A Comparison of Voluntary and Mandatory Adoption of Radio Frequency Identification (RFID) Technology in Organizations

The purpose of this study is to compare the organizational adoption factors of Radio Frequency Identification (RFID) between adopters and non-adopters in mandatory and voluntary environments respectively. This paper presents the result of an empirical study that investigates the adoption behaviour of livestock farms in relation to RFID technology adoption in the context of Australia. The quantitative research approach has been taken for this study. The finding of this study confirmed that external pressure and organizations' management-related factors are considered as significant by both adopters and non-adopters. Moreover, adopters considered that compatibility is another important factor for RFID adoption; while the non-adopters emphasized on costs of and expected-benefits from RFID. Implications of the results are discussed.

Field of Research: Supply chain management

1. Introduction

Radio Frequency Identification (RFID) is a generic term which implies a combined architecture of RFID hardware and Information System (IS). RFID is defined as "… a system that transmits the identity (in terms of a unique serial number) of an object or person wirelessly" (RFID-Journal, 2005) without manual interventions but using radio waves (Bacheldor, 2003). It is an automatic identification and wireless tracking technology that allows a reader to communicate with a transponder attached to, or embedded in, an item without a physical contact between the reader and the tag.

In Australia, identifying cattle using RFID technology is mandatory while it is voluntary for other animal-identification. Most of the cattle farms adopted RFID because of the mandate (Hossain and Quaddus, 2011). On the contrary, the sheep farms (non-adopters, technically, the 'yet-to-be adopters') are mostly driven by the voluntary choice and rely on own judgment. A particular issue can be interpreted differently by these two different groups. Consider an example with perceived complexity. As in a mandatory environment, the perceived complexity might not hinder the adoption process; but in a voluntary environment perceived complexity may deter the prospective adopters' decision. In both cases perceived ease of use may increase the adoption and adoption-rate. But the question remains that does this factor really has impact in both environments?

Literature considers that RFID adoption factors are different for adopters and non-adopters (Wang et al., 2010), early-adopters and later-adopters (Roh et al., 2009), mandatory and voluntary adopters (Wen et al., 2009), and individual adopters (Müller-Seitz, Dautzenberg et al., 2009) and organizational adopters (Hossain and Quaddus, 2011). Extensive body of knowledge has been developed in voluntary adoption of innovations, mostly in individual contexts. However, the established

relationships of those studies and models have not tested in a mandatory environment to see whether those models are applicable in both settings. Scholars demonstrate that as the adoption of RFID technology is moving from mandatory to voluntary, firms are looking for tools, frameworks, and methodologies to enable them to evaluate the real impact of RFID technology on their business processes (Linda and Samuel, 2007; Wen et al., 2009), which underscores the necessity of studying the adoption of RFID under the light of mandatory pressure as well as a voluntary choice. This study examines the adopters and non-adopters, and mandatory and voluntary adopters from an organizational perspective, while studying the factors from early adopters and later adopters as well as individuals are beyond the scope of this research.

The paper is organized as follows. The next section presents the background literature while developing the hypotheses followed by presenting the research method, results of the data analyses, and discussion of the results. This paper concludes with the implication and a conclusion section.

2. Background Literature

Adoption diffusion of an innovation at organizational-level has been studied primarily by two theories: Innovation Diffusion Theory (IDT) (Rogers, 1995), and Technology-Organization-Environment (TOE) Framework (Tornatzky and Fleischer, 1990). IDT focuses on both individual and organizational factors of an innovation while TOE model emphasises on organization. It is believed that TOE is consistent with, and is an extension and integration of IDT and Davis's (Davis, 1989) Technology Acceptance Model (TAM). TOE posits that the adoption of an innovation is dependent on technological, organizational, and environmental characteristics. Rogers's innovation attributes (relative advantage, compatibility, complexity, trialability, and observability) are considered as the technological characteristics in a TOE framework. Organizational factors (e.g., innovativeness), and environmental factors (e.g., socioeconomic characteristics) of TOE are also somewhat explained in IDT. To investigate the organizational adoption factors for RFID, a number of studies including (Zhu et al., 2003; Brown and Russell 2007; Lin and Ho, 2009; Schmitt and Michahelles, 2009; Wen et al., 2009) used TOE model.

