ANTECEDENTS OF CONTINUANCE INTENTION OF RFID TECHNOLOGY IN WESTERN AUSTRALIAN FARMS

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Abstract

In literature, adoption and continuance of an innovation have been considered as discrete events and discussed in separate models. This study argues that these are interrelated and continuous processes. The objective of this study is to investigate the adoption and continuance behaviour of a technological innovation in a single framework taking Radio Frequency Identification (RFID) as the context. Applying the quantitative research approach, this study finds that external environment, the technology itself, and the organization factors influence RFID adoption whereas the continuance of RFID technology is dependent on confirmation and satisfaction from using the technology. Moreover, confirmation is the immediate next stage of adoption where the adopters justify their adoption decision and take required actions and/or adjustments. Data were analysed using Partial Least Square (PLS)-based Structured Equation Modelling (SEM) tool. The discussion and implications on the findings are discussed in detail.

Keywords: RFID; adoption; diffusion; continuance; TOE; ECM

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1 INTRODUCTION

A significant numbers of ‘mad cow’ disease outbreaks around the globe as well as the recent food safety concern in Japan, Europe, and Korea increased the necessity of a lifetime traceable information system (IS) of animals. Such an IS would record every animal, their movements, and trace back the source animal during a disease outbreak. Though there is numerous animal identification technologies available to livestock producers including Radio Frequency Identification (RFID), DNA, and biometrics (i.e., retinal imaging) (Marchant 2002), RFID is the most recommended because it is the most appropriate for the current industry needs. The reason is that RFID has enormous capabilities in identifying animals uniquely and tracking and tracing-back animal history, when needed, as quickly as in 12 hours. By definition, RFID is “a system that transmits the identity (in terms of a unique serial number) of an object or person wirelessly” (RFID Journal 2005). RFID uses electromagnetic wave to read object from distance without requiring a contact or manual intervention and direct line of sight (Moon and Ngai 2008). Hence, the major meat-importing countries in the world have either already made or going to make RFID-based animal identification as a prime requirement for farms (Baker 2005).

In Australia, livestock industry is the most important after mining; considering the revenue-generation and export earnings. In 2010-11 the gross value of Australian livestock production is $21.8 billion (ABARE 2011). In general, Australia exports approximately 70% of livestock production (Electrocom 2007) which made Australia the second-largest exporter of beef, mutton, and lamb in the world, exporting to more than 100 countries, and world’s largest beef exporter (Fletcher et al. 2009; Tonsor et al. 2006). During 2010-11 the total value of exports from livestock sector was $14.7 billion which is the second highest single sector, apart from minerals export (ABARE 2011). Considering its huge dependency on the export of livestock and livestock-products, Australia is serious addressing the requirement of the buyer-markets. In late-1990s European countries started exercising pressure on the meat-exporting countries to develop a ’lifetime traceable’ system of animals so that the history of each single animal can be generated from “paddock to plate”. The similar requirement is asked also by Australia’s other two important markets (Japan and Korea). Therefore, in 1999 Australia introduced world’s largest RFID-based animal-identification system, called the National Livestock Identification System (NLIS) and made it mandatory in 2005 (for cattle).

When the use is mandatory the mandated organizations only can accept it, either reluctantly or whole-heatedly. If the organizations do not accept the innovation whole-heartedly they would suffer from dissatisfaction and could delay or obstruct the implementation, and resent, underutilize or sabotage the innovation (Brown et al. 2002; Kimberly et al. 1981; Leonard-Barton 1988). NLIS in particular, if the movement of a single animal is not updated (timely) the whole system gets vulnerable and faulty. Therefore, understanding the antecedents of RFID adoption, of the farmers, is vital. Moreover, scholars established that, though the initial adoption of an IS is important, the long-term viability and its eventual success depend on its continued use (Bhattacherjee 2001; Rogers 1995). In Australian livestock sector although RFID has been adopted (mostly by the cattle farmers) initially it has been observed that the farmers are less interested to continue its use at farms. Many of them could discontinue this system if they were allowed to (Hossain and Quaddus 2011a). To the best of the authors’ knowledge, no study investigated what makes the farmers to adopt RFID and to continue with the adoption has not been researched comprehensively. Hence, to study the continuance process of RFID in Australian livestock industry is worthwhile and timely.

Most of the studies investigating the adoption of a technological innovation are investigated by academics who selected various fields without employing that much attention in agricultural sector. In other words, how a technological innovation is accepted or rejected by the farmers, what factors they look at for their judgment and eventual decision is not studied in a large scale. In the same way, the researchers, interested in agriculture, are predominantly economists (Adesina et al. 1995) and, therefore, the perceptions of the farmers are fed into economic models to determine the adoption variables (Adesina et al. 1995; Gershon et al. 1985; Shakya et al. 1985; Strauss et al. 1991). The empirical study considering farmers’ perception toward an innovation through a survey is rarely found which proves that the researchers “did not have access direct observations on farmers’ perceptions”

(Adesina et al. 1995, p. 1). Therefore, a prime objective of this research is to determine the perceptions of the farmers toward RFID technology and to determine the effect of these perceptions on their adoption and continuance behavior, by a first-hand survey data.

