Factors Influencing the Mandatory Adoption of RFID: An Empirical Investigation from Australian Livestock Industry

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ABSTRACT

The purpose of this study is to examine the factors of RFID adoption in a mandatory environment. This paper presents the result of an empirical study that investigates the adoption behaviour of livestock farms in relation to Radio Frequency Identification (RFID) technology in the context of Australia. A mixed method consisting qualitative and quantitative research approach has been taken for this study. The finding of this study confirmed that external environment, technological characteristics, and organizational factors are significant for RFID adoption. Alternatively, expectations from RFID-adoption do not have an influence on RFID adoption when the adoption is mandatory.

Keywords: innovation, technology, technology innovation, information system

Radio Frequency Identification (RFID) is an automated system that uses electromagnetic waves to read object from a distance without having a contact and direct line of sight (Moon & Ngai 2008). It is an electronic identification and automated data-collection technology which also processes the acquired data to produce predefined tasks. Because of its industrial and organizational deployment in the last decade, the researchers are keen to explore the important factors of RFID, both in organizational (LaTour & Peat 1979; Brown & Russell 2007; Shih, Chiu, Chang & Yen 2008; Schmitt & Michahelles 2009; Tsai, Lee & Wu 2010) and individual settings (Müller-Seitz, Dautzenberg, Creusen & Stromereder 2009). However, most of those studies have dealt with RFID factors in voluntary settings which were not verified in a mandatory environment. Moreover, no studies took initiative to explore what the adopters expect from an RFID system and how the expectations affect the adoption decision of RFID. To understand the adopters' expectations, integrate those factors in an mandatory-adoption model, and to find the effect of those expectations on adoption process is invaluable because scholars argued that continued use of an innovation is much important than its

initial adoption (Bhattacherjee 2001) and continued usage intention is dependent mainly on the accomplishment of the expectations. 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 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.

BACKGROUND LITERATUR AND HYPOTHESES DEVELOPMENT

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, Wei & Benbasat 2003). However, Tornatzky & 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. 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 & Russell (2007), Schmitt & Michahelles (2009), Lin & Ho (2009), Chau & Tam (1997), Zhu Kraemer & Xu (2003, 2006), Zhang, Cui, Huang & Zhang (2007) and Wen, Zailani & Fernando (2009), among many, used TOE model successfully.

'Perceived benefit' or 'perceived relative advantage' (commonly termed as 'perceived usefulness') has been discussed as a technological characteristic and a characteristic of the innovation itself in TOE and IDT respectively. This study argues that, 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 (Davis 1989). Moreover, adoption of RFID is a long-term strategic decision which involves extensive business process changes and comparatively higher investment on components, infrastructure, and people. Therefore, the adopters *expect* some desired outcomes rather than relying on their *perceptions*. Supporting this claim, consumer behaviour literature established that a consumer develop some expectations out of that product which influences the customer's intention to purchase and repurchase that product (Oliver 1980). Similarly, in Information System (IS) research, the continued usage intention is dependent on the accomplishment of distinct pre-defined expectations (Khalifa & Liu 2003). 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 introduced 'expectation' with organizational-level adoption variables.

The following sections present the theoretical background of the relevant factors for RFID and develop the hypotheses.

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. In general, external environment has been recognized to play a very significant role in innovation adoption-diffusion research (Zhu et al. 2003) and so as for RFID (Wen et al. 2009; Hossain & Quaddus 2011). External environmental factors can be grouped into external pressure, external support, and external uncertainty.

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. The pressure may come in different forms including legislation, mandate, competition, and business advantage (Robertson & Gatignon 1986). It is commonly believed that government mandate can speed up the rate of RFID adoption. Similarly, an ultimate reason to adopt RFID is the increasing market pressure and business mandate

imposed by (resource dominant) organizations and important customers (Chang, Hung, Yen & Chen 2008; Schmitt & Michahelles 2009). Similarly, due to fierce competition, organizations are more willing to adopt RFID in order to maintain their competitive positions (Huyskens & Loebbecke 2007; Chang et al. 2008). Finally, according to institutional theory, organizations also are encountered with mimetic and normative pressures (Teo et al. 2003). Livestock farms may experience mimetic pressure if they perceive that their competitors are gaining benefits from RFID and/or are treated differently by the customers. Similarly, as a social recognition or as a social commitment, some organizations may experience normative pressure to adopt RFID. As a collective manner, external pressure has been considered as a significant factor in innovation adoption research; not surprisingly is also treated similarly for RFID adoption (Schmitt & Michahelles 2009). The following hypothesis is developed:

