these factors to the firm and its environment helps to evaluate the issues surrounding the firm's ability to innovate. For example, it was found that RFID was simply not suitable in some business scenarios; RFID technology was not compatible with some existing supply chain applications; it was perceived there was little support for the deployment of RFID at various points in a supply chain; and supply chain partners were waiting for each other to deploy or initiate RFID. This paper follows on a previous survey on the uptake of RFID in New Zealand's supply chains and discusses some of the challenges that firms face when evaluating the use of RFID/SC. We found some relationships between adoption factors that are worth pursuing. For example, it was found that Compatibility, Facilitating Condition, and Readiness are key "ability" factors affecting RFID adoption.

Keywords: Diffusion of innovation, RFID, Supply chain management, Technology adoption

Introduction

The discovery of electromagnetism by Michael Faraday and James Clerk Maxwell has led to many subsequent developments of applications such as the radio transceiver and radar. Commercially available RFID applications are used in electronic article surveillance, electronic road toll collection systems, and facility access control systems to name a few. In the late 1990s RFID started to emerge in supply chain management with the development of electronic product codes (Soon, 2009). Since then, research in RFID/SC has been substantial. Many studies are focused on the technical aspects of radio frequency (Alu, Sapia, Toscano, and Vegni, 2006; Li, Visich, Khumawala, and Zhang, 2006; Porter, Billo, and Mickle, 2006). Others describe the impacts, benefits, and visions of RFID on business (Jones, Clarke-Hill, Hillier, and Comfort, 2005; Smith, 2005; Twist, 2005). There are, however, few empirical studies on RFID implementation (Martínez-Sala, Egea-López, García-Sánchez, and García-Haro, 2009; Tewary, Kosalge, and Motwani, 2009; Vijayaraman and Osyk, 2006). It is thus the intention of this research to add to the knowledge field of technology by investigating the adoption of RFID in supply chains using a case study research methodology. The purpose is to identify the barriers to technology adoption in a firm and its supply chain. Thus, this paper adopts an exploratory approach to find out how organizations adopt RFID technology. The research question is, "How will firms adopt RFID technology in their supply chains?"

The paper is organized as follows. In the next section, the technology adoption literature is reviewed. The paper then discusses the theoretical framework and research method employed. This is followed by the discussion of the cases studied. In the conclusions section, there is a highlight of the research significance, the limitations of the study and future research plans.

Literature Review

In the technology adoption literature, there are several stages of technology acceptance. They can be categorized into individual technology adoption and usage, and organizational technology adoption and implementation.

In the individual technology adoption and usage literature, most studies looked at the antecedents of individual behavior in relation to information technology acceptance. Individual behavior that has an effect on beliefs and attitudes forms the underlying principle of individual technology adoption theories. The models are constructed around users' perceived attributes of an innovation (Gallivan, 2001) and, at a later stage, about the formation of intentions to adopt and use the innovation (Agarwal, 2000). This paper looks at the Technology Acceptance Model (TAM) (Davis, 1989) and the Theory of Planned Behavior (TPB) (Ajzen, 1991).

TAM posits only two beliefs: perceived usefulness and perceived ease of use (Davis, 1989). Fishbein and Ajzen (1975) "view most social behavior as being volitional, barring unforeseen events, a person should perform those behaviors he intends to perform" (p. 15). Unfortunately, in reality, there are constraints, particularly those beyond the control of individuals, which may limit the performance, or lead to the non-performance of behaviors. Fishbein and Ajzen (1975) recognize that the performance of an individual may depend on other individuals' actions. They found that lack of ability is the only factor that breaks the relation between intention and behavior. That is, "people do not intend to perform behaviors that they realize are beyond their ability" (Fishbein and Ajzen, 1975, p. 372). Therefore, if a control measure takes into account the ability to perform a behavior, a person's intention may predict her behavior. The TPB introduces a control mechanism that measures the influence for performance and non-performance. The perceived behavioral control "reflects an individual's perceptions that there exist personal and situational impediments to the performance of" a behavior"(Agarwal, 2000, p. 87).

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

In the early organizational technology adoption literature, Zaltman et al. (1973) suggest that technology adoption took place at the organizational level before it leads to individual usage. Usually, a firm makes the decision to adopt a technology and cascades the adoption to individual users. In their study, Zaltman et al. (1973) examined technology adoption as contingent on a prior event, thus making it a two-stage adoption model. In more recent literature, the study on organizational technology adoption suggests "the most common pattern within firms is a consensus-based primary adoption decision (at the management level), followed by an authority-based secondary adoption ... mandated adoption at user level" (Gallivan, 2001, p. 54). A widely referenced work is Rogers' (1995) work on the Diffusion of Innovations (DOI). Rogers (1995) suggests five factors (characteristics of innovation) that are consistently found to be significant in most of the seminal literature. They are Relative Advantage, Compatibility, Complexity, Trialability, and Observability. Relative Advantage and Compatibility are two commonly used factors in the diffusion body of work and probably the most significant predictors of adoption (Rogers, 1995). Relative Advantage is positively related to the rate of adoption. It is "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 1995, p. 229). Rogers (1995) describes Compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (p. 240). Here, Compatibility is referred to as fitness to organizational beliefs and interaction with external firms. Technology must be aligned and compatible with organizational practices and policies (Singh, Lai, and Cheng, 2007). Incompatibility with organizational values and beliefs can be a barrier to technology adoption. Complexity is the level of difficulty. Trialability is the degree of experimentation possible with the technology. Observability is the visibility of the outcomes as a result of using the technology.

Comparing the models

TAM, TPB, and DOI are well-referenced models in the technology adoption literature. It has been recognized that the individual models are each suited to specific situations. TAM has been widely tested and found to be a powerful prediction model in individual and volitionary technology adoption situations. Its perceived usefulness has been constantly found significant by researchers. However, its perceived ease of use may not be a strong predictor of user's intention over a period of time. TPB has developed to include the measure of uncertainties around the ability of individuals to achieve an intended behavior. The inclusion of Behavior Control in TPB brings in the consideration of the availability of resources and opportunities. It measures the perception not only of ease, but also the difficulty in achieving a behavior. Thus, TPB overcomes the weakness of perceived ease of use in situations where resources and opportunities are important. Nevertheless, both TAM and TPB are too simplistic in their prediction of behavior. In reality, there are additional constraints such as time, dependency on trading partners, and cooperation with others (Mathieson, 1991). Neither TAM nor TPB have explicit measures for such external factors.

DOI literature looks at the adoption of technology as a process and identifies five factors that are predictors of adoption. The five factors are found to be relevant to organizational technology adoption by researchers (Christensen, Anthony, and Roth, 2004; Singh et al., 2007). Rogers (1995) describes the five factors in the organizational and technological aspects. For example, he suggests the need to consider Compatibility with organizational values and the integration of systems. However, it was not clear that the measurement of the five factors should be applied to the external environment, although in some of his examples, Rogers (1995) refers to external factors such as climate in agricultural innovation. Thus, DOI may not include considerations of the external forces (environmental aspects), which are important in technology adoption at the supply chain

level. Figure 1 shows the positions of the models in relation to the technology and organization contexts.

The organization characteristics axis represents the units of analysis that the models are deemed to fit best based on the literature. The technology characteristics axis represents a set of social factors that either have lower or higher social influence on technology innovation. For example, in a case where users have the power to use, or not to use, a technology, it is usually a knowledge tool designed for individual consumption and thus volitional. Technologies with higher social influence are usually group systems and, in certain situations, a mandate has been issued or pressure has been exerted for its adoption, such as, the case of electronic data interchange (EDI) adoption in the Government sector (Iacovou, Benbasat, and Dexter, 1995). What is not shown in Figure 1 is the environmental context. It is assumed that in a highly social context, such as a group technology that involves inter-organizational units, the external environment needs to be considered when evaluating the adoption behaviors of the units.