Moreover, a body of research has been conducted on exploring the innovative applications of RFID technology detailing the technical challenges. As mentioned by Schmitt and Michahelles (2009), the overall research on the adoption drivers and the adoption-diffusion process is still limited. Moreover, the influencing factors that lead various industries and organizations to adopt RFID is not prominent (Prater et al. 2005). To some extent researchers have studied the individual adopters' characteristics and their perceptions on RFID adoption-diffusion and continuance process (Müller-Seitz et al. 2009, for example). However, it is glaringly observed that the extent of RFID research, especially on behavioral context, on organizational setting is still limited. Moreover, most researchers (Koh et al. 2010; Adamson and Shine 2003; Sørebø and Eikebrokk 2008, for example) assume that the *adoption* and *continuance* are discrete events. However, we argue that these two decision-variables are related - not discrete. Most studies on RFID adoption (Cheng and Yang 2007; Lee and Shim 2007; Chang et al. 2008; Schmitt and Michahelles 2009) and consumer acceptance of RFID (Hossain and Prybutok 2008; Müller-Seitz et al. 2009), dominantly in supply chain and logistics management sectors, did not study beyond the *adoption*. Alternatively, the studies dealing with the *continuance intention* of RFID concentrate on the *post-adoption* factors, completely ignoring the adoption stage as done by Chen et al. (2008) on RFID use in hospitals' emergency rooms. This current study examines the adoption and post-adoption behavior of organizations toward using RFID technology, taking the Australian livestock industry as the case subject.

The remainder of this paper proceeds as follows. The next section presents the background literature. The third section develops the hypotheses from literature and presents the research method. The fourth section describes the research method adopted for this study. The fifth section presents the results of the data analyses followed by the section that discusses about the implications of the research findings. This paper concludes with a 'conclusion' section.

2 BACKGROUND

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 organizational-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 Technology-Organization-Environment (TOE) Framework. It is believed that TOE framework is an integration and extension of IDT, and institutional theory. However, the major difference between IDT and TOE is: TOE framework considers that TOE factors are interdependent whereas Rogers assumes that all these factors are independent from one another. Scholars showed that TOE framework is a powerful tool for understanding technological innovation-adoption by organizations (Scupola 2003). A number of studies including Brown and Russell (2007), Schmitt and Michahelles (2009), Lin and Ho (2009), Chau and Tam (1997), Zhu et al. (2003, 2006), Zhang et al. (2007) and Wen et al. (2009), among many, used TOE model successfully.

On the other hand, one of the most popular theories dealing with the continuance of an IS is the Expectation Confirmation Model (ECM), proposed by Bhattacherjee (2001). ECT has been derived from Expectation Confirmation Theory (Oliver 1980); a very popular theory used in consumer behaviour. For a comparative analysis between ECT and ECM, see Hossain and Quaddus (2011b). ECM is predominantly concentrated on post-acceptance variables (such as *post-usage expectations* rather than on *pre-use expectations*) because, ECM posits that the post-usage expectations are more important for IS use and "the effects of any pre-acceptance variables are already captured within the confirmation and satisfaction constructs" (Bhattacherjee 2001, p.355). However, scholars argue that the *pre-usage expectations* should not be underestimated, as has been done by ECM, because these are the basis of the expectation-confirmation process (Khalifa and Liu 2003). Similarly, Oliver and Burke (1999) emphasised that *satisfaction* is a function of pre-purchase *expectations*. Therefore, it is important to consider both *pre-purchase expectations* and *post-purchase expectations* in an expectation-confirmation process. The migration from *expectation* to *perceived usefulness*, as done by ECM, is not also unchallenged. *Perceived usefulness*, as proposed in ECM, is the perception about the IS that convince the prospective adopters, especially in a voluntary environment. Alternatively, in a mandatory environment, because the adopters are enforced to adopt the IS, they *desire* and/or *deserve* some positive outcomes (expectation) from the IS rather than just relying on the *perceptions*. Therefore, *expectations* are more logical to be considered especially in a mandatory-use setting. Moreover, theoretically, *confirmation* is the difference between 'what was expected' and 'what is achieved' (Bhattacherjee, 2001; Oliver, 1980, 1993). Thus, by using the *expectation* measures the IS researchers may establish a subjective differences between the *expectation* and *performance* which can further be confirmed by the *satisfaction* measures. Moreover, the ECM overstates the role of post-usage *perceived usefulness* in the *expectation-satisfaction-continued use* process; *expectation* is more appropriate which includes diverse set of variables including usefulness, ease of use, compatibility, profit, risk, etc.

Moreover, and more importantly, ECM defined confirmation as "the congruence between expectation and actual performance" (Bhattacherjee 2001, p.359) and removed the *performance* construct of ECT because ECM assumes that the influence of perceived performance is already explained by *confirmation*. This research adopted the same approach.

3 HYPOTHESES DEVELOPMENT

3.1 Hypotheses Related to RFID Adoption

As claimed by the TOE framework the adoption of a technological innovation is dependent on (external) environmental, technological, and organizational factors.

3.1.1 External Environment

Tornatzky and Klein (1982) demonstrated that *external environment* refers to those variables that are usually beyond the control of organization, and that can either create threat or opportunity to the organization.

