Adoption Factors of RFID in a Voluntary Environment: An Empirical Investigation from Australian Livestock Industry

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Abstract

The objective of this study is to investigate the contributing factors for Radio Frequency Identification (RFID) adoption in a voluntary setting. Adopting a mixed method consisting both qualitative and quantitative approaches, the findings of this study reveals that external pressure, RFID costs, and management attitude toward RFID are the main factor to intend to adopt RFID. Moreover, expectations from RFID use are significantly important for its adoption.

Keywords: RFID, adoption, environment, technology, organization, expectation.

Introduction

In 1999 Australian livestock industry, one of the biggest in the world, introduced the world's first and largest RFID-based animal identification system, called the National Livestock Identification System (NLIS) (Tonsor and Schroeder, 2006) and made it mandatory in July 2005 (for cattle). However, still a large number of farms have not adopted RFID for sheep and other animal-identification. To achieve the decisive success from RFID, an integrated RFID-system is required. Thus, it is quite important to examine the intention of the yet-to-be adopters toward RFID adoption. Most studies on RFID adoption, predominantly concentrated in supply chain management, have dealt with various factors but none of those studies took initiative to explore what the potential adopters *expect* from an RFID system. To understand their expectations, integrate those factors in an adoption model, and to find the effect of those expectations on adoption intention is invaluable (Bhattacherjee, 2001). This study, therefore, extends the RFID adoption behaviour of an organization by incorporating the traditional adoption-diffusion factors with a fundamental construct from the consumer literature; 'expectation'. The next section presents the background literature while developing the hypotheses followed by presenting the results of the data analyses, discussion, and conclusion section.

Background Literature and Hypotheses

Many behavioural theories and models have been developed explaining the adoption behaviour of individual adopters; however, not many theories are available to examine the adoption nature of the organizations. Adoption diffusion of an innovation at organisational-level has been studied primarily by Innovation Diffusion Theory (IDT) (Rogers, 1995) and Institutional Theory (Teo *et al*. 2003). However, Tornatzky and Fleischer (1990) revealed that the adoption of an innovation is dependent on technological, organizational, and environmental characteristics, and consequently proposed the TOE Framework. TOE framework is an integration and extension of IDT, and institutional theory. To investigate the organizational adoption factors for RFID, a number of studies (Zhu *et al*. 2003; Brown and

Russell, 2007, for example) used TOE model successfully. However, consumer behaviour literature established that, before purchasing a product, potential consumers develop some expectations out of the product which influences the intention to purchase that product (Oliver, 1980). This phenomenon may be true for organizational adoption decision too, because organizations will not accept an innovation until they realise some expected benefits from using the innovation. Therefore, to examine the 'intention to adopt RFID', for the first time, this study introduces 'expectation' construct in organizational setting along with organizational-level adoption variables. The following sections present the theoretical background of the relevant factors for RFID and develop the hypotheses.

External Environment

External environmental factors refer to those variables that are usually beyond the control of the organizational management but are important in functioning and decision-making behaviour (Tornatzky and Fleischer, 1990; Quaddus and Hofmeyer, 2007). External environmental factors can be decomposed into external pressure, external support, and external uncertainty (Hossain and Quaddus, 2011). External pressure may come in different forms including legislation, government and business mandate, market pressure, competition, mimetic and normative pressure which have direct positive effect on RFID adoption (Iacovou *et al*. 1995; Teo *et al*. 2003; Chang *et al*. 2008; Schmitt and Michahelles, 2009; Hossain and Quaddus, 2011). External support may come from various sources including government (Lin and Ho, 2009), technology providers (vendors) (Huyskens and Loebbecke, 2007), communication network (Rogers, 1995) and affects RFID adoption positively. Finally, external uncertainty may affect RFID adoption either positively (Zhu *et al*. 2003; Lee and Shim, 2007) or negatively (Whang, 2010). However, this study postulates that uncertainty increases farmers' incentive to adopt RFID technology. Thus, the hypotheses are proposed:

H1a: External pressure will positively influence the intention to adopt RFID.

H1b: External support will positively influence the intention to adopt RFID.

H1c: External uncertainty will positively influence the intention to adopt RFID.

Technological Factors: Technological characteristics refer to the technological variables that represent the perceived characteristics of the innovation (Tornatzky and Fleischer, 1990). Literature finds that technological factors have a significant effect on RFID adoption. The relevant technological factor for RFID adoption includes ease of use, compatibility, trialability, cost, and standard (Brown and Russell, 2007). Uniquely for RFID, along with hardware standardisation, the requested data also needs to be standardised as different market's differing data-requirement deter RFID adoption intention (Hossain and Quaddus, 2011). The hypotheses became:

H2a: Perceived ease of use will positively influence the intention to adopt RFID.
H2b: Perceived compatibility will positively influence the intention to adopt RFID.
H2c: Perceived compatibility will positively influence the intention to adopt RFID.
H2d: Perceived RFID-cost will negatively influence the intention to adopt RFID.
H2e: Perceived RFID-standardization will positively influence the intention to adopt RFID.