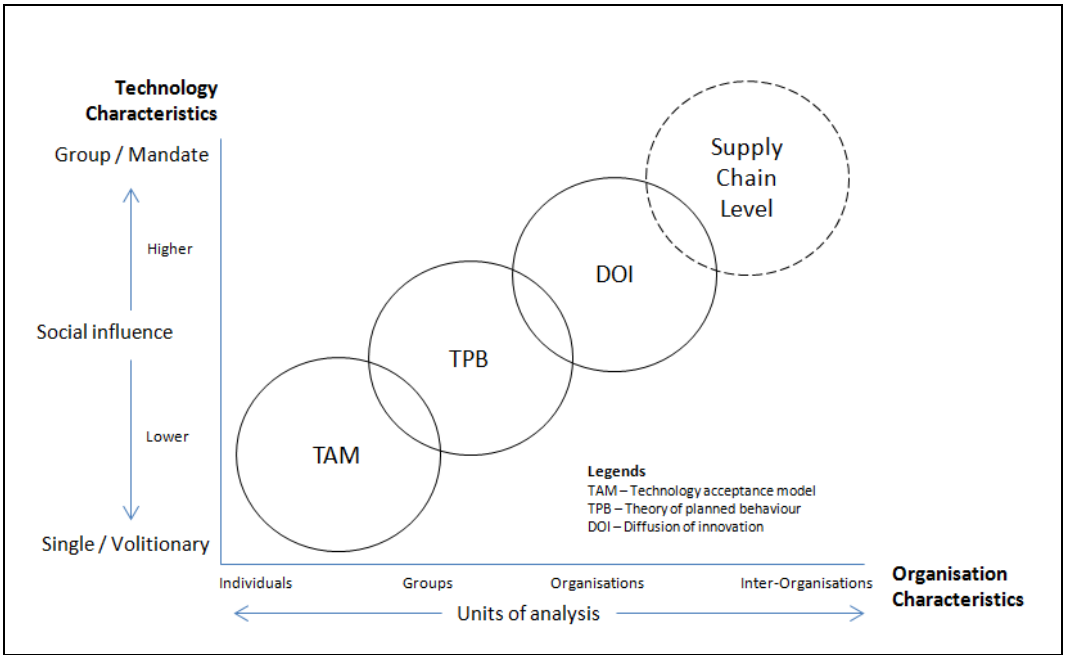

Figure 1 - Technology Adoption Models

An innovation framework relevant to this research is that of Rogers' (1995) five-stage innovation process which is categorized into two main phases. Scholars often use a process approach to study adoption, implementation, and assimilation of technology, such as, EDI, computer-aided software engineering, and client-server systems. The two phases are initiation and implementation. In the initiation phase, firms are involved in data gathering to conceptualize and process information for the planning of technology adoption. In the implementation phase, the decision to adopt a technology is underway, putting the technology to use. The aim of this research is to understand how firms decide to adopt a technology. Hence, the initiation phase is of particular interest here.

In the initiation phase, firms are involved in the gathering of information about problems, needs, and solutions. A key characteristic in this stage is the prioritization of needs and problems. There are often several problems that an organization faces but with little knowledge of the possible solutions.

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

Therefore, prioritizing the problems is a logical step in dealing with issues under constraints and uncertainty. Another key characteristic is how firms identify an appropriate technology. In most cases, the awareness of the technology as a potential solution, rather than the need to solve a problem, is the main driver for firms to further explore the technology. Rogers (1995) notes that sometimes it is the knowledge of an innovation that triggers the innovation adoption process which results in a perceived need for the technology even though there may not be a related problem in the firm. Once there is a need identified for the technology, the matching stage starts. Organizations attempt to match the technology to their problems. According to Rogers (1995), this process is planned and designed. It is a crucial stage in the adoption process where the decision to adopt or not to adopt is formed. Firms evaluate the fitness of the technology to their values and processes. According to Zaltman et al. (1973), individual members of the firm, by this stage, would have already formed certain attitudes towards the technology. Two main attitudes were highlighted. First is openness to the innovation, second is the perception of the benefits of the innovation. That is, are the individual members willing to consider the technology and what are the perceived benefits for the innovation? Since most innovations are discovered prior to a problem (Rogers, 1995), the matching stage becomes a milestone in technology adoption. It is important that, at this stage, there is sufficient information about the technology and the organization for the decision to adopt the technology to take place. It can be argued that firms may already have formed a preconception of the technology at the agenda setting stage. Since the agenda setting stage could take up to several years (Rogers, 1995), firms would be gathering sufficient information about the technology during this period. The missing link between the agenda setting and matching stages is the focus in this research.

Research in RFID has grown in recent years with an increasing number of journals calling for papers on RFID-related topics, or including RFID as a topic. More literature on RFID/SC was published from 2007 to 2009 than previously. A search in a publications database, using 'RFID' and 'Supply Chain' as key words, shows 99 scholarly publications on RFID in supply chain were published from 2007 to 2009, compared to 45 from 2004 to 2006. Technical papers and papers on the benefits and issues of RFID/SC dominate as research interests, followed by implementation of RFID. Topics discussed are generally the impacts of RFID in specific areas, such as in the Fast Moving Consumer Goods (FMCG) industry (Bottani and Rizzi, 2008; Miragliotta, Perego, and Tumino, 2009), inventory control (Heese, 2007; Szmerekovsky and Zhang, 2008). in specific industries, such as textiles (Kwok and Wu, 2009), pharmaceuticals (Matalka, Visich, and Li, 2009), and in specific countries such as Sweden (Johansson and Pålsson, 2009), China (Luo, Yen, Tan, and Ni, 2008), and Taiwan (Shih, Chiu, Chang, and Yen, 2008).

In terms of research methods, while conceptual and analytical approaches are common, field research using case studies is also widely adopted among these publications. Most of the case study research is focused on a single unit (Martínez-Sala et al., 2009; Tewary et al., 2009) and few are focused on multiple units (Moon and Ngai, 2008; Wamba and Chatfield, 2009). Implementation dominates as the research topic in the pool of case study research.

Theoretical Background

This paper is guided by several technology adoption theories, both individual and organizational. The theories are widely studied and referenced in the IS literature. For example, the TAM has been successful in predicting IS usage and it has proved a simple, easy-to-use model. The TPB explores the motivational and ability aspects of users to predict intentions and usage. The perceived behavioral control in the TPB makes it applicable to most situations of

technology adoption as long as the context and controls are specific and consistent. Diffusion of Innovation has several models. Rogers' (1995) five characteristics of innovation are claimed to be the closest to a single theory for innovation (Fichman, 2000). Nevertheless, it still falls short of a theory that can be applied universally to complex technology adoption situations (Fichman, 2000). The ability to track items along supply chains suggests RFID implementation is a cross-organizational project. The fact that firms were unable to find a business case for RFID suggests that investigation of wider implementation – across multiple operation areas – is desirable. For this reason, a supply chain view of technology adoption is proposed (Wamba and Chatfield, 2009). The discussion in this paper is at the supplier, distributor, and retailer levels as links in a supply chain.

While this paper is an explorative study, for the purpose of finding out how firms adopt RFID technology in their supply chains, an understanding of what prior research has found important would help to define and ascertain the scope of this study (Yin, 2003). Table 1 summarizes six key factors affecting technology adoption, derived from the literature review.

The factors are well-defined in the above articles. For the purpose of discussion, the factors are briefly described here and used in the discussion of the case studies.

Table 1 - Some Key Factors Affecting Technology Adoption

Factor	Source
Compatibility	1, 2, 8, 13, 14, 21, 22, 24, 26, 28, 29, 30, 33
Relative Advantage	1, 2, 3, 4, 6, 7, 14, 17, 20, 22, 24, 31, 34
Pressure	2, 4, 6, 7, 14, 17, 20, 23, 25, 26, 30, 31
Readiness	2, 4, 6, 7, 13, 14, 17, 20, 33
Subjective Norm	5, 10, 30
Facilitating Condition	2, 6, 15, 17, 21, 22, 25, 26, 28, 30, 32

(Agarwal and Prasad, 1997)	1	(Lippert and Forman, 2006)	18
(Al-Qirim, 2005)	2	(Mahmood and Becker, 1986)	19
(Amoako-Gyampah and Salam, 2003)	3	(Mehrtens, Cragg, and Mills, 2001)	20
(Beckinsale, Levy, and Powell, 2006)	4	(Moore and Benbasat, 1991)	21
(Brown, Massey, Montoya-Weiss, and Burkman, 2002)	5	(Plouffe, Hulland, and Vandenbosch, 2001)	22
(Chau and Hui, 2001)	6	(Premkumar and Ramamurthy, 1995)	23
(Chwelos, Benbasat, and Dexter, 2001)	7	(Premkumar, Ramamurthy, and Nilakanta, 1994)	24
(Cooper and Zmud, 1990)	8	(Premkumar, Ramamurthy, and Crum, 1997)	25
(Daugherty, Germain, and Dröge, 1995)	9	(Ramamurthy, Premkumar, and Crum, 1999)	26
(Davis, Bagozzi, and Warshaw, 1989)	10	(Raymond, 1990)	27
(Fichman, 2000)	11	(Rogers, 1995)	28
(Gallivan, 2001)	12	(Singh, et al., 2007)	29
(Goodhue, 1995)	13	(Taylor and Todd, 1995)	30
(Iacovou, et al., 1995)	14	(Teo, Wei, and Benbasat, 2003)	31
(Jimenez-Martinez and Polo-Redondo, 2004)	15	(Venkatesh, Morris, Davis, and Davis, 2003)	32
(Knol and Stroeken, 2001)	16	(Zaltman, et al., 1973)	33
(Kuan and Chau, 2001)	17	(Zhu, Kraemer, and Xu, 2006)	34

Compatibility is defined as the degree to which a technology is perceived as consistent with existing technological standards, organizational values and needs of potential adopters which includes other supply chain members.