External pressure: The motivation to adopt a technology may come from pressure from the external environment (Gatignon and Robertson 1989). External pressure has been considered as a significant factor in adoption research; not surprisingly is also treated similarly for RFID adoption (Matta and Moberg 2007; Schmitt and Michahelles 2009). External pressure can be exercised by different authorities: coercive pressure from government through regulatory bodies (Kuan and Chau 2001), various markets and market-dominant organizations (Chang et al. 2008; Ranganathan and Jha 2005), vendors (Shih et al. 2008), mimetic pressure from the business environment, and the normative pressure from the social environment and the organization itself (Teo et al. 2003).

External support: External support for relevant technology is considered as an important factor that matters to potential adopters (Huyskens and Loebbecke 2007). *External support* can have different sources varying from country to country and from region to region within a same country. Government is considered as an important environmental actor for RFID adoption (Lin and Ho 2009). Similarly, support from technology providers or vendors (Huyskens and Loebbecke 2007) is also very important as many organizations may not have the internal expertise to try and implement RFID projects, and would therefore rely on external providers (Lee and Shim 2007). Finally, the support from the associations is also a significant source of external support.

External environmental uncertainty: Environmental uncertainty would influence the innovation adoption. Zhu et al. (2003) and Lee and Shim (2007) found that market *uncertainty* is important to help understanding RFID adoption because organizations usually pay more attention on innovations when they face an environment with higher instability and chaos (Gatignon and Robertson 1989; Patterson et al. 2003). Alternatively, uncertainty about the innovation itself may hinder the adoption process because organizations do not adopt an innovation if there is not a significant level of assurance of the utility of the innovation.

In a cumulative manner, it is hypothesised that:

Hypothesis 1: External environment will have a positive influence on RFID adoption.

3.1.2 Technological Factors

Technological characteristics of an innovation are the main focus in many relevant theories and are related to the technological variables of an innovation. On the context of RFID the relevant technological factors are complexity, compatibility, trialability, cost, and standard.

Ease of use: Complexity, the opposite meaning of *ease of use*, "is the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers 1995, p.242). 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 *ease of use* is positively associated with innovation adoption and the rate of adoption (Tornatzky and Klein 1982; Premkumar, Ramamurthy et al. 1994; Rogers 1995; Premkumar and Roberts 1999); and the same for RFID adoption (Schmitt and Michahelles 2009).

Compatibility: In the context of RFID, *compatibility* refers to the degree to which RFID technology is perceived to be consistent with an organization's needs, intent, infrastructure, and practices (Premkumar and Roberts 1999; Teo, Chan et al. 2004). Compatibility has been accepted as an important predictor of an innovation adoption (Cooper and Zmud 1990; Zhu, Kraemer et al. 2006). 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; Wang et al. 2010).

Trialability and divisibility: Trialability "is the degree to which an innovation may be experienced with on a limited basis" (Rogers 1995, p. 243). On the other hand, divisibility is the degree to which an innovation can be partitioned to allow rapid trial. Hence, trialability and divisibility are complementary to one another. *Trialability* and *divisibility* are important attributes of innovation that affect the adoption decisions of both individuals (Rogers 1995) and organizations (Zaltman, Duncan et al. 1973). Leonard-Barton (1988) argued that the ability to reverse an adoption-decision allows flexibility of the innovation and lessen commitments which enable the adopters to adjust the innovation; an individual or an organization "will more readily adopt an innovation that can be adopted piecemeal" (Leonard-Barton 1988, p. 613). Discussing the nature and effect of *divisibility* and *trialability* it is coherent to study these two variables as a single construct.

Cost: Cost is proved as a very strong inhibitor of technology acceptance and use (Tornatzky and Klein 1982). The cost of RFID tags, especially, is perceived as one of the most significant inhibitors for RFID adoption (Roberti 2003; Brown and Russell 2007; Schmitt and Michahelles 2009; Tsai, Lee et al. 2010). Numerous researchers found that cheaper tags will increase RFID adoption significantly (Sharma and Citurs 2005; Sharma, Citurs et al. 2007; Schmitt, Michahelles et al. 2008).

Standard: There is a lack of industry-wide global standards for RFID applications. It is stated that "the biggest stumbling block for the technology is a lack of standards" (cited in Roberti 2003). Studies found that most supply chain organizations are reluctant to adopt RFID because of the absence of pervasive and global RFID standards (Asif and Mandviwalla 2005; Wen, Zailani et al. 2009; Tsai, Lee et al. 2010).

In a cumulative manner, it is hypothesised that:

Hypothesis 2: Technological factors will have a positive influence on RFID adoption.

3.1.3 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 obviously an innovation (Rogers 1995). Studies found that organizational characteristics have a significant effect on the adoption of technical innovations. However, these factors can be grouped into organizational resource and management factors.