'Perceived benefit' or 'perceived relative advantage' (commonly termed as 'perceived usefulness') has been discussed as a technological characteristic and considered as a characteristic of the innovation itself in TOE and IDT respectively. This study argues that, consistent with TAM (Davis, 1989), perceived usefulness is much an independent multifaceted construct (consisting variables from technology, and business processes and operations) than a technological factor; thus has its own significance on the adoption intention especially to a complex technological innovation like RFID.

This study argues that for a complex technological innovation like RFID the prospective adopters *expect* some positive outcomes from the innovation rather than solely rely on the *perceptions* about the characteristics of that innovation, especially in a mandatory adoption process. Whitaker et al. (2007) stated that the "unfortunate" suppliers/producers who are "forced" to adopt RFID technology and had to bear the costs of RFID because of a partner mandate expect an early return on their RFID investments. Studies argue that though the external pressure enforces many

organizations to adopt RFID technology but the benefits expected from RFID adoption is a significant factor influencing firms' adoption decision (Tellkamp et al., 2006; Roh et al., 2009). Thus, along with Roh et al.'s study this study focused on the firms' expectations on a RFID system. Hence, to examine the intention to adopt RFID, this study introduces 'expectation' with organizational-level adoption variables.

External Environmental Factors

External environmental factors include the 'global' factors which are beyond organization's control but are important in functioning and decision-making behaviour. External environmental factors can be grouped into external pressure, external support, and external uncertainty (Hossain and Quaddus, 2011).

External Pressure: External pressure can be defined as the formal or informal pressures from outside of the organization to adopt a specific innovation or technique (Robertson and Gatignon 1986). External pressure has been considered as a significant factor in innovation adoption research; not surprisingly is also treated similarly for RFID adoption (Schmitt and Michahelles 2009). Market pressure and business mandate (Chang et al., 2008; Schmitt and Michahelles, 2009), competition/competitive pressure (Huyskens and Loebbecke, 2007; Chang et al., 2008), government mandate (Hossain and Quaddus, 2011), mimetic, and normative pressures (Teo et al., 2003) are the important components of external pressure. It is hypothesised as:

H1a: External pressure will positively influence RFID adoption.

External Support: External support can be defined as the support from the external bodies to inspire the adoption of an innovation (Premkumar et al., 1999). External supports may come from various sources; support from government (Lin and Ho 2009), technology providers (vendors) (Huyskens and Loebbecke, 2007; Lee and Shim, 2007), and relevant associations (Hossain and Quaddus, 2011) are considered as the sources of external support. In a cumulative manner the following hypothesis is suggested:

H1b: External support will positively influence RFID adoption.

External Uncertainty: External uncertainty can be defined as the uncertainty caused by external sources. Literature found that uncertainty increases organizations' incentive to adopt new technologies (Zhu et al., 2003) and RFID (Lee and Shim, 2007). However, others argued that uncertainty negatively influences the adoption of RFID (Schmitt and Michahelles, 2009). In this current context, if the prospective adopters find that the markets do not guarantee the demand of RFID data for a reasonable duration and/or are uncertain that a new technology will replace RFID soon, they would not adopt RFID. Therefore, the hypothesis is proposed as follows:

H1c: External uncertainty will negatively influence RFID adoption.

Technological Factors

Literature finds that technological factors have significant effect on RFID adoption (Schmitt and Michahelles, 2009). In adoption literature, technological factors are complexity, compatibility, perceived benefit, and cost (Schmitt and Michahelles, 2009). In this study, perceived benefit has been excluded from technological factors

while ‘RFID standard’ is included as a technological factor which was examined as an external environmental factor by previous studies.

Perceived Ease of Use (EoU): EoU is a well-accepted variable for an innovation. A complex innovation like RFID involves different levels of technical, operational, and managerial complexity, depending on level of RFID-use (Brown and Russell, 2007). Literature found that EoU, associated with RFID implementation and use, positively influences its adoption (Schmitt and Michahelles, 2009). Therefore, the following hypothesis is proposed:

H2a: Perceived ease of use will positively influence RFID adoption.