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

Relative Advantage is defined in this research as the degree to which using a technology is perceived as beneficial to the organization and its performance.

Pressure is defined as the degree to which the intention to adopt a technology is perceived to be influenced by a firm's network.

Readiness is defined as the degree of perceived availability of resources and technical support for technology adoption.

Subjective Norm is defined as the degree of perceived social influence on technology adoption.

Facilitating Condition is defined as the degree to which technical, organizational, and external support that facilitate the adoption of a technology are perceived to be available.

Research Method

Prior to undertaking the case studies, a survey had been carried out and reported in Soon and Gutierrez (2008). It was found that early adopters had low satisfaction levels due to unexpected systems integration and compatibility issues. There were also issues surrounding the ability to implement RFID. This paper presents follow-on research using case studies to identify how firms evaluate RFID technology for adoption.

The Case Studies

The purpose of the case studies is to conduct an inquiry into how firms evaluate and adopt technology. Each case study looked at the initial adoption phase and identified the factors that impact on the technology adoption. The case study also attempts to investigate the behaviors surrounding the process leading to adoption.

Validity and Reliability

In validating the quality of the case study design, some key case study research conditions (Yin, 2003) were noted and followed. First, an important aspect of a research effort is to form a set of operational measures (Yin, 2003). In making sure that the measures used in the study are relevant (construct validity), an extensive literature review was carried out and multiple sources of evidence were used. In order to avoid making the wrong conclusions from the interviews, a researcher requires extensive knowledge on the subject and its context. Second, to satisfy internal validity, the authors familiarized themselves with RFID developments in New Zealand by participating in events related to RFID and supply chains. The similarity in the groups' perceptions is also an indication of sound internal validity (Yin, 2003) which helps to minimize the risk of having preconceptions that might lead to making wrong inferences. Third, and in order to achieve consistency in the inquiry, semi-structured questions were used in the interviews. Lastly, a pilot case study was conducted to test the interview design and validate the interview questions.

Case Selection and the Interviews

The selection of cases is based on the firms' involvement in RFID in New Zealand. All case organizations (hereafter referred to as "cases") have some form of RFID experience or interest. A total of eleven firms were selected and they are categorized as follows: four firms are in the supplier/manufacturer category, four firms are in the distributor/logistics service provider category, and three firms are in the retailer category (a fourth retailer could not be contacted). The cases are of similar size in terms of employees. They are considered large enterprises in relation to New Zealand standards; most firms in New Zealand consist of fewer than five full-time employees, while the cases selected have at least 100 employees throughout New Zealand. The 'stretched' geographical landscape of New Zealand means that long-haul transportation forms a major part of logistics activity for New Zealand firms, which mostly use either rail or roads. Exporting is a key economic contributor and due to the relatively smaller size of New Zealand firms, larger entities servicing a group of suppliers or growers are often formed to deal with international markets.

The case interview consists of structured and unstructured questions. A total of 23 questions were asked, of which 18 were related to the six factors discussed above and the remaining two were related to the intention and extent of future RFID usage. The unstructured questions adopted Rogers' five-stage innovation adoption process to understand how the cases approached their RFID adoption decisions.

Case Study

The case study is best discussed by using three supply chain groups: suppliers, distributors, and retailers. The aim is to identify patterns among the groups at the supply chain level. The three groups form a simplistic view of a supply chain and this approach is sufficient for discussion purposes. The key attributes of each group are summarized below. To maintain the confidentiality of the firms, the firms' profiles are aggregated, as shown in Figure 2.

Most of the information in Figure 2 is self-explanatory except perhaps Champion and Business case. Champion means the organization has a person interested or in charge of RFID, and Business case means the organization has a case to justify the implementation of RFID. This information was collected to identify whether the cases had someone driving the initiative and whether there was a case for them to adopt RFID.

Facts	Supplier	Distributor	Retailer
Years in operations	> 45	> 50	> 70
Industry type	Dairy, Manufacturing	Engineering, Export, Transport	Retail
Finance turnover (NZ$ mil)	> 3,000	> 1,500	> 1,000
Systems used	ERP, SAP, VoIP, MS CRM, AS/RS, Voice picking, barcoding sys	Virtualisation, SAP, VMWare, AIS, Ship tracking systems, Vehicle/Freight booking, EDI	SAP, Business Ware, Biztalk, POS, EDI, in-house ICT
Current RFID usage/planning*	2	3	1
Future RFID usage*	3	5	2
Champion (RFID)	Mostly Yes	Mostly Yes	Mostly No
Business case (Yes/No)	No	Neutral	No
Have trialed RFID (Yes/No)	Mostly No	Mostly Yes	Mostly No
What comes first? (Problem/RFID)	Mostly RFID	Mostly RFID	RFID

*Refer to the scale below for the degree of usage

1 Not Extensive 2 3 4 Extensive 5 6 7 Very Extensive

Figure 2 - Supply Chain Group Profile

The retailer group has had longer operational experience in New Zealand while the supplier group seems more profitable. Most cases in all three groups have some sort of enterprise system and are mostly vertically integrated. In terms of current and future RFID usage, the distributor group is more innovative as evidenced by their trialing of RFID, followed by the supplier group, and then the retailer group with the least evidence of trials. The

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

latter group, which is the least likely to adopt RFID, does not have a champion in their firms to drive RFID initiatives. Most cases were unable to find a business case for RFID adoption and became aware of RFID technology first, as opposed to initially recognizing a problem which had a need for RFID.

Results – Group Analysis

The group profiles shown in Figure 2 depict the various characteristics of the three supply chain groups. Most of the members of the suppliers group had a champion for RFID, they knew of RFID but did not do trials on RFID and reported no business cases for using RFID.

> *"Technology [RFID] doesn't fit at the moment; cost is not an issue … we buy raw material and build and install heavy machinery for our clients. [The manufacturing process is complex]."*
>
> *"We have state-of-the-art storage and retrieval systems and voice picking … all fully automated. RFID is only mentioned briefly in our company meeting. What can RFID do to help us [the company]?"*

Most of the members of the distributors group had a champion for RFID, they knew of RFID first, had done some trials on RFID but were split in their reported business cases.

> *"Containers don't come back to the port often and we rely on shippers for container tagging."*
>
> *"Customers are not ready, supply chain is not ready ... the impacts [of using RFID] will be more supply chain information than before and improvement to our recall process to specific batches."*
>
> *"We need a quick ROI to get sign-off from our Board within our financial budget. We see the real benefits by using hand-held RFID readers in arranging [cars] for manifest [advance shipping notice] ... and could easily trial RFID with eight different models and adding new features to justify a business case."*
>
> *"... a possible mandate from Customs? [government] or from big shippers or exporters ... it is not so much of a competitive advantage, but we like to do more for less and increase our services. We have some conceptual plans for RFID and will take a real hard look at RFID and other technologies within two to three years."*

The retailers group, in contrast, mostly did not have a champion; they knew about RFID but had not done trials on RFID, and they reported no business cases either.

> *"Suppliers are not capable of implementing [RFID] and there is no scale in the supply."*
>
> *"Wait for RFID to mature … someone is observing RFID development [at the top management level]."*
>
> *"There was no major issue with RFID but the applicability of it for a business case [is not there]. Trials were conducted mainly on in-store replenishment and not so much on supply chain management."*

This simple categorization shows that the distributors are leading in trialing of RFID and, possibly, in adoption, given that some of the distributors had already identified business cases for use of RFID. The suppliers are the second most likely group to adopt RFID. This is supported by the findings of their reported likelihood of adopting the technology if asked by their key business partners. However, the retailers had a mixed understanding of RFID, especially in terms of technical compatibility. Their pessimistic perception of Facilitating

Condition and Readiness may deter their adoption of the technology. Thus, retailers are the least likely group to adopt RFID in New Zealand.