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, Ramamurthy & Crum 1997). External supports may come from various sources. First, government is treated as an important environmental actor for technology adoption (Lin & Ho 2009) which can play an important role in adoption process through providing infrastructure, counselling, training, and incentives, and facilitating research and development. Supports may also come from technology providers (vendors) (Huyskens & Loebbecke 2007). Many livestock producers may not have the internal expertise to trial and implement RFID projects, and would thus rely on external providers (Lee & Shim 2007). The providers can supply application-specific information, resources, assist in developing RFID setup, and provide support on troubleshooting. Finally, the speed and level of adoption of RFID depends on the communication behaviour of the adopters to its networks (Rogers 1995). This study posits an effect of 'associative support' to RFID adoption. 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. External uncertainty is the result of customer-producer miscommunication, inability to

predict the demand of RFID data, adopters' concern of replacing RFID with a better technology, and changing customers' need and preference (Lee & Shim 2007; Schmitt & Michahelles 2009). Literature found that uncertainty increases organizations' incentive to adopt new technologies (Zhu et al. 2003) and RFID (Lee & Shim 2007). However, others argued that uncertainty negatively influences the adoption of RFID (Schmitt & 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 delay RFID adoption. 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. In adoption literature, technological factors are complexity, compatibility, perceived benefit, and cost (Schmitt & Michahelles 2009). In this study, perceived benefit has been excluded from technological factors while 'RFID standard' is included as a technological factor which is usually examined as an external environmental factor by previous studies.

Perceived complexity: Complexity 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 & Russell 2007). Literature found that complexity, associated with RFID implementation and use, negatively influences its adoption (Schmitt & Michahelles 2009). Therefore, the following hypothesis is proposed:

H2a: Perceived complexity will negatively 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 & 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 & Ngai 2008). Scholars

argue that a compatible and flexible RFID system would increase RFID adoption (Schmitt & Michahelles 2009). Therefore, the following hypothesis is proposed:

H2b: Perceived compatibility 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 & Russell 2007; Schmitt & Michahelles 2009). Therefore, the following hypothesis is proposed:

H2c: 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 & 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:

H2d: 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 adoption research; RFID is not an exception. The organizational characteristics can be grouped into organizational resources and management-related factors.

Organisational resources: In adoption literature, organization size is treated as the most powerful and most supported variable; larger organizations tend to achieve 'economy-of-scale' and therefore are more likely to adopt RFID (Tornatzky & Fleischer 1990; Ghadim, Pannell & Burton 2005). RFID integration-depth comes with the financial, human, and technological resources of the organization (Iacovou, Benbasat & Dexter 1995; Huyskens & Loebbecke 2007). An organization with quality human-resources will have higher ability to understand the innovation and therefore increases the possibility of its adoption (Lin & Ho 2009). Similarly, the availability of technical resources and

technical know-how are critical for RFID adoption (Brown & Russell 2007). Organization's physical proximity to other adopters is positively related to adoption (Hossain & Quaddus 2011) as more distant farmers are less informed and less confident on an innovation and therefore are less interested to adopt. Thus, it is hypothesised that:

H3a: Organizational resources will positively influence RFID adoption.

Management-related factors: Management-related factors are considered as important for RFID adoption. Management attitude (management support) of an organization has been considered as one of the best predictors of RFID adoption (Schmitt & Michahelles 2009) because RFID implementation require positive attitude to address business process changes (Hoske 2004). Furthermore, organizational readiness (Iacovou et al. 1995), organizational cultural/willingness to go beyond traditional methods (Hoske 2004), organizational innovativeness, and risk-attitude (Ghadim et al. 2005) significantly influence RFID-adoption. As combined, it is thus proposed that:

H3b: Organizational management-related factors will positively influence RFID adoption.

Expectation

Expectations are the desired outcomes of adopting an innovation. Roh, Kunnathur & Tarafdar (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 the intervention of 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 & Quaddus 2011). Literature suggests that though the external pressure made many organizations to adopt RFID technology but the benefits expected from RFID are the most influential drivers influencing RFID adoption (Mehrtens, Cragg & Mills 2001; Roh *et al*. 2009). Therefore, it is hypothesised that:

H4: Expectation will positively influence RFID adoption.

RESEARCH METHOD

Sample and Procedure

The research process for this study involved three distinct phases. First, an extensive literature review was carried out within innovation-adoption domain and then extended into RFID adoption issues. Based on literature, particularly dealing with organizational adoption, an initial research model was developed. The second phase involved a qualitative field study to enhance the initial research model developed from the literature. For the field study, eight adopters of RFID technology from the Australian livestock industry have been interviewed using semi-structured interview technique. For details of the qualitative field study, see Hossain & Quaddus (2011). Integrating the conceptual and revised model, a combined research-model consisting ten factors was developed. The final phase of the research involved a quantitative survey which is the main of focus of this current study.