Perceived compatibility: Compatibility is the degree to which a technology is perceived to be consistent with an organization’s strategy, infrastructure, practices, and needs (Premkumar and Roberts, 1999). Compatibility is more important in RFID context as RFID systems need to be consistent worldwide; especially when tags are interrogated in different countries (Moon and Ngai, 2008). Scholars argue that a compatible and flexible RFID system would increase RFID adoption (Schmitt and Michahelles, 2009). Therefore, the following hypothesis is proposed:

H2b: Perceived compatibility will positively influence RFID adoption.

Perceived trialability: Trialability is recognised as an important technological innovation characteristic, the extent to which a new technology can be broken into set of components and that can be implemented or “tried” in steps (Hage 1980; Tornatzky and Fleischer, 1990). Social Cognitive Theory (SCT) finds that trialability is one of the most important characteristics of an innovation that can affect the ease of adoption (Bandura, 2001). Moreover, the trialability through displaying demonstration projects by the RFID vendors will also contribute to speed up RFID adoption (Leimeister et al., 2007). Hence, it is proposed that:

H2d: Perceived trialability will positively influence RFID adoption.

Perceived cost: RFID is perceived to be an expensive system. Though the basic cost of RFID is just the costs of RFID tags but an integrated system involves the costs with RFID readers, software, business processes re-engineering, operation, and maintenance (Kinsella, 2003). The associated cost of RFID is perceived as one of the most significant inhibitors for RFID adoption (Brown and Russell, 2007; Schmitt and Michahelles, 2009). Therefore, the following hypothesis is proposed:

H2d: Perceived RFID-cost will negatively influence RFID adoption.

RFID standard: Lack of RFID standard is considered as one of the main inhibitors of RFID adoption (Brown and Russell, 2007). RFID-standards are important particularly for those organizations whose products are interrogated by different organizations in different countries. Different RFID-standards confuses the adopters and hinders RFID adoption. Therefore, the following hypothesis is proposed:

H2e: Perceived RFID-standardization will positively influence RFID adoption.

Organizational Factors

Tornatzky and Fleischer (1990) argued that organizational factors are extremely relevant and must be considered in any organizational innovation adoption research;

RFID is not an exception. Organizational factors can be decomposed into organizational resources and organization's management-related factors.

In adoption literature, organization size is treated as the most powerful and supported variable; larger organizations tend to achieve "economy-of-scale" and therefore are more likely to adopt RFID (Tornatzky and Fleischer, 1990; Ghadim et al., 2005). RFID adoption also depends on financial, human, and technological resources of the organization (Iacovou et al., 1995; Huyskens and Loebbecke, 2007). Financial resources are required to pay for implementation and upgrade costs of the technology, and its maintenance (O'Callaghan et al., 1992; Iacovou et al., 1995). An organization with better quality human-resources will have higher ability to understand the innovation and therefore increases the possibility of its adoption (Lin, 2009). Similarly, the availability of technical resources and technical know-how are critical for RFID adoption (Brown and Russell, 2007). Organization's physical proximity to other adopters is positively related to adoption Hossain and Quaddus (2011) as more distant farmers are less informed and less confident on an innovation and therefore are less interested to adopt.

H3a: Organizational resources will positively influence RFID adoption.

Like the resources, management-based factors are also considered as important for RFID adoption. Management attitude (management support) of an organization has been considered as an important factor RFID adoption (Schmitt and Michahelles, 2009). Furthermore, organizational readiness (Iacovou et al., 1995), organizational cultural/willingness to go beyond traditional methods (Hoske, 2004), organizational innovativeness (Thong and Yap, 1995), and risk-attitude (Ghadim et al., 2005) significantly influences RFID adoption.

H3a: Organization's management-related factors will positively influence RFID adoption.