In general, the suppliers and retailers rate Compatibility and Relative Advantage lower than the distributors and are more likely to adopt RFID if asked by their key business partners. While the suppliers had a positive perception of their external trading partners, the distributors and retailers were more pessimistic about their trading environments, and especially their suppliers.

> *"Offshore has the same issue of infrastructure. There is a need to set up infrastructure [RFID] in our offshore ports but no ability along the supply chain to achieve this yet."*
>
> *"There is no agreement from customers [suppliers] to use the [RFID] system."*
>
> *"Suppliers are not capable of implementing [RFID] and there is no scale in the supply."*

Initiation Phase

In the agenda setting stage, most of the case firms came to know RFID before identifying suitable problems, except in two cases, a supplier and a distributor. The supplier case explored RFID as they had the need to solve their product tracking issues. They had been studying RFID for a while but did not conduct any trials. The distributor case had long been looking for a solution to their logistical issues. They believed that RFID was only a part of the solution and they were looking out for other technologies at the same time.

> *"For benefits, couple RFID with OCR [optical character recognition] to identify containers for reporting at the gates, and to direct drivers and notify the office of the arrivals."*

They had conducted trials on RFID within their operations areas. They reported, after the interview for this research, that they were investigating the possibility of using RFID together with OCR to improve security and tracking performance. Therefore, the notion of recognizing the problem or the technology first, does not suggest any significant impact on technology adoption. It does, however, draw attention to the process of how information about the technology is being processed by firms. This is supported by the analysis of the suppliers group where there is little difference between one supplier and the rest of the suppliers in their perceived attitudes towards RFID. They mentioned that barcode systems are servicing them well and there is no reason to switch to RFID at the moment. The retailers, apart from one, were not actively involved in information seeking. They, however, perceived that the technology was not ready for adoption and that it was not compatible with their systems.

> *"Four years ago we engaged a consultant to investigate RFID … no trial was needed as there was no need for RFID at that stage."*

Given that these firms did not carry out trials, one can argue that the lack of information on and the preconceptions of a technology could lead to a lower adoption rate. Lacking information, an organization could form an unfavorable opinion of the Facilitating Condition and Readiness that would otherwise support the technology adoption. The retailers in this study had lower perceptions of Facilitating Condition and Readiness, while the distributors and suppliers seemed to have more activities related to RFID, but the suppliers stopped short of conducting any RFID trials.

In the matching stage, the case firms seemed to evaluate adoption more against the environment in which they operate and in relation to the readiness of their supply chain partners. A few respondents had done some trials on RFID within their own operations areas but had found no business case to justify further investment in RFID. One case suggested that they were able to justify the investment only by expanding the

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

implementation beyond their stages of the supply chain. In doing so, they were able to make significant reductions in operating inefficiency and, as a result, end up with a better cost/benefit model. Some of the cases also reported that they were waiting until their supply chain partners had adopted RFID. This suggests that they were aware of RFID systems requiring the collaboration or participation of supply chain members to implement the technology meaningfully. An explicit mandate is a motivation that might push these members to adopt RFID. Table 2 shows the supply chain groups' perceptions of the factors.

Discussion

This section discusses the themes developed out of the case study findings. The themes are formed around the six factors identified earlier. Table 2 shows the meaningful themes and factors found when describing RFID/SC adoption.

Table 2 - Findings and Themes

Findings and themes	Evaluation	Retained Factors
Finding 1: Compatibility, Readiness, and the Facilitating Condition are important factors in the evaluation of technology for adoption	Important influence	Yes
Finding 2: The Facilitating Condition has some effects on Readiness	Some impact	Yes
Finding 3: The Complexity of systems integration has some effects on Compatibility	Some impact	Weak
Finding 4: Compatibility and Relative Advantage are associated with one another	Some impact	Weak
Finding 5: The Subjective Norm has some effects on the level of engagement in information seeking about a technology	Some impact	Weak
Finding 6: The Subjective Norm may become significant in technology adoption when Dependency on trading partners is high	Some impact	Weak
Finding 7: Dependency on trading partners has some effects on technology adoption	Important influence	New

Important Factors Affecting RFID Adoption

Finding 1: Compatibility, Readiness, and the Facilitating Condition are important factors in the evaluation of technology for adoption.

Three factors have been found as common themes in the case studies. They are Compatibility, Readiness, and the Facilitating Condition. It was found that the suppliers and distributors were most likely to adopt RFID/SC whereas the retailers were not. The retailers in this case have lower perceptions of Compatibility, Readiness, and Facilitating Condition than the suppliers and distributors. The contrast provides some evidence that the three factors have an effect on the adoption of RFID/SC. In terms of Readiness and the Facilitating Condition, the suppliers believed that their environments were favorable in facilitating the adoption of RFID/SC. They believed that their customers as well as the technology were ready. They also believed that support would be available to facilitate their adoption of RFID/SC if they needed it. The trialability of RFID and the availability of vendors to support the adoption were two common themes contributing to a favorable

adoption environment. These two aspects, trialability and availability, are categorized in the Facilitating Condition as the technological and environmental dimensions respectively. Trialability allowed the suppliers and distributors to try out RFID/SC in various forms that suited their business processes. As a result, they were able to know specifically where RFID would be useful for them. The availability of RFID vendors to support their trials also provided a positive impression of the availability of support to facilitate RFID/SC implementation. In contrast, the retailers believed that their suppliers were then not capable and that RFID technology was not easily tested. In addition, they felt that there was no expertise within their firms or qualified external vendors in New Zealand to support their RFID implementation.

Finding 2: The Facilitating Condition has some effects on Readiness.

An in-depth interview with the cases that have conducted RFID trials found that the Facilitating Condition is an important attribute in technology adoption. The initiation phase study found that most of the cases knew about RFID technology before they evaluated how the technology could be useful to their businesses. In part of their evaluation, the ability to trial the technology and the availability of vendor support were important to the advancement of the initiation phase – that is, the decision to trial and subsequently to adopt or not to adopt the technology. When the cases formed a positive perception on the Facilitating Condition, they then had a positive perception on Readiness. Therefore, the case studies found that the Facilitating Condition has some influence on Readiness.

Finding 3: The Complexity of systems integration has some effects on Compatibility.

When asked about the Compatibility of the RFID technology with their firms, the suppliers and distributors indicated in general that RFID was compatible. RFID allowed traceability of products along supply chains which had been a key attribute that the firms believed RFID technology could deliver. As a potential solution to supply chain visibility, RFID was one of the few technologies that the firms were investigating. However, it is found that the Compatibility factor is relative to the firms' existing infrastructure or machinery. For example, the manufacturers indicated that RFID was not compatible with their existing standards and systems. This could be due to the complexity of systems integration that the manufacturers foresaw if they implemented RFID. A contrast to this is the example of the dairy cases. The dairy industry has been working on animal tracking using primarily manual or barcoding systems. The barcoding systems, which have similar characteristics, are more compatible with the RFID technology; therefore, it is not surprising that the dairy cases perceptions were positive on the Compatibility factor and the intention to adopt RFID/SC. This further supports the claim that Compatibility is positively related to the intention to adopt RFID/SC. The perceived complexity issues faced by the manufacturers in systems integration, shows that the complexity of systems integration has some effects on the perception of Compatibility.

Finding 4: Compatibility and Relative Advantage are associated with one another.

Further investigation revealed that Compatibility and Relative Advantage may be associated with one another. Using the above examples, the dairy cases had a more positive perception of Compatibility and Relative Advantage than the manufacturers' cases. Due to the complexity of integrating RFID into their existing systems, the manufacturers perceived there was little benefit in adopting the technology. One of the manufacturers had adopted barcoding systems instead. The distributors generally perceived the Compatibility and Relative Advantage factors positively. They perceived that RFID was compatible with their existing systems and processes while providing the benefits of product traceability and sharing of information. The distributors believed that RFID speeds up order fulfillment and improves shipping accuracy (Soon and Gutierrez, 2008). Thus, Compatibility and

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

Relative Advantage are associated with one another in the context of RFID/SC adoption.