Organizational Factors:

Tornatzky and Fleischer (1990) argued that organizational factors are extremely relevant and must be considered in any organizational innovation adoption research. Organisational characteristics refer to those variables that determine the organizational structure, and could

be adjust or changed to suit its change environment. Generally, organizations with more resources are more in a position to adopt RFID. Resources examined for RFID adoption includes financial, human, and technological resources of the organization (O'Callaghan, Kaufmann *et al*. 1992; Iacovou *et al*. 1995; Huyskens and Loebbecke, 2007; Lin, 2009), organizational-knowledge-base (Brown and Russell, 2007), and organization's physical proximity to other adopters (Hossain and Quaddus, 2011). Management attitude (management support) (Hoske, 2004; Schmitt and Michahelles, 2009), organizational readiness (Iacovou *et al*. 1995), organizational cultural/willingness (Hoske, 2004), organizational innovativeness (Thong and Yap, 1995), and risk-attitude (Ghadim and Pannell, 1999) of an organization have been considered as the important management-oriented factors to intend to adopt RFID. Therefore, the hypotheses are suggested:

H3a: Organizational resource will positively influence the intention to adopt RFID.
H3b: Positive management-attitude will positively influence the intention to adopt RFID.

Expectation

Expectations are the desired outcomes of adopting an innovation. Roh *et al*. (2009) considered that expected benefits are the *anticipated* advantages that an innovation can provide; however, expectations are *deserved* or *expected* outcomes. Hence, expectations are stronger than perceptions or anticipations. Expectations are somehow diffused into the potential adopters by technology vendors, government agencies, and markets. Therefore, expectations from RFID use are the *expected* features of RFID without which the prospective adopters would not adopt it: "*Without the feature of benefits it is just ludicrous (to adopt RFID); you just won't do it"* (Hossain and Quaddus, 2011). Literature suggests that thought the external pressure made many organizations to adopt RFID technology but the benefits expected from RFID adoption are the most influential drivers influencing RFID adoption (Mehrtens *et al*. 2001; Roh *et al*. 2009). Therefore, the following hypothesis is proposed:

H4: Expectation will positively influence the intention to adopt RFID.

Research Method

The research process for this study involved three distinct phases. First, an extensive literature review was carried out within innovation-adoption and RFID domain. Based on literature, particularly dealing with organizational adoption, an initial research model was developed. In the second phase, using semi-structured interview technique, the initial research model was modified by the findings of a field study interviewing eight farms from the Australian livestock industry, (see Hossain and Quaddus, 2011 for detail). Integrating the conceptual and revised model, a combined research-model consisting eleven factors was developed. In that model, all the constructs except 'external uncertainty' were operationalised as reflective constructs. The indicators of 'uncertainty' (data uncertainty, demand uncertainty, and technology uncertainty) are not necessarily correlated among each other, rather they *form* the construct (Jarvis *et al*. 2003; Teo *et al*. 2003). The research model was validated by a survey. For the survey, 560 farms were selected randomly from the Department of Agriculture, Western Australia DAFWA's database and were invited to attend the survey *if they have not adopted RFID yet*. Concurrently, a web link was provided to some other government agencies and associations which they attached with each newsletter to the farms. Thus, the survey was conducted at Australian national level and the number of the sample

could not be established. Overall, 135 returned surveys were usable. The data were analysed by partial least squares (PLS)-based structural equation modelling.

Results and Discussion

The research model consists of 63 observed variables. Following the recommendation of Igbaria *et al*. (1995), 8 items were discarded (loading below 0.45). An item with the lowest loading was deleted from 'external support' as the construct could not achieve the acceptable AVE value though it satisfied the acceptable loading value. The internal consistencies and AVEs of all reflective constructs were significantly high satisfying 0.7 (Barclay *et al*. 1995) and 0.5 (Fornell and Larcker, 1981) threshold limits respectively. Discriminant validity at construct level was also performed; the variance shared between measures of two different constructs were lower than the AVE for the items measuring each construct (Fornell and Larcker, 1981). Finally, discriminant validity test was performed in a form of cross-loading matrix. To save space, the tables are not presented in this paper. Alternatively, the structural model deals with testing the hypothesised relationships. Hypotheses and corollaries testing were performed by examining the sign and significance of the path coefficient, and the *t*-value of the constructs respectively. The result-details are provided in Figure 1, where the values in brackets refer to *t*-values and the others are path-coefficients. It is observed that among the hypotheses H1a, H2d, H3b, and H4 were supported (significant *t*-values and path coefficients, results in bold numbers). The results indicate that the model explained 63% of the variance of the intention to adopt, satisfying the required value of 10% (Teo *et al*. 2003).