Expectation

Expectations are the desired outcomes of using/adopting a product/innovation. Consumer research found that 'expectation' is the fundamental factor that a customer considers to (intend to) (re)purchase a product. "*Without the feature of benefits it is just ludicrous (to adopt RFID); you just won't do it"* (Hossain and Quaddus, 2011). Expected benefits have been considered as the most influential driver for RFID adoption (Mehrtens et al., 2001). The adopters expect various monetary and non-monetary features from RFID. Monetary expectations include positive return on investment (ROI), quick pay-back period, increased profit, competitive advantage, and penetrating into new markets (Hossain and Quaddus, 2011). Business-process expectations included lifetime traceability, better farming, farm-efficiency, and reduce animal theft. Therefore, it is hypothesised that:

H4: Expectation will positively influence RFID adoption.

Figure 1 depicts the hypothesized model.

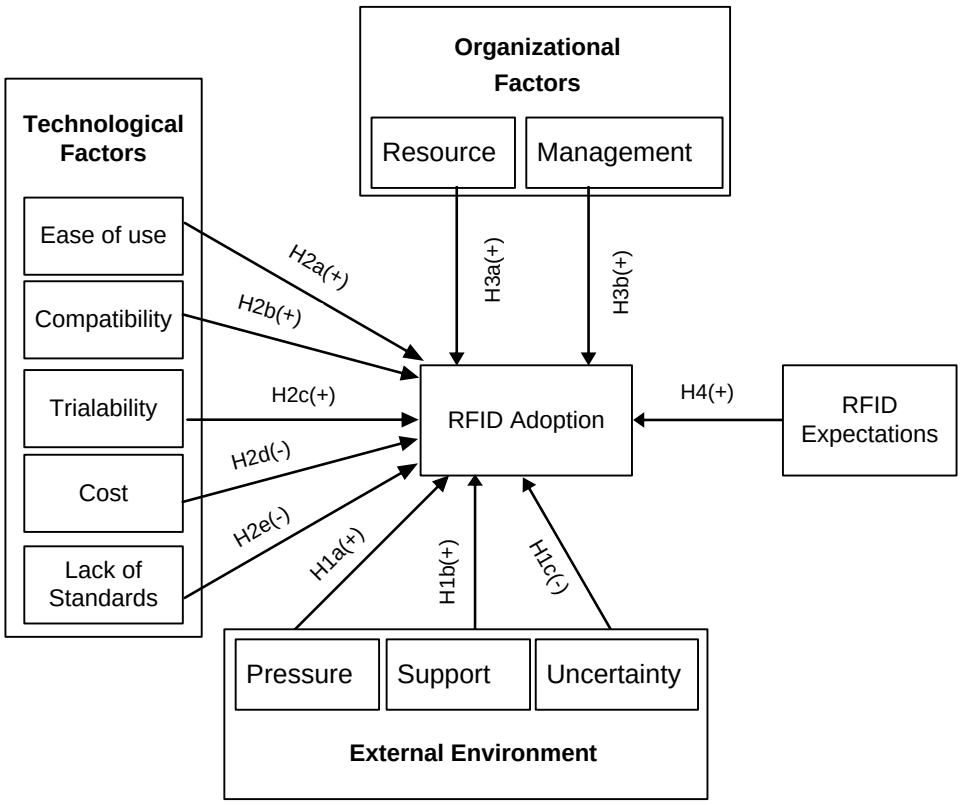

Figure 1. The adoption model for RFID

3. Methodology

3.1 Sample and Procedure

The research process for this study involved two distinct phases. First, an extensive literature review was carried out within innovation-adoption domain and then extended into RFID adoption issues. The second phase involved a quantitative survey. For the survey, 2,500 farms were selected randomly from the Department of Agriculture, Western Australia (DAFWA) database and were invited to attend the survey. Two sets of questionnaire were sent; one set targeted the 'already adopters' (mandatory adopters) and another aimed the 'non-adopters' (voluntary adopters). The implicit assumption of this study is that the adopters are coerced by the mandatory government-legislation whereas the non-adopters represent the voluntary adopters who would adopt RFID not because of the legislation but by a voluntary decision. The mail survey-form included a web link so that respondents could attend the online survey. Concurrently, a web link was supplied to several agencies which they attached with each newsletter to the farms. In this way, the questionnaires were distributed among the livestock farms in Australia. The number of sample could not be established because of the innovative nature of this survey. Overall, 135 responses from 'voluntary' and 229 from 'mandatory'-sample were usable.