When considering a rival theory explanation (Yin, 2003), one could argue that a firm could have a positive perception of the Relative Advantage of RFID and have a lower Compatibility. This could be true in the case of a supplier where the nature of their products did not suit the use of RFID due to various economic reasons. Thus, RFID was perceived as incompatible with the firm's existing values/beliefs. Barcoding systems were used instead by that case. During their evaluation of RFID at the agenda setting stage, the case had evaluated RFID based on the various operational issues they had, and had come to know about RFID when they were looking for solutions to their problems. Therefore, the evaluation was based on how well RFID could solve the problems and, thus, Relative Advantage may have overshadowed the importance of Compatibility in this case.

In the case of the retailers, the Compatibility factor seemed to be inadequately assessed. While RFID was compatible with their existing systems and processes, the retailers perceived that RFID was less compatible with their suppliers and customers. It was found that the retailers were not actively involved in seeking information about RFID but rather had relied upon hearing or learning about RFID from peers and media sources. The results were mixed perceptions on RFID capabilities. Therefore, information about the technology influenced the perception of the Compatibility factor. A retailer case demonstrated this claim with their active involvement in RFID research, and they had related positively to the Compatibility factor. Compatibility is further linked to how a firm perceives the technology based on information from their sources; that is, the Subjective Norm of what others think about the firm in terms of RFID usage.

Finding 5: The Subjective Norm has some effects on the level of engagement in information seeking about a technology.

This research found some evidence that the Subjective Norm increased the information seeking activities. For example, the cases had participated in an earlier survey (Soon and Gutierrez, 2008) and later participated in this case study. This showed that, to a certain extent, they were involved in activities to seek more information about RFID. Four of the cases became members of a RFID interest group formed by industry members in New Zealand to look at RFID development. This was particularly evident in the search for more information about the technical aspects of RFID as the group focused on business cases and technical standards of RFID. Cases that had high perceptions in the Subjective Norm also had high perceptions in Compatibility and Relative Advantage. This has been explained earlier in the agenda setting process – the firms were engaged in hearing and learning about RFID from peers, the media, and other channels. The level of engagement seems to be related to the firms' perceived Subjective Norm on what their supply chain partners think about their potential use of RFID/SC. For example, the retailers did not perceive that their supply chain partners thought they should use RFID so their level of engagement in RFID information seeking was notably lower than the suppliers' and distributors'. This could lead to inadequate information when evaluating the Compatibility and Relative Advantage factors, which may explain the inconsistency found in the retailers' responses. Therefore, there is some evidence that the Subjective Norm influences the level of engagement in information seeking which, in turn, affects the Compatibility and Relative Advantage factors. The Subjective Norm is, however, found to have no direct influence on the intention to adopt RFID/SC.

Finding 6: The Subjective Norm may become influential in technology adoption only when Dependency on trading partners is high,

While the Subjective Norm increased information seeking activities, there was no evidence to suggest that the Subjective Norm has a direct impact on RFID/SC adoption. It merely drove the search for more information

in the cases studied. For example, the retailers rated highly in the technological and organizational aspects of the Subjective Norm, but did not actively search for information. This could be due to their perceived Subjective Norm about their supply chain partners. The retailers perceived that their supply chain partners did not think that they should use RFID. However, they indicated a slight increase in usage of RFID over the next three years. Therefore, it can be argued that the Subjective Norm is important only when there is a dependency on supply chain partners. If a firm is dependent on its supply chain partners, the Subjective Norm of whether the firm should adopt a technology or not becomes more influential. This is similar to the individual adoption of technology, where several research studies found the Subjective Norm is a significant factor contributing to the intention to use IT (Brown et al., 2002; Taylor and Todd, 1995).

Finding 7: Dependency on trading partners has some effects on technology adoption.

The firm may be under the impression that using the technology will improve their relationships with their supply chain partners. This could be an indication of pressure to adopt the technology. Similar to the Subjective Norm, Pressure as a factor is not significant to the adoption of RFID/SC. Most cases were not susceptible to pressure to adopt RFID/SC. In the case of suppliers, although they claimed to be willing to adopt RFID when asked by one of their key trading partners, they would not be under pressure to adopt the technology if they did not have a business case to do so. In the case of the distributors, they are more likely to adopt RFID/SC when asked due to their high dependency on their supply chain partners. Nevertheless, there are few cases where Dependency was high but they claimed that they would not adopt under pressure. These cases are those that have done some form of trials on RFID and knew specifically where RFID would benefit their business. They would implement RFID in a more collaborative way rather than adopting for the sake of satisfying their trading partners. Thus, both the Subjective Norm and Pressure do not have a significant impact on the adoption of RFID/SC. It is the dependency on trading partners that has surfaced as an important factor in the adoption of RFID/SC.

In the case studies, Dependency is found to play an important role in initiating technology adoption. Finding 7 suggests that the degree of dependency on trading partners has impacts on technology adoption. The impacts can be negative or positive depending upon the nature of the dependency on trading partners. The study of supply chains in New Zealand revealed that Dependency has indeed impeded the uptake of RFID. The suppliers in the cases thought that they were ready and would adopt RFID when asked by their key supply chain partners. However, the distributors thought that the suppliers were not ready and, thus, were reluctant to push for adoption. On the downstream end of the supply chain, the retailers thought that their suppliers and customers were not ready. Although this may be a perceived Readiness issue, Dependency on trading partners does influence the perception of facilitation that is required in supply chain technology adoption. The case of a distributor, where their upstream supplier adopted the RFID technology, supports this claim. With the upstream supplier adopting the technology, it facilitated the adoption of similar technology for the firm who would otherwise have looked at barcoding systems rather than at RFID.

Dependency can also be looked at in terms of dependency on systems for business transactions. In the case of the manufacturers, they were highly dependent on their existing systems for their daily operations. Thus, they perceived the complexity of integrating RFID into the existing operations as difficult. As a result, the trial or adoption rate was lower for the manufacturers when compared to the dairy cases. Dependency, therefore, can be applied to the framework for a more complete evaluation of technology adoption.

Comparison with other research

This paper supports other research findings in stating that Compatibility (Premkumar et al.,

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

1994; Singh et al., 2007), Facilitating Condition (Al-Qirim, 2005; Chau and Hui, 2001; Jimenez-Martinez and Polo-Redondo, 2004) and Readiness (Kuan and Chau, 2001; Mehrtens et al., 2001) are important factors relating to technology adoption. In addition, there are three contributions offered by this study.

First, none of the studies found linkages between the Facilitating Condition and Readiness. The closest is the study of the trialability factor as a determinant of whether there are resources available to facilitate the implementation of the technology. It was argued that during trials a firm might come to realize that a trading partner is not ready for adoption of RFID technology. For this reason, there is a possible influence of the Facilitating Condition on the Readiness of a firm. Matta (2008) finds that top management is "critical in providing adequate resources and developing a supportive climate for adoption of new technologies" (p. 71). By providing adequate resources and a supportive environment, a firm will be well-positioned in terms of the Readiness factor for technology adoption.

While Compatibility is defined as an important factor in the adoption of RFID/SC, its assessment is somewhat influenced by the perceived Complexity of systems integration. Rogers (1995) defined complexity as the degree of perceived difficulty to understand and use. Complexity is also used as a separate factor in the evaluation of innovation diffusion by Premkumar et al. (1994) in their EDI adoption study. Complexity was hypothesized as having a negative impact on EDI adoption. Premkumar et al. (1994) state that although a technology may be useful, there may not be expertise within a firm to implement or use it. The technology may be perceived as complex and difficult to understand and use. Nonetheless, complexity was not found as a significant factor by Premkumar et al. (1994). This could be explained by the technical compatibility which was found as a key predictor of EDI adoption and internal diffusion in their study. Technical compatibility was defined by Premkumar et al. (1994) as the perceived consistency with present systems such as data formats, hardware/software, network protocols, and electronic interaction with trading partners. Subsequent diffusion becomes more complex and problematic as the technology is introduced to other departments. It would also require more commitment and major changes to processes or work practices and was thus perceived as incompatible. It is noted that in their explanation, Premkumar et al. (1994) suggest that an inherent feeling may exist that the innovation is faulty and problems with existing hardware/software and standards may deter diffusion. From the results, it appears that Complexity is embedded in the technical aspect of the Compatibility factor. Similar to this research finding, Premkumar et al. (1994) seem to suggest that technical compatibility as a result of complexity has, to a certain extent, an impact on adoption and internal diffusion, defined as the initiation phase in this study. Thus, there is some support for the finding that perceived complexity of systems integration has some effect on Compatibility.