Organizational resource: A complex and expensive technological innovation like RFID needs strong resource-base. Among the organizational resources *organization size* is treated as one of the most powerful variables and the most supported variable in literature (Patterson, Grimm et al. 2003; Spencer 2003) which facilitates innovation adoption (Tornatzky and Fleischer 1990; Damanpour 1992; Grover 1993; Premkumar and Roberts 1999) because large organizations have greater resources to experiment and implement with innovation and have greater ability to afford risks and costs (Thong 1999). Among others, *financial resource* (Iacovou, Benbasat et al. 1995), *technical expertise* (Premkumar and Roberts 1999; Lee and Shim 2007), *human resource* (Lin 2009), *slack resource, and knowledge-base* (Brown and Bakhru 2007) are considered as important variables for technological innovation adoption.

Organizational management: Not only the resources but also the organizational mind-set is very important for the adoption-diffusion of an innovation. Studies found that innovation-adoption is positively associated with top management support (Grover 1993; Premkumar and Roberts 1999; Schmitt and Michahelles 2009). In the current context, organization-wide readiness is also an important factor for RFID adoption (Asif and Mandviwalla 2005) as organizations must be prepared to make business process changes (Kinsella 2003). Similarly, the innovativeness, and risk-attitude (Tsur, Sternberg et al. 1990; Feder and Umali 1993) are important too.

In a cumulative manner, it is hypothesised that:

> *Hypothesis 3: Organizational factors will have a positive influence on RFID adoption.*

3.2 Hypotheses Related to RFID Continuance

3.2.1 Expectation

Roh et al. (2009) argued that though the external pressure enforces many organizations to adopt RFID technology but the benefits expected from RFID adoption is a significant driving factor influencing firms' adoption decision (Mehrtens, Cragg et al. 2001). Wu et al. (2006) stated that "expectations of RFID benefits can be broken down into two parts: cost reduction and value creation". The *cost reduction* can be viewed as a direct operational benefit while value creation is an indirect (intangible) benefit (Roh et al. 2009). The cost reduction can be achieved by reducing labour costs, inventory costs, etc. (Curtin et al. 2007). *Value creation* is expected by increasing revenue, increasing customer satisfaction due to responsiveness, and anti-counterfeiting (Wu, Nystrom et al. 2006). An empirical study by Tellkamp, Wiechert et al. (2006) reported that supermarket retailers adopted RFID primarily because they expected benefits from RFID. Thus, along with Roh et al. (2009) and Khalifa and Liu (2003) this research emphasises the effect of expectation on the adoption of RFID technology and hypothesises that:

> *Hypothesis 4: Expectations will have a positive influence on RFID adoption.*

Literature suggests that *expectation* has a positive influence on *confirmation* (Anderson 1973) because while raising the expectations about a product may enhance the perception about the performance of the product which also increases the magnitude of *confirmation*. However, Chen, Wu et al. (2008) found that *expectation* and *confirmation* are inversely related; the more the *expectation* the less is the *confirmation*. With less support from literature this study intends to examine a positive relationship between *expectation* and *confirmation*. Therefore, this study posits that:

> *Hypothesis 5: Expectations will have a positive influence on confirmation.*

Oliver and Burke (1999) emphasised that *expectation* is a function of *satisfaction* (Wu and Padgett 2004). The effect of *expectation* on *satisfaction* is somewhat mixed. In a later extension of ECT, named as 'the Expectancy Disconfirmation with Performance Model', Oliver and Burke (1999) found a direct and strong effect of *expectation* on *satisfaction.* It is found by literature that users' expectation has a direct negative influence on *satisfaction* (Oliver 1993; Anderson and Sullivan 1993; Yin 1990). Other studies found a direct and positive relationship between *expectation* and *satisfaction* (Oliver 1980a, 1981; Churchill and Surprenant 1982). This current study posits that the more the adopters expect (rationally) from an RFID system the more they satisfied are, compared to those who do not have any expectations or less expectations from RFID.

Hypothesis 6: Expectations will have a positive influence on satisfaction.

3.2.2 Adoption

In the context of RFID, because of its novelty and complexity, people may have *desires* from RFID technology during the pre-adoption stage but the realistic *expectations* are generated after using the technology, at least in a pilot stage. Like other IS adoption, some expectations can also be developed/modified at the adoption stage when, for example, the adopters find that the system is reaching to a considerable critical-mass. Therefore, the adoption stage itself is vital. Moreover, conceptually, the continuance study of an IS ideally should start with the beginning point; the adoption. Feder and Umali (1993, p.216) argued that "diffusion studies do not consider the innovation process, but begin at a point in time when the innovation is already in use". The examination of the effect of the initial stage on the later stages of the same process is imperative. In this research, therefore, *adoption* is considered as the antecedent of *confirmation*. This approach has been supported by Rogers' Innovation Diffusion Theory (IDT) (1995). IDT suggests that, after adopting an innovation, the adopters justify their adoption-decision at confirmation stage, and also reduce the dissonance level by seeking expert opinion. Therefore, the following hypothesis is developed:

Hypothesis 7: RFID adoption will have a positive influence on confirmation.