For the survey, 2500 farms were selected randomly from the Department of Agriculture, Western Australia DAFWA's database and were invited to attend the survey if they *already have adopted* RFID. Along with a postage-paid return envelope, the survey-letter included a web link so that respondents could attend the online survey, alternatively. Concurrently, a web link was provided to some other government agencies and associations which they attached with each newsletter to their subscribers. Thus, the survey was conducted at Australian national level and the number of the sample could not be established. Overall, 229 returned surveys were usable. The data were analysed by partial least squares (PLS) based structural equation modelling.

Measures

The 10 factors described earlier (in Section 2) have been measured with great care. These factors were operationalised first from the literature which was further contextualised through the field study. The constructs, except external uncertainty, are considered as reflective constructs. External uncertainty was operationalised as a formative, emergent construct formed from three indicators: data uncertainty, demand uncertainty, technology uncertainty. The theoretical rationale is that these three items are not necessarily correlated among each other, rather, these three items *form* the external environment

construct (Jarvis, MacKenzie & Podsakoff 2003; Teo et al. 2003). Six-point Likert scale ranging from 'strongly disagree' to 'strongly agree' has been used to measure 48 items. Two items (of RFID adoption) were measured using 'less than 1' to 'more than 5' scale. The complete list of measures is shown in Table 1.

RESULTS

Evaluating the Measurement Model

The research model consists of 48 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 Hair Jr, Anderson, Tatham & Black (1998), five items were discarded (loading below 0.5). The revised model with 43 observed variables was again tested using PLS and all items passed the item-reliability test. This study followed the recommended value of internal consistency 0.7 or greater (Barclay, Higgins & Thomson 1995) and AVE at least 0.5 (Fornell & Larcker 1981). The results (in Table 2) show that internal consistencies and AVEs of all reflective constructs are significantly high. Internal consistency and AVEs for external uncertainty have not been included into this calculation as these measures are not required for formative constructs (Jarvis et al. 2003). Discriminant validity at construct level was also performed (see Table 3); the variance shared between measures of two different constructs is lower than the AVE for the items measuring each construct (Fornell & Larcker 1981).

Evaluating the Measurement Model

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 and *t*-statistics are summarised in Table 4. It is observed that hypotheses H1a, H2b, and H3b are supported. R^2 for RFID adoption was found as 0.56 which indicates that the model explained 56% of the variance of the RFID adoption, satisfying the required value of 10% (Teo et al. 2003).

DISCUSSION OF FINDINGS

From the results, generally, it is observed that factors of external environmental, organizational, and technology but 'expectations' have significant influence on mandatory adoption of RFID in livestock farms. The results of the data analyses provide partial support that the research model explains the RFID adoption behaviour in a mandatory environment. We now discuss the results in detail.

The findings of this study showed that there is significant statistical evidence to support a positive relationship between the *external pressure* and RFID adoption. More precisely, the more the pressure from the external environment the greater is the RFID adoption (Shih et al. 2008; Schmitt & Michahelles 2009; Lin & Ho 2009; Wen et al. 2009). More specifically, the mandatory pressure is proved here as one of the most significant factors for RFID adoption. *External support* is not supported which is somewhat contradictory to the existing literature. However, literature dealing 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. Similarly, *external uncertainty* does not have an influence to convince the farmers to adopt RFID, which is supported by literature (Schmitt & Michahelles 2009; Lin & Ho 2009).

This study shows that technological factors including ease of use, costs, and standards have no significant influence on RFID adoption. Rejecting the *complexity* on RFID adoption is surprising which is, however, consistent with Schmitt & Michahelles's (2009) study. Like the EPCglobal members in Schmitt and Michahelles's study, the farmers in Australia do not perceive RFID technology as too complex to implement and use. This is an important finding because the earlier RFID adoption studies often stated that adopters perceive RFID as very complex and hard to understand. *Compatibility* is the only technological factor which is important in a mandatory setting. The positive influence of compatibility is supported by Schmitt & Michahelles (2009). This study finds that *RFID costs* do not have an influence on RFID adoption. In other words, reduction in RFID costs does not guarantee RFID adoption. It is well accepted that RFID-tag cost is increasingly

'disappearing or at least getting lower' (O'Connor 2005) and the recent development of non-silicon-based (polymer based) chip-less RFID tags could bring tag price down below one cent (RFID-Journal 2005). Similarly, the livestock producers do not think that the *RFID-standard* is a significant issue which could affects their adoption decision. The findings of this study are supported by literature. The past researchers predicted that RFID costs, especially the cost of RFID tags, and RFID standards would increase RFID adoption significantly. Over the years, the findings of the past researchers appear to be wrong; 'while tag prices are dropping and standards are in place (e.g., EPC and ISO), the adoption [of RFID] still remains low' (Schmitt & Michahelles 2009, p. 7). Therefore it is suggested that RFID costs and RFID standards are not that important as they were thought, particularly in a mandatory adoption situation.