Relative Advantage is not a decisive influential factor in this research study. However, it has been consistently found to be important to IS adoption in other research (Iacovou et al., 1995; Plouffe et al., 2001; Premkumar et al., 1994). In this research study, it is found that because the evaluation of RFID/SC adoption included the technological aspects, Compatibility becomes a more important factor in the intention to adopt RFID/SC. This is supported by the finding of a case where the approach to the evaluation of RFID/SC is from the point of view of existing problems that require solutions. The case's perceived benefits of RFID are found to be important to them as the firm searched for a better way to supersede their existing innovation. Plouffe et al. (2001), although finding that Relative Advantage is a significant factor, caution that it is a collection of other factors that is equally important, if not more important, than Relative Advantage. They argue that other innovation characteristics have a direct impact on

intentions without the effects of Usefulness or Relative Advantage. Their argument is supported by other studies such as Agarwal and Prasad (1997) and Chin and Gopal (1995). Both studies found that Compatibility was more important than Usefulness as a predictor of intentions. It is thus consistent with the findings of this research study that Relative Advantage is less important than Compatibility. What is not explained in these prior studies are the possible associations between Relative Advantage and Compatibility. The case studies in this research lead us to the finding that the perceived Relative Advantage of RFID/SC is aligned with the Compatibility concerns. That is, RFID application is perceived as a fit with the firm's existing systems and processes in areas that have the highest perceived benefits. It is also found in this research study that Relative Advantage may be the first consideration in the early stage of the evaluation of a technology. When it comes to intentions to adopt the technology, however, Compatibility plays a larger role as a potential barrier to the adoption. In agreement with prior studies, Relative Advantage is secondary to Compatibility as a predictor of intentions.

Third, Subjective Norm and Dependency are two factors of concern. Subjective Norm has been widely studied in the IS field. Most of the studies have found Subjective Norm to be a significant factor of intention behavior (Brown et al., 2002), particularly in organizational settings (Taylor and Todd, 1995). There are some cases where the Subjective Norm is found not to be important to the adoption decision. For example, Davis et al. (1989) found that the Subjective Norm is not a significant predictor of intentions in personal and individual application adoption.

In this study, there are three findings about the Subjective Norm. First, the Subjective Norm is less significant compared to Compatibility, Readiness, and the Facilitating Condition. It is only significant when Dependency on trading partners is high. Second, the Subjective Norm has some effect on information seeking activities and, third, the Subjective Norm has some associations with the information seeking process of a firm. In contrast to prior studies where the Subjective Norm is found to be significant in organizational settings, it was found in this study that it was not an important factor in the intention to use RFID/SC. This could be explained from the perspective of information about the technology. Most cases had heard about RFID/SC and started enquiring about the technology. In the early stage of information gathering, firms may have to rely on their trading partners and other channels to form the perceived Subjective Norm about RFID/SC. The Subjective Norm may trigger the information seeking process, but it may become less important as firms start to consider formally the adoption decision. As the firms form an understanding of the technology through rounds of information processing, their Subjective Norm may again shift as a consequence. One of the cases in this research study claimed that they may change their adoption status if they see real benefits when their trading partners start to yield a return on investments with RFID.

In prior studies, Dependency has been studied in the adoption of EDI. It is often studied as an external pressure or coercive pressure (Iacovou et al., 1995; Teo et al., 2003). Dependency on trading partners or government has been found to be significant in the adoption of organizational applications. Firms that are highly dependent on their trading partners or government are willing to adopt technology when requested. The fact that some cases in this research study are willing to adopt RFID/SC when requested by their trading partners, suggests that the Subjective Norm will become important when the cases are highly dependent on their trading partners.

Conclusions

A total of seven findings are discussed in this paper. Eight factors were discussed in those findings. They are shown in Figure 3. The figure shows the theoretical framework of the adoption of technologies derived from the case studies. This framework is proposed to

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

suit the evaluation of RFID/SC technology adoption at organizational supply chain levels. It shows the seven findings. The dotted arrows indicate the weak propositions found in the study that have some impacts on the factors pointed to. The solid-line arrows indicate an important influence on the intention to adopt RFID/SC. The framework presents the important aspects of technology adoption that practitioners should be aware of when consulting or assessing a technology implementation.

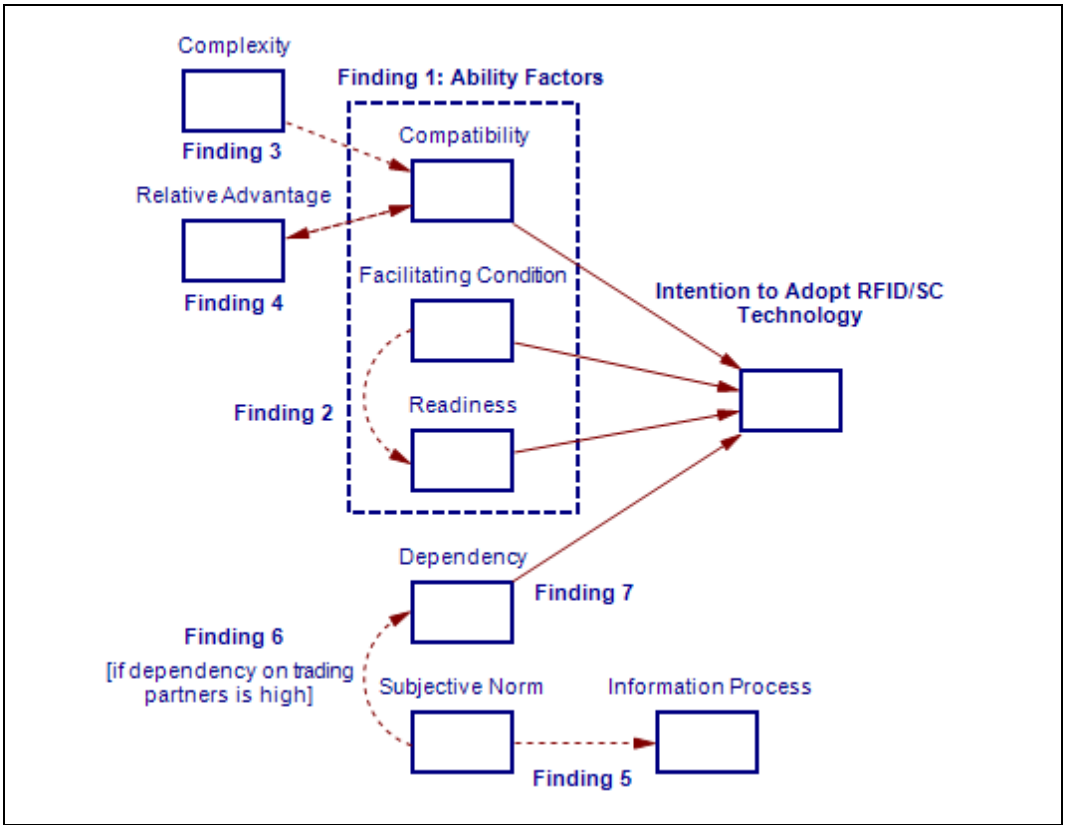

Figure 3 - Proposed Theoretical Framework of Technology Adoption

It is worth highlighting that the three key factors are classified as the "ability" factors. There are two aspects in this finding. First, it shows the importance of the ability to innovate, as suggested in Christensen et al. (2004). Firms require these ability factors to facilitate the adoption of technology. The research shows that these are key factors for firms when deciding on the adoption of RFID/SC and they are clearly lacking in the New Zealand context. The good news, according to Christensen et al. (2004), is that the government and other institutions can intervene to increase firms' capabilities to innovate by creating technological or operational abilities. Operational abilities in this case include the facilitation of RFID implementation across supply chain partners. Second, the fact those firms are primarily concerned with the ability factors means that they may already have their own motivation to adopt RFID/SC. A few of the cases were able to find motivation by looking at a wider implementation scope beyond their supply chains.

Factors uncovered in the case studies that are not in Table 1 are Complexity and Dependency. It is found that the perceived complexity of systems integration had deterred the cases from adopting the technology. This is especially obvious with the manufacturers as they are heavy users of multiple systems and machineries.