3.2.3 Confirmation

Confirmation, popularly disconfirmation, is defined as the discrepancy between *performance* and *expectation*. However, this study treats *confirmation* as an evaluation *process* rather than a measurement step (Hossain and Quaddus 2011b) where multiple actors and factors act together to justify RFID investment with the difference between expectations and perceived performance. In this process adopters try to figure out their investment justification. Therefore, *confirmation* is the evaluation of *actual experience* with *expectations*. *Confirmation* results when the perceived performance matches the *expectations* whereas *disconfirmation* results from a mismatch (Yin 1990). According to ECT, consumers form a feeling of (dis)satisfaction based on their confirmation level; a moderate satisfaction level will be maintained by confirmation, enhanced by the delight of confirmation, and decreased by disconfirmation. As such, positive disconfirmation is expected to strengthen adopters' subjective response; satisfaction. Studies found the *confirmation* as one of the key variables affecting *consumer satisfaction* (Oliver 1980a; McKinney, Yoon et al. 2002). Many studies found a strong link between *confirmation* and *satisfaction* (McKinney et al. 2002; Khalifa and Liu 2003; Yen and Lu 2008; Oliver 1980a). Moreover, the direct effect of *confirmation* on *continuance intention* is also prominent (Yi 1990). Therefore, this research posits that:

Hypothesis 8: Confirmation of expectations from an RFID system positively influences satisfaction.

Hypothesis 9: Confirmation of expectations from an RFID system positively influences intention to continued use.

3.2.4 Satisfaction

ECM holds that *satisfaction* has a direct effect on users' *continuance intention*. It is treated as a collective outcome of perception, evaluation, and psychological reactions to the consumption experience with a product/service (Yi 1990). Literature unanimously suggests that *satisfaction* is one of the most contributing predictors of users' *continued intention* of an IS (Müller-Seitz et al., 2009; Khalifa and Liu, 2003). Therefore, the following hypothesis is proposed:

Hypothesis 10: Satisfaction from an RFID system positively influences continuance intention.

Based on the above discussion the following model (Figure 1) has been developed which is further investigated by the quantitative data.

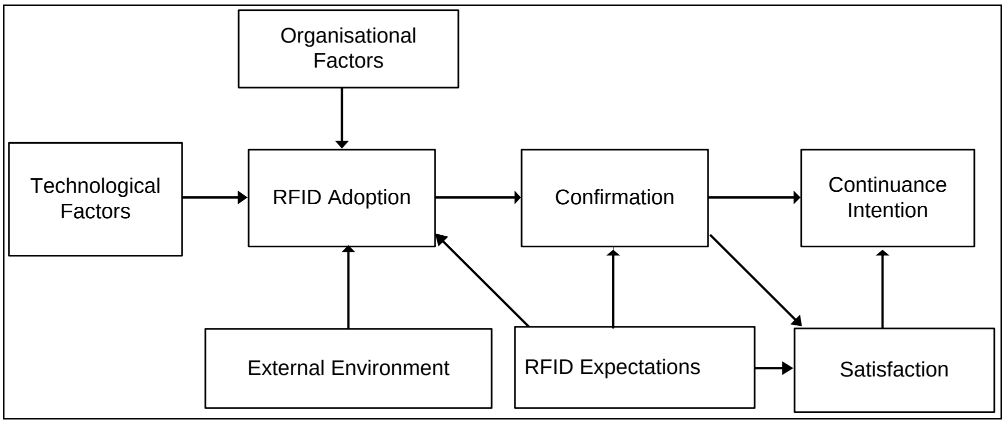

Figure 1. The research model for RFID adoption and continuance in livestock farms

4 RESEARH METHOD

4.1 Sample

This research struggled initially conducting the survey especially to collect the contacts of the sample. Because of the strong *privacy* provision with every agencies and farmers' association in Australia the researcher found it very hard to collect the information. However, a technique to retrieve the contacts from a government online-database was provided by the Department of Food, Western Australia (DAFWA). Additionally, a contact list of 2,600 Western Australia (WA) cattle farms were provided by the DAFWA. In total, 1,200 randomly-selected farms were mailed and invited to participate the survey. Each paper-based questionnaire also provided a temporary URL (web link) so that respondents could alternatively use the online version in *Survey Monkey*. Moreover, a national agency (Sheep CRC) agreed to attach an electronic version of the questionnaire with electronic newsletters to its members/subscribers.

Unlike other surveys, this survey did not include a 'follow-up' procedure. This was actually not possible; because, the questionnaire did not include any reference-code to check whether a particular respondent replied or not. This was intentionally done to increase the reliability. Overall, 220 returned surveys were useable. The response rate could not be established because, as discussed in the first paragraph of this section, the URL could be passed to a farm not listed on our sample, and the number of responses from the Sheep CRC members could not be distinguished. However, the response rate seems to be low which is not uncommon for small businesses in Australia (Quaddus and Hofmeyer 2007).

4.2 Data Examination

As mentioned earlier, this research was conducted through an online survey as well as through the traditional mail survey. The responses from the mail survey were split into early and late respondents. Also, the online survey-respondents were considered as the early respondents. Therefore, the responses were grouped into Wave 1 and Wave 2 sample. 139 responses were in Wave 1 and the rest 81 were in Wave 2. Independent sample Mann-Whitney U Test was performed to test the significant differences between two different waves. The minimum acceptable value of Z-value in Mann Whitney U Test is 0.05 that detect the non-response bias. The test was performed in terms of gender, highest level of education, and age of the person completing the survey; income of the farm; and one indicator from the research model. The results established that the distribution of gender, for example, is same across two different waves of the survey sample which showed that there was negligible non-response bias between Wave 1 and Wave 2 sample. This meant that the response for Wave 1 and Wave 2 samples could be combined for data analysis. The number of usable responses met the requirement level: 10 times the number of items in the most complex formative construct or the largest number of antecedent constructs leading to an endogenous construct in the research model, as argued by Barclay et al. (1995).