3.2 Measures

The factors described earlier (in Section 2) have been measured with great care. The constructs, except 'external uncertainty', were operationalised as reflective. External uncertainty was operationalised as a formative, emergent construct formed from three formative indicators. The theoretical rationale is that these three indicators are not necessarily correlated among each other, rather, these three items *form* the external uncertainty construct (Jarvis et al., 2003; Teo et al., 2003). Six-point Likert scale ranging from 'strongly disagree' to 'strongly agree' has been used to measure 50 items. Two items (of RFID adoption) were measured using 'less than 1' to 'more than 5' scale.

4. Results

4.1 Evaluating the Measurement Model

The research model consists of 50 observed variables. To assess the reflective constructs of the measurement model, two tests were evaluated: (1) item reliability, (2) internal consistency and AVE. Following the recommendation of Igbaria et al. (1995), seven items from voluntary and five items from mandatory model were discarded (loading below 0.45). The revised models were again tested using PLS and all items passed the item-reliability test. Considering the advice by Jiang et al., (2002), this research considered 0.45 as the acceptable minimum value of AVE. Internal consistency and AVE for 'external uncertainty' have not been included into this calculation as these measures are not required for formative constructs (Jarvis et al., 2003). Internal consistency and AVE for 'trialability' in mandatory model is also excluded because only one item was left after reaching the item reliability test.

Table 1. Internal Consistencies and AVEs

Latent variable	*Int. consistency (Voluntary)*	*AVE (Voluntary)*	*Int. consistency (Mandatory)*	*AVE (Mandatory)*
External pressure	0.913	0.54	0.889	0.504
External support	0.842	0.572	0.885	0.565
Ease of use	0.822	0.611	0.924	0.803
Compatibility	0.889	0.801	0.932	0.821
Trialability	0.867	0.767	-	-
Cost	0.916	0.733	0.829	0.624
Standard	0.824	0.621	0.872	0.701
Org. Resource	0.878	0.593	0.852	0.657
Management	0.863	0.563	0.89	0.621
Expectation	0.860	0.512	0.928	0.684
Adoption	0.882	0.655	0.666	0.481

For both models, to establish discriminant validity, the square root of the AVE was compared to the inter-construct correlations. For each construct, the square root of AVE for that construct was greater than the variance shared between a construct and other constructs in the model (Barclay et al., 1995). Finally, the cross-loading matrices have been constructed to ensure the discriminant validity. To save space theses tables are not provided.

4.2 Testing the Structural Model and Hypotheses

The structural model deals with testing the hypothesised relationships. We have used bootstrap method to test the hypotheses. Hypotheses were tested by examining the value and sign of the path coefficients and *t*-values. The results detailing the path coefficients, weights, and *t*-statistics are summarised in Table 2. It is observed that in voluntary model H1a, H2c, H2d, H3b, and H4 are supported (significant *t*-values and path coefficients), while in mandatory model H1a, H2b, and H3b are supported. R^2 for voluntary model is 64.3% which is 56.9% in mandatory model- satisfying the required value of 10% (Teo et al., 2003).

Table 2. Test of Hypotheses

Hypothesis	*Path Coefficient*	*t-value*	*Supported*	*Path Coefficient*	*t-value*	*Supported*
H1a	0.219	2.818**	Yes	0.323	4.839**	Yes
H1b	0.045	0.595	No	-0.002	0.039	No
H1c	0.015[1]	0.187	No	0.044	0.875	No
H2a	0.181	1.404	No	0.008	0.079	No
H2b	0.073	0.622	No	0.179	1.724*	Yes
H2c	0.175	1.647*	Yes	-0.063	1.182	No
H2c	-0.573	8.078**	Yes	0.03	0.496	No
H2e	0.09	1.16	No	0.036	0.774	No
H3a	0.074	0.674	No	0.033	0.497	No
H3b	0.321	1.715*	Yes	0.342	4.469**	Yes
H4	0.529	2.788**	Yes	0.03	0.533	No