Complexity is a contributing factor to a lower intention to adopt technology through Compatibility issues. The more complex the perceived integration is, the lower the intention to adopt technology. Complexity of systems integration is, therefore, included in the theoretical framework. As the adoption of RFID/SC is a supply chain effort, Dependency on trading partners is commonly cited as a criterion when the cases evaluate the type of standards, levels of tagging, and sharing of information with their trading partners. This issue is critical in New Zealand supply chains, as found in the cases studied. The distributors and retailers perceived that the suppliers were not ready, while the suppliers claimed that there was no request from their trading partners to adopt RFID in their supply chains.

Managerial Implications

There are three key managerial implications worth pointing out. First, firms need to possess the ability factors to be in a position to start an RFID adoption process. The technology needs to be compatible with the firm's systems as well as with its trading partners. The firm's and its trading partners' infrastructure needs to be ready for such a supply chain technology. Facilitating trials with trading partners helps to highlight the readiness of their supply chain, as well as any possible teething issues with compatibility.

Second, firms need to gather not only adequate but relevant information about RFID so that appropriate levels of evaluation can be conducted. The Subjective Norm of the cases informs us that inadequacy of relevant information led the retailers to different assumptions. Firms can get the latest information about a technology by attending industry and academic forums, and, in particular for RFID standards, the local governmental Privacy and Radio Wave Commissions are highly recommended sources of information.

Third, in cases where Dependency on trading partners is high, information about the firm's trading partners is even more important. The mixed perceptions of their suppliers' and customers' readiness have misinformed the cases that their supply chains were not ready for RFID. Thus, collaboration is crucial at the supply chain level. Firms need to collaborate and work with current information.

This RFID/SC adoption framework hopes to inform practitioners with a useful guide in their quest to adopt RFID/SC.

Research Significance

The framework proposed in this research helps to uncover the important factors in the adoption of technologies. While most IS research is focused on individual technology adoption, or on intra-organizational technology adoption, this research is focused on technology adoption that involves or has impacts on trading partners. It provides a framework that encourages practitioners to not only look at internal, but also external factors when evaluating supply chain technologies.

The contribution of this research to the field of operations management and supply chains is the introduction of well-known IS theoretical frameworks. The use of these theories to evaluate supply chain technology adoption not only introduces a new theoretical framework, but also adds to the knowledge pool of the supply chain and operations management disciplines.

Limitations and Future Research

In this study, as with all research, there are limitations. While this research demonstrates strong validity in terms of knowledge of the subject and the extensive literature review, the reliability of the research is somewhat difficult to measure. RFID/SC, as a topic in the IS and operations management fields, is fairly new. There are only a handful of research studies on the topic specifically in the supply chain context. In order for the research to be replicated by other researchers, the theories used were carefully selected and crafted to suit the context and to avoid errors or biases in the study (Yin, 2003).

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204

Another limitation follows on from the above. This research is a cross-sectional empirical study. Data collected are, thus, a "snap-shot" of the perceived evaluations by the cases studied. As part of the research is to determine how firms can overcome the barriers identified, a longitudinal approach may well fit this intention. Unfortunately, due to the short timeframe available for this research and the fast-changing pace of firms, the research design is limited to a self-reported snap-shot of the cases' intentions to use or adopt RFID.

Another limitation of this research lies with the selected firms for the case studies. Although the selection of cases has gone through a rigorous process, it is, however, acknowledged that the available cases are only a fraction of firms in New Zealand that were involved in RFID in some way.

Last but not least, there are some unresolved findings for Subjective Norm, Relative Advantage, Complexity, and Pressure. Further investigation of the findings is necessary to uncover the meanings these factors have in relation to adoption intention.

With the limitations acknowledged, the research presents opportunities within those limitations and other areas discussed earlier for further research. The future research studies proposed are:

1. Replicate this research methodology with other cases of cross-organization technology adoption.
2. Conduct a longitudinal study to validate the findings found by this research.
3. Conduct the same research focusing on specific supply chain members, such as, in the transport industry, courier services, and other non-retail specific supply chains such as public transport. The inclusion of external pressure is suggested as a factor in the study.

Further investigate the effects of Relative Advantage, Complexity, and Subjective Norm on RFID/SC adoption at the supply chain level.

References

Agarwal, R. (2000). "Individual Acceptance of Information Technologies," In R. W. Zmud (Ed.), *Framing the Domains of IT Management: Projecting the Future Through the Past* (pp. 85-104). Cincinnati: Pinnaflex.

Agarwal, R., & Prasad, J. (1997). "The Role of Innovation Characteristics and Perceived Voluntariness in the Acceptance of Information Technology," *Decision Sciences,* 28(3), 557-582.

Ajzen, I. (1991). "The Theory of Planned Behavior," *Organizational Behavior and Human Decision Processes,* 50(2), 179-211.

Al-Qirim, N. (2005). "An Empirical Investigation of an E-Commerce Adoption-Capability Model in Small Business in New Zealand," *Electronic Markets,* 15(4), 418-437.

Alu, A., Sapia, C., Toscano, A., & Vegni, L. (2006). "Radio Frequency Animal Identification: Electromagnetic analysis and experimental evaluation of the transponder-gate system," *International Journal of Radio Frequency Technology and Applications,* 1(1), 90-106.

Amoako-Gyampah, K., & Salam, A. F. (2003). "An Extension of the Technology Acceptance Model in an ERP Implementation Environment," *Information & Management,* 41, 731-745.

Beckinsale, M., Levy, M., & Powell, P. (2006). "Exploring Internet Adoption Drivers in SMEs," *Electronic Markets,* 16(4), 361-370.

Bottani, E., & Rizzi, A. (2008). "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), 548.

Brown, S. A., Massey, A. P., Montoya-Weiss, M. M., & Burkman, J. R. (2002). "Do I really have to? User acceptance of mandated technology," *European Journal of Information Systems,* 11(4), 283-295.

Chau, P. Y. K., & Hui, K. L. (2001). "Determinants of Small Business EDI Adoption: An Empirical Investigation," [Online]. *Journal of Organizational Computing and Electronic Commerce,* 11(4), 229-252.

Chin, W. W., & Gopal, A. (1995). "Adoption intentions in GSS: Relative importance of beliefs," *Data Base Advance,* 26(2), 42-64.

Christensen, C. M., Anthony, S. D., & Roth, E. A. (2004). *Seeing What's Next: Using the Theories of Innovation to Predict Industry Change*. Boston: Harvard Business School Press.

Chwelos, P., Benbasat, I., & Dexter, A. S. (2001). "Research Report: Empirical Test of an EDI Adoption Model," *Information Systems Research,* 12(3), 304-321.

Cooper, R. B., & Zmud, R. W. (1990). "Information Technology Implementation Research: A Technology Diffusion Approach," *Management Science*, 36(2), 123-139.

Daugherty, P. J., Germain, R., & Dröge, C. (1995). "Predicting EDI Technology Adoption in Logistics Management: The Influence of Context and Structure," *Logistics and Transportation Review,* 31(4), 309-324.

Davis, F. D. (1989). "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly,* 13(3), 319.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science,* 35(8), 982-1003.

Fichman, R. G. (2000). "The Diffusion and Assimilation of Information Technology Innovations. In R. W. Zmud (Ed.)," *Framing the Domains of IT Management: Projecting the Future Through the Past* (pp. 105-127). Cincinnati: Pinnaflex.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. MA: Addison-Wesley.

Gallivan, M. J. (2001). "Organizational Adoption and Assimilation of Complex Technological Innovations: Development and Application of a New Framework," *The DATA BASE for Advances in Information Systems,* 32(3), 51-85.

Goodhue, D. L. (1995). "Understanding User Evaluations of Information Systems," *Management Science,* 41(12), 1827-1844.

Heese, H. S. (2007). "Inventory Record Inaccuracy, Double Marginalization, and RFID Adoption," *Production and Operations Management,* 16(5), 542.

Iacovou, C. L., Benbasat, I., & Dexter, A. S. (1995). "Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology," *MIS Quarterly,* 19(4), 465-485.

Jimenez-Martinez, J., & Polo-Redondo, Y. (2004). "The Influence of EDI Adoption over its Perceived Benefits," [Online]. *Technovation,* 24, 73-79.

Johansson, O., & Pålsson, H. (2009). "The impact of Auto-ID on logistics performance," *Benchmarking,* 16(4), 504-522.

DOI: 10.17705/1pais.02204

Jones, P., Clarke-Hill, C., Hillier, D., & Comfort, D. (2005). "The benefits, challenges and impacts of radio frequency identification technology (RFID) for retailers in the UK," *Marketing Intelligence & Planning,* 23(4).