4.3 Measures

The eight factors described earlier (see Figure 1) have been measured with great care. The factors were operationalized first from the literature which was further enhanced through the field study (Hossain and Quaddus 2011a). The complete list of measures is shown in Table 1. Six-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’ has been used to measure 60 items while two items (of RFID adoption) were measure with “<1>, <2>, <3>, <4>, <5>, <more than 5> years/applications” scale.

4.4 Data Analysis Technique

The research paradigm of this current study is quantitative-positivist. The research model presented earlier (Figure 1) is relatively complex and the phenomenon under study is new or changing. Moreover, the sample size is relatively small. Therefore, component-based structural equation modelling (SEM) using PLS has been adopted considering its suitability over covariance-based SEM with regard to model complexity, sample size, and distributional properties (Chin 2010; Teo et al. 2003). It is evident that PLS has better ability to model latent constructs under non-normality conditions. Moreover, PLS is more appropriate when the measurement items are not well established and are used within a new measurement context (Barclay et al. 1995). In other words, PLS has been selected because of its suitability when the primary objective of research is explaining (the model variance for one or more constructs), predicting, and theory-development. As such, data were analyzed using PLS-Graph version 3.0 (Chin 2010).

5 RESULTS

5.1 Assessment of measurement properties

As par the PLS procedure (Barclay et al. 1995; Hulland 1999), the research model was tested for item reliability, internal consistency, and discriminant validity to assess the measurement adequacy of the model. The research model consisted of 61 observed variables. Referring to Igbaria et al.’s (1995) argument this research adopted the minimum cut-off level of 0.45 for item loading; and following this rule, eight items were discarded (discarded items are denote with ‘a’). The revised model with 53 observed variables were again tested using PLS and all item reliabilities exceeded the acceptable limit. This result confirms that all items are sufficient to represent their respective construct.

I have analysed composite reliability and AVE to evaluate the model for internal consistency (Fornell and Larcker’s 1981). Referring to Table 1, all constructs met the acceptable criterion for composite reliability (0.7 or more) (Jiang et al. 2002). Similarly, the AVE values for every constructs exceeded the recommended value of 0.5, which means that convergent analysis for these constructs is satisfied.

Construct	Item	Loading	CR	AVE
External environment	EE1. Government legislation	-0.0432[a]	0.891	0.781
	EE2. Government intervention	-0.2224[a]		
	EE3. Market demand	0.7121		
	EE4. Trading requirement	0.5945		
	EE5. Business pressure	0.7987		
	EE6. Competitive pressure	0.4111[a]		
	EE7. Competition	0.8123		
	EE8. Mimetic pressure	0.6091		
	EE9. Favorability	0.7052		
	EE10. Normative pressure	0.7829		
	EE11. Subjective norm	0.5915		
	EE12. Information service support	0.8137		
	EE13. Infrastructure support	0.8160		
	EE14. Taxation benefit	0.1679[a]		
	EE15. Training support	0.7450		
	EE16. Demonstration by externals	0.7732		
	EE17. Publications on farm magazine	0.7152		
	EE18. Discussion among peers	0.6144		
	EE 18. Data uncertainty	0.4941		
	EE 19. Demand uncertainty	0.0622[a]		
	EE 20. Technology uncertainty	0.0463[a]		
Organizational factors	ORG1. Location	0.2486[a]	0.881	0.52
	ORG2. Financial resource	0.7549		
	ORG3. Knowledge-base	0.8089		
	ORG4. Human resource	0.7774		
	ORG5. Future-orientation	0.6366		
	ORG6. Willingness	0.8588		
	ORG7. Farm innovativeness	0.7880		
	ORG8. Management support	0.8711		
	ORG9. Risk attitude	0.7638		
Technological factors	TF1. Ease of interaction	0.8543	0.736	0.714
	TF2. Required effort	0.8991		
	TF3. Overall ease of use	0.9334		
	TF4. Compatibility with existing practice	0.9175		
	TF5. Compatibility for integration	0.9293		
	TF6. Data compatibility	0.8711		
	TF7. Trialability	0.7684		
	TF8. Divisibility	-0.2222[a]		
	TF9. Overall costs	0.8144		
	TF10. Cost-Benefit	0.9175		
	TF11. Share of costs	0.6059		
	TF12. Global hardware	0.9113		
	TF13. Interoperability of RFID system	0.9572		
	TF14. Data standardization	0.5980		
Expectation	EXP1. Competitive advantage	0.7925	0.921	0.661
	EXP2. Return on investment (ROI)	0.8326		
	EXP3. Farm efficiency	0.8495		
	EXP4. Profit	0.8666		
	EXP5. Productivity	0.8523		
	EXP6. Proof of ownership	0.7651		
Adoption	ADP1. Significance	0.9414	0.751	0.613
	ADP2. Duration	0.4640		
	ADP3. Extent	0.4562		
Confirmation	CFM1. Positive confirmation	0.8457	0.781	0.547
	CFM2. Just confirmation	0.6071		
	CFM3. Overall confirmation	0.7472		
Satisfaction	STF1. Judgment	0.9308	0.91	0.772
	STF2. Wise decision	0.9304		
	STF3. Re-adopt	0.7640		