* $p<0.05$ **$p<0.005$

5. Discussion of Findings

The findings of this study showed that, in both mandatory and voluntary environment, there is significant statistical evidence to support a positive relationship between external pressure and RFID adoption (Shih et al., 2008; Lin and Ho, 2009; Schmitt and Michahelles, 2009; Wen et al., 2009). In a mandatory setting when the organizations experience pressure from the external environment they have no choice but to adopt the technology. On the other hand, in a voluntary environment, RFID adoption takes place when the organizations find that such adoption preserves their competitive position and/or increase the competitive advantage, for example. External support is not supported in either model which is somewhat contradictory to the existing literature. This result is supported by practice; the continuous support from USA government (e.g., cost exemptions, incentives) could not influence RFID adoption of its farmers (Swedberg, 2007). In addition, eternal support is rejected may be because of trusting farms' self-capability and self-efficacy. Similarly, external uncertainty does not have an influence to convince the farmers to adopt RFID, which is supported by literature (Schmitt and Michahelles, 2009; Lin and Ho, 2009).

[1] Weight was considered because of the formative nature

It is found that perceived complexity and and perceived lack of standards related to RFID do not affect farms' RFID-adotion decision. Schmitt and Michahelles (2009) too did not find a negative relationship between complexity and RFID adoption. In a mandatory environment this finding is not suprising as organizations need to comply with the requirement and therefore do not consider other such isues. However, in a voluntary setting this is empricially proven by literature that perceived complexity and lack of standards would deter the organizations to adopt RFID. In this current study it can be interpreted that the voluntary farms do not conider these issues as important for their decision; rather, they might emphasize on other issues such as expected benefits and so on. Moreover, as they have not adopted yet they might not aware of these issues. The positive influence of compatibility in mandatory model is supported by Schmitt and Michahelles (2009) while cost in voluntary model is supported by Brown and Russell (2007), Shih et al. (2008) and Schmitt and Michahelles (2009). It is found that when organizations are forced to adopt RFID, from technological perspective, compatibility is the most important factor they consider. On the contrary the voluntary farms consider trialability and costs of RFID technology as important. The voluntary prospective-adopters want to trial RFID technology and get convinced if RFID systems can be implemented in an increment fashion; while RFID costs are one of the main concerns.

It is interesting to find that the availability of organizational resources does not influence RFID adoption but the organization's management-related factors do. This finding support that an organization with tremendous resources which is not innovative, for example, may not adopt RFID technology whereas a firm with limited resource and positive mindset may adopt RFID technology. In a mandatory environment all firms need to adopt RFID (unless they quit the business) regardless of their resources; however, a firm with positive management-attitude or innovativeness could be an early adopter.

Finally, in a mandatory adoption the adopters' expectations do not influence the adoption decision because they do not possess the luxury to expect but to follow the rules. In contrast, the voluntary farms adopt RFID technology when they convince themselves that RFID could address their expectations. The more they expect from an RFID system the more positive they are to adopt RFID.

6. Concluding Remarks

This study has discovered the state-of-the-art of RFID adoption in both voluntary as well as mandatory environment. Another major theoretical contribution of this study, apart from incorporating relevant variables from innovation and RFID adoption literature, is considering 'expectations' as an independent construct that has a direct and leading role in adoption behavior, especially in a voluntary setting.

This study used a research model that extends the TOE model and incorporated a well-accepted construct from marketing literature namely 'expectation' in order to identify the significant factors that influence the RFID adoption. The constructs and the variables were developed from a comprehensive literature review. This effort makes a theoretical contribution to the adoption-diffusion literature as well as practical contributions to the relevant industries. Depending on the nature of adoption, mandatory or voluntary, deploying agencies and/or organizations may use

the findings of this study to prepare themselves address the significant relevant factors.

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