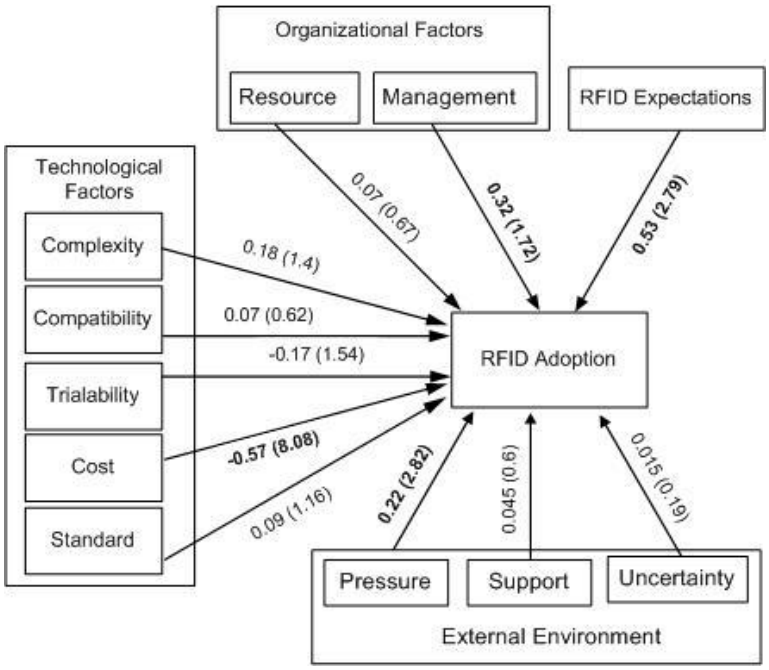

Figure 1. Research model for RFID adoption in Australian livestock industry

There is significant statistical evidence to support a positive relationship between *external pressure* and intention to adopt RFID which is consistent with other studies (Schmitt *et al*. 2009; Shih *et al*. 2008; Lin and Ho, 2009; Wen *et al*. 2009). *External support* is not supported

which is somewhat contradictory to the existing literature. However, literature deals with external support on individual's adoption which does not guarantee the same result in organizations. Interestingly, 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). External support is rejected may be because of trusting adopters' self-capability and self-efficacy observed from the past RFID use (in cattle). *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). *Cost* is the only supported technological factor. Studies including the current research find that cost negatively influences the RFID adoption (Brown and Russell, 2007; Schmitt and Michahelles, 2009; Shih *et al*. 2008). Rejecting the *complexity* on RFID adoption is surprising which is consistent with Schmitt and Michahelles (2009) study. Like this study Schmitt and Michahelles did not find support for *compatibility* on RFID adoption. An explanation of rejecting compatibility and *trialability* can be that, from the past observation/experience from RFID for cattle identification, the farmers may perceive that RFID is already compatible with their farming practices and implementable in a trial basis as they want. Regarding the organisational factors, interestingly, the intention to adopt RFID is more dependent on *management attitude* (Lin and Ho, 2009; Schmitt and Michahelles, 2009; Tsai *et al*. 2010) than the *resources*. Brown and Russell (2007) and LaTour and Peat (1979) also did not find the significance of resource on RFID adoption. Finally, farmers intend to adopt RFID when they *expect* some desired outcomes from adopting RFID (Sharma *et al*. 2008; Shih *et al*. 2008). This finding strengthens the inclusion of expectation on RFID adoption model.

Concluding Remarks

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 intention to adopt RFID technology. The findings of this study found that: not the resources but organizational mindset toward RFID is the main for its adoption. Therefore, the relevant actors should realise that, when RFID adoption is a voluntary choice, organizational attitude and their readiness is the single most important factor to drive RFID adoption and therefore they should work to develop positive attitude among the prospective adopters toward RFID. With the ever-spreading nature of Internet, the physical proximity of the adopters is no longer a serious issue. This study also emphasises the importance of the external pressures. Unlike the cattle products, the members of sheep supply chain are yet to be loud to make the farms to adopt electronic traceability. Nonetheless, a comprehensive pressure from the government, markets, and consumers will increase RFID adoption. Concurrently, RFID manufacturers should consider reducing RFID costs to instigate its quick adoption. Furthermore, government and vendors may run display centres, conduct workshops to increase the awareness of and rational expectations from RFID.

The most critical limitation of this study is the relatively small sample size returned. Furthermore, Australian states have slightly different regulation on animal identification; the failure to establish the physical location of the respondents is another flaw of this study. In future a comparative study can be performed which would compare the adoption variables considered by adopters verses non-adopters.

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