Intention for Continued Use	ICU1. Continue than discontinue	0.8116	0.847	0.649
	ICU2. Intention	0.8061		
	ICU3. Discontinue	0.7985		

[a]*Low loading discarded-items*

Table 1. Psychometric properties for the constructs

This study used the square root of the AVE and cross-loading matrix to assess the discriminant validity as suggested by Igbaria et al. (1995b) and Barclay et al. (1995). The result indicates that all items demonstrate higher loadings in their respective constructs in comparison to their cross loadings in other constructs. Therefore, it confirms that the measurement model has strong discriminant validity at the items level which means that all the latent variables are different from each other. To save space, the tables are not presented in this paper.

5.2 Assessment of the Structural Model

The structural model deals with testing the hypothesised relationships. We have used bootstrap method to test the hypotheses. The results detailing the path coefficients and *t*-statistics are summarised in Table 2. It is observed that all hypotheses except H4 are supported (significant *t*-value).

The nomological validity or explanatory power of the proposed model can be assessed by observing the R^2 values of the endogenous constructs (Santosa et al. 2005). The model explains 42.1% of the variance (R^2) of the *Continuance Intension* of RFID technology. Overall findings show that all scores of R^2 value satisfy the requirement for the 0.10 cut off value (Falk and Miller 1992).

Hypothesis	Link	Path Coefficient	*t*-value	Supported?
H1	Ext. Environment to Adoption	0.353	5.168***	Yes
H2	Technology to Adoption	0.228	2.583***	Yes
H3	Organization to Adoption	0.252	3.412***	Yes
H4	Expectation to Adoption	0.03	0.533	No
H5	Expectation to Confirmation	0.115	2.026**	Yes
H6	Expectation to Satisfaction	0.1	1.675*	Yes
H7	Adoption to Confirmation	0.514	8.907***	Yes
H8	Confirmation to Satisfaction	0.62	15.35***	Yes
H9	Confirmation to Continuance	0.17	2.016**	Yes
H10	Satisfaction to Continuance	0.338	3.266***	Yes

*Table 2: Evaluation of the research hypotheses for the antecedents factors; Significant *p<0.05, **p<0.025, ***p<0.005*

6 DISCUSSION AND IMPLICATIONS

6.1 Summary of Findings

This study provided empirical evidence investigating the *adoption* and *continuance* in a single framework. It is confirmed that *adoption* and *confirmation* are the antecedents of *continuance* while *satisfaction* from current use also important. After adopting RFID technology the adopters evaluate their adoption decision; whether they are getting the things which they expect during pre and post-adoption. If they find a mismatch, they intend to either discontinue its use or seek expert advice to restructure their expectation and usage. This study found that *confirmation* plays the most significant role in the *expectation-satisfaction* process; the more the expectations are confirmed the more satisfied the adopters are and the more they intend to continue RFID use. This is well-supported by marketing and information system (McKinney et al. 2002; Khalifa and Liu 2003; Yen and Lu 2008; Oliver 1980).

The findings of this study showed that there is significant statistical evidence to support a positive relationship between *external environment* and RFID *adoption*. This is supported by literature (Shih et al., 2008; Lin and Ho, 2009; Schmitt and Michahelles, 2009; Wen et al., 2009). That means farms' RFID adoption-decision is influenced by the externals where it operates; they adopt RFID when they find that such adoption preserves their competitive position and/or increase the competitive advantage, for example. Also, the *external support* enhances RFID *adoption*.

Technological factors have been found as important antecedents of RFID adoption. This finding is supported by previous researches (Lin and Ho, 2009; Schmitt and Michahelles, 2009; Wen et al., 2009). This finding re-establishes that farms adopt RFID when they perceive that the innovation is easy to implement and use, compatible with their existing practice and business requirements, and cost effective.

Organizational factors are proven to be important for RFID adoption which is consistent with other similar studies (Lin and Ho 2009; Schmitt and Michahelles 2009; Tsai *et al*. 2010). It implies that both *organizational resources* as well as *organizational mindset* are important for RFID adoption.

The results of this study also find that the *expectation* from RFID technology does not influence RFID adoption, which is surprising but not unusual; Schmitt and Michahelles (2009) and Sharma et al. (2008) also could not find a relationship between *perceived benefits* and *RFID adoption*. In a mandatory environment the adopters' expectations do not influence the adoption decision because they do not possess the 'luxury' to expect but to follow the rules; the demand of their customers or the government mandate. In this current context, for the traceability reason they rather may follow a 'slap and ship' approach; just attaching a tag to comply with the mandate.