Knol, W. H. C., & Stroeken, J. H. M. (2001). "The Diffusion and Adoption of Information Technology in Small- and Medium-sized Enterprises through IT Scenarios," *Technology Analysis & Strategic Management,* 13(2), 227-246.

Kuan, K. K. Y., & Chau, P. Y. K. (2001). "A Perception-based Model for EDI Adoption in Small Businesses using a Technology-Organization-Environment Framework," *Information & Management,* 38, 507-521.

Kwok, S. K., & Wu, K. K. W. (2009). "RFID-based intra-supply chain in textile industry," *Industrial Management + Data Systems,* 109(9), 1166.

Li, S., Visich, J. K., Khumawala, B. M., & Zhang, C. (2006). "Radio Frequency Identification Technology: Applications, technical challenges and strategies," *Sensor Review,* 26(3).

Lippert, S. K., & Forman, H. (2006). "A Supply Chain Study of Technology Trust and Antecedents to Technology Internalization Consequences," *International Journal of Physical Distribution & Logistics Management,* 36(4), 271-288.

Luo, Z., Yen, B., Tan, Z., & Ni, Z. (2008). "Value Analysis Framework for RFID Technology Adoption in Retailers in China," *Communications of the AIS,* 23(17), 295-318.

Mahmood, M. A., & Becker, J. D. (1986). "Effect of Organizational Maturity on End-Users' Satisfaction with Information Systems," *Journal of Management Information Systems,* 2(3), 37-64.

Martínez-Sala, A., Egea-López, E., García-Sánchez, F., & García-Haro, J. (2009). "Tracking of Returnable Packaging and Transport Units with active RFID in the grocery supply chain," *Computers in Industry,* 60(3), 161.

Matalka, M., Visich, J., & Li, S. (2009). "Reviewing the drivers and challenges in RFID implementation in the pharmaceutical supply chain," *International Journal of Electronic Business,* 7(5), 473.

Mathieson, K. (1991). "Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior," [Online]. *Information Systems Research,* 2(3), 173-191.

Matta, V. A. (2008). *Predicting the Adoption of Radio Frequency Identification Systems in the Supply Chain.* Ohio University, Ohio.

Mehrtens, J., Cragg, P. B., & Mills, A. M. (2001). "A Model of Internet Adoption by SMEs," *Information & Management,* 39, 165-176.

Miragliotta, G., Perego, A., & Tumino, A. (2009). "A quantitative model for the introduction of RFID in the fast moving consumer goods supply chain," *International Journal of Operations & Production Management,* 29(10), 1049-1082.

Moon, K. L., & Ngai, E. W. T. (2008). "The adoption of RFID in fashion retailing: a business value-added framework," *Industrial Management + Data Systems,* 108(5), 596.

Moore, G. C., & Benbasat, I. (1991). "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation," [Online]. *Information Systems Research,* 2(3), 192-222.

Plouffe, C. R., Hulland, J. S., & Vandenbosch, M. (2001). "Research report: Richness versus parsimony in modeling technology adoption decisions - Understanding merchant adoption of a smart card-based payment system," *Information Systems Research,* 12(2), 208-222.

Porter, J. D., Billo, R. E., & Mickle, M. H. (2006). "Effect of active interference on the performance of radio frequency identification systems," *International Journal of Radio Frequency Technology and Applications*, 1(1).

Premkumar, G., & Ramamurthy, K. (1995). "The Role of Interorganizational and Organizational Factors on the Decision Mode for Adoption of Interorganizational Systems," *Decision Sciences,* 26(3), 303-336.

Premkumar, G., Ramamurthy, K., & Crum, M. (1997). "Determinants of EDI Adoption in the Transportation Industry," *European Journal of Information Systems,* 6, 107-121.

Premkumar, G., Ramamurthy, K., & Nilakanta, S. (1994). "Implementation of Electronic Data Interchange: An Innovation Diffusion Perspective," *Journal of Management Information Systems,* 11(2), 157-186.

Ramamurthy, K., Premkumar, G., & Crum, M. R. (1999). "Organizational and Interorganizational Determinants of EDI Diffusion and Organizational Performance: A Causal Model," *Journal of Organizational Computing and Electronic Commerce,* 9(4), 253-285.

Raymond, L. (1990). "Organizational Context and Information Systems Success: A Contingency Approach," *Journal of Management Information Systems,* 6(4), 5-20.

Rogers, E. M. (1995). *Diffusion of Innovations* (4th ed.). New York: The Free Press.

Shih, D., Chiu, Y., Chang, S., & Yen, D. (2008). « An Empirical Study of Factors Affecting RFID's Adoption in Taiwan," *Journal of Global Information Management,* 16(2), 58.

Singh, N., Lai, K.-H., & Cheng, T. C. E. (2007). "Intra-Organisational Perspectives on IT-Enabled Supply Chains," *Communications of the ACM,* 50(1), 59-65.

Smith, A. D. (2005). "Exploring radio frequency identification technology and its impact on business systems," *Information Management & Computer Security,* 13(1), 16-28.

Soon, C. B. (2009). "Radio Frequency Identification History and Development," In J. Symonds, J. Ayoade & D. Parry (Eds.), *Auto-Identification and Ubiquitous Computing Application: RFID and Smart Technologies for Information Convergence* (pp. 1-17). NY: Information Science Reference.

Soon, C. B., & Gutierrez, J. A. (2008). "Where is New Zealand at with Radio Frequency Identification in the Supply Chain? - A Survey Result," In *the Proceedings of 2008 International Conference on Information Resources Management*, Niagara Falls, Canada.

Szmerekovsky, J., & Zhang, J. (2008). "Coordination and adoption of item-level RFID with vendor-managed inventory," *International Journal of Production Economics,* 114(1), 388.

Taylor, S., & Todd, P. A. (1995). "Understanding Information Technology Usage: A Test of Competing Models," *Information Systems Research,* 6(2), 144-176.

Teo, H. H., Wei, K. K., & Benbasat, I. (2003). "Predicting Intention to Adopt

DOI: 10.17705/1pais.02204

Interorganizational Linkages: An Institutional Perspective," [Online]. *MIS Quarterly,* 27(1), 19-49.

Tewary, A., Kosalge, P., & Motwani, J. (2009). "Challenges in piloting a RFID implementation: A case study of an aerospace and defence supply chain," *International Journal of Electronic Business,* 7(1), 3.

Twist, D. C. (2005). "The impact of radio frequency identification on supply chain facilities," *Journal of Facilities Management*, 3(3), 226-239.

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

Vijayaraman, B. S., & Osyk, B. A. (2006). "An empirical study of RFID implementation in the warehousing industry," *The International Journal of Logistics Management,* 17(1), 6-20.

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

Yin, R. K. (2003). *Case Study Research Design and Methods* (3rd ed. Vol. 5). CA: Sage Publications.

Zaltman, G., Duncan, R., & Holbeck, J. (1973). *Innovations and Organizations*. New York: Wiley & Sons.

Zhu, K., Kraemer, K. L., & Xu, S. (2006). „The Process of Innovation Assimilation by Firms in Different Countries: A Technology Diffusion Perspective on E-Business.," *Management Science,* 52(10), 1557-1576

About the Authors

Chin Boo Soon is a Lecturer in Information Systems and Operations Management at the University of Auckland Business School, New Zealand. He is also a Research Associate at the Centre for Supply Chain Management, a Research Centre at the University of Auckland Business School. His current research topics are the adoption of radio frequency identification in the supply chains, logistics and transport, business process management, and reverse logistics. Chin Boo has worked in the logistics industry for ten years. He received a Bachelor of Commerce in Information Systems (First Class Honors, 2002), a Masters degree in Information Systems (2003), and a Ph.D. in Information Systems and Operations Management (2010) from The University of Auckland.

Jairo A. Gutiérrez is a Full Professor with the Systems Engineering Department, Universidad Tecnológica de Bolívar (UTB) and Director of Research and Innovation for UTB, Cartagena, Colombia. He has recently been with the Information Systems Department at the University of Auckland. He was the Editor-in-Chief of the International Journal of Business Data Communications and Networking (2004-2008). He received his Systems and Engineering degree from Universidad de Los Andes, a Masters degree in Computer Science from Texas A&M University, and a Ph.D. in Information Systems from the University of Auckland. His current research topics are in network management systems, viable business models for mobile commerce, ubiquitous network services, and quality of service issues associated with Internet protocols.

https://aisel.aisnet.org/pajais/vol2/iss2/5
DOI: 10.17705/1pais.02204