In a mandatory environment the adopters do not have any choice but to continue RFID use though still they are allowed to feel satisfied or not. The satisfied adopters are more likely to adopt RFID in other applications- the more important issue than the mere adoption. It is proved from this study that *satisfaction* is the main criteria in a mandatory environment for the *continuance decision*. There is an enormous support and consensus supporting the role of *satisfaction* on *continuance* (Yi 1990; Khalifa and Liu 2003; Sørebø and Eikebrokk 2008; Müller-Seitz et al. 2009).

6.2 Implications for Theory

This study extended and integrated the current adoption theories and continuance theory/model explaining *adoption* and *continuance* in a single framework. It is empirically established that *confirmation* is the next stage to *RFID adoption* where the adopters evaluate their adoption decision. Later, in order to intent for continued use of the RFID system *satisfaction* from the current system is important than any other factors; *satisfaction* drives for continued use whereas *dissatisfaction* deters from continuance.

The founder of ECT Oliver (1980) argued conceptually and proved empirically that *expectation* and *confirmation* are unrelated. Alternatively, Chen et al. (2008) found that *expectation* and *confirmation* are inversely related; the more the *expectation* the less is the *confirmation*. Another theoretical contribution of this study is the re-establishment of *expectation* on *confirmation.* Our study found that *confirmation* is positively related with *confirmation.* This finding implies that the expectations will be more confirmed when the (rational) expectations are high; raising expectations may enhance the perceived performance of the RFID system.

6.3 Implications for Practice

The implications of this research are highly relevant for the livestock agencies, RFID manufacturers and vendors, and farms.

The findings suggest that the interventions of the external actors are important if an extensive adoption of RFID is the objective. The influence can be exercised either as pressure or support or both; and both can be exercised by government and/or market. For example, the growing demand from the meat consumers on meat producers to have a reliable source-of-origin of livestock products needs to be converted into pressure which would increase RFID adoption among the livestock farms. Regarding the support, proactive and aggressive approach from RFID vendors (by demonstrating RFID projects and providing technical support, for example) would inspire farmers embracing more RFID applications and services. Moreover, a positive approach from farming associations toward RFID technology is crucial. A national RFID system cannot be a successful without having the *political* support from the farming associations. Therefore, the government should work closely with the associations to minimize any *hype* related to RFID. Similarly, the associations should act rationally, not just to oppose a *new* system. Finally, government and technology-vendors should take more proactive approach to minimise any uncertainty. For example, a political commitment between the meat-importing country(ies) and meat-exporting countries would reduce the *market uncertainty*. Similarly, a clearer demonstration regarding the technological base of RFID would prove its superiority over other technologies and would assure the prospective-adopters that the technology would not be replaced in a near future.

The implication of finding related to technological factors is important for the RFID manufacturers, architects, and vendors. As seen in last couple of years the lower cost of RFID tags has increased the adoption rate of RFID technology, but not in a substantial manner which emphasizes the importance to look at the other issues along with *cost*. For example, in livestock business *compatibility* of a RFID system is more important than its *costs*. Similarly, RFID architects should realize that a global standard of RFID-components and data-sharing architecture would increase RFID adoption in a significant rate. The current lack of standards regarding the requested information (by the markets to the producers) about the animal is slowing the whole adoption process ("requirement standardization"); different markets demand different details of data. Farmers thus face a dilemma situation: entertaining with the markets, which require less detail of data does not satisfy the markets which ask for extended data. On the other hand, investment for capturing extended data is not guaranteed from the markets which demand basic data.

The implications the finding regarding organizational factors is: the adoption decision is a management-decision, not a technical/technological/financial decision. The management first needs to understand RFID capability and get convinced and then can decide the adoption-timing and adoption-breadth depending on the available and acquirable resources. However, the importance of resources should not be undermined although the resource without organizational management-factors (e.g., innovativeness) do not help that much.

In a mandatory environment, *confirmation* is very important because it drives the farms for continued use of a system and/or secure the system from any sabotage resulted from dissatisfaction. Therefore, in the later stage of adoption the imposing body (e.g., government agency or the market) needs to assess whether the mandatory system is on the track to fulfil the expectations. In case of any mismatch they need to revisit the system and take necessary actions. Evaluating the *satisfaction* status of the adopters would provide an indicator about the impact and usage of the system. As the success (and failure) of the system is completely dependent on the adopters' use the agency/imposing-body needs to conceive policies so that the adopters gain a reasonable, if not the full, satisfaction from using the system; otherwise, sabotage is not unlikely. And, the satisfaction is to be evaluated at a continuous interval. A system might be satisfactory at 'year 1' which could be not true at 'year 2' and 'diminishing marginal utility' also plays a role.

7 CONCLUSION

This study developed an adoption-continuance model of a technological innovation - taking the RFID technology as the case. The model posits that the continuance of an innovation is dependent on confirmation and satisfaction using the innovation where the adoption is one of the most important antecedent factors. Moreover, the adoption is dependent on external environment, technological factors, and organizational characteristics. This model has the potential to be applied in other similar studies and tested. However, continuing using the innovation in current applications as well as in newer application(s) decides the ultimate success of an innovation. Therefore, future studies could investigate the 'extended usage behaviour' of RFID technology by further extension of this proposed model. Also, testing this model separately with adopters and non-adopters would be worthwhile and interesting.

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