Regarding the organisational factors, interestingly, RFID adoption is more dependent on *management-related factors* than the *organizational resources,* which is consistent with other similar studies (Lin & Ho, 2009; Schmitt & Michahelles, 2009; Tsai *et al*. 2010). Brown & Russell (2007) and LaTour & Peat (1979) did not find the significance of resource on RFID adoption. The only item that had low loading (in organisational factor) was the *physical proximity*. It was supported by the field study that distance from the nearest city and so on becomes less prominent with the ever-spreading nature of Internet.

The result of this study not finding an influence of expectation on adoption is surprising but not exceptional; Schmitt & Michahelles (2009) also could not find a relationship between perceived benefits and RFID adoption. The farmers who already have adopted RFID technology do not seems to expect benefits from the use of RFID technology, at least at the present time. This means that they adopted RFID only because of the demand of their customers or the government mandate. Moreover, many of these adopters may not have an integrated system in their farming activities; as a result, they do not expect any benefits from it. They rather may follow a 'slap and ship' approach; just attaching a tag to comply with the mandate.

CONCLUDING REMARKS

Implications

This effort makes a theoretical contribution to the adoption-diffusion literature as well as practical contributions to the relevant industries. The findings of this study could be used by organizations and/or agencies that plan for a mandatory adoption of RFID technology. Countries may consider the findings of this study to plan their future strategies and policies by comparing their perceptions and/or experience with the findings of this study. For example, this study finds that the livestock producers demand for RFID-costs be shared by every member of the supply chain, from producers to meat-consumers. Similarly, the manufacturers need to emphasize more in increasing compatibility.

Direction for Further Research and Conclusion

This study used a research model that extends the institutional theory and TOE framework, and incorporated a well-accepted construct from marketing literature namely 'expectation' in order to identify the significant factors that influence the RFID adoption especially in a mandatory environment. The constructs and the variables were developed from a comprehensive literature review which were validated and enhanced by a field study. This study concludes that external pressure, compatibility, and organizations' attitude are the driving factors that determine RFID adoption in a mandatory environment. This finding proves that when the users are mandated to use an innovation they are more concerned about the compatibility of the innovation than costs or standards. This study explicates that RFID users perceive that the body which imposes the mandate would assist the adopters to implement the RFID system and would train them, to some extent, to use it. Similarly, to increase the adoption, the authority would develop some standards. Therefore the complexity or standardisation issues are not matters of concern. Rather, farms are more concerned about RFID compatibility. However, the standardisation could be an issue at collective level.

In future, it will be interesting to explore the non-adopters' thoughts and perceptions toward RFID and examine the comparative findings. Moreover, the afterward effects of adoption, which are especially important for a mandatory adoption (namely the continuance and extended usage intention), can be investigated.

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Table 1. List of Measures and Relevant References

Construct	*Measures*	*Sources*
External environment	Government mandate, market pressure, competitive pressure, mimetic pressure, normative pressure. Government support, vendor support, support from peer farms, associative support. Technology uncertainty, market uncertainty	Shih et al. 2008; Premkumar and Roberts 1999; Teo et al. 2003; Davis 1989; Huyskens and Loebbecke 2007
Technological factors	Complexity (ease of use), compatibility, cost, standard	Davis 1989; Premkumar and Roberts 1999; Schmitt and Michahelles 20089; Shih et al. 2008; Hoske 2004; Kinsella 2003
Organizational factors	Physical proximity, financial resource, knowledge-base, human resource, technical expertise, positive attitude, risk attitude, innovativeness	Iacovou and Benbasat 1995; Lee and Shim 2007; Lin and Ho 2009; Tsai et al. 2010; Brown & Russell 2007
Expectation	Competitive advantage, positive return on investment (ROI), increase labour productivity, increase profit, better faming by accurate	Shih et al. 2008; Davis 1989; Premkumar and Roberts 1999; field study

	information, reduce animal theft	
Adoption	Importance, duration, frequency, and number of applications	Brown & Russell 2007; Teo et al. 2003

Table 2. Internal Consistencies and AVEs

Latent variable	*Internal consistency*	*AVE*
External pressure (EP)	0.889	0.504
External support (ES)	0.885	0.565
Complexity (CPX)	0.924	0.803
Compatibility (CPT)	0.932	0.821
Cost (CST)	0.829	0.624
Standard (STD)	0.872	0.702
Organisational resources (OR)	0.852	0.657
Management-related factors (MF)	0.89	0.621
Expectation (EXP)	0.929	0.685
Adoption (ADP)	0.67	0.52

Table 3. Correlation of Latent Variables and the Square Root of AVE

	EP	ES	CPX	CPT	CST	STD	OR	MF	EXP	ADP
EP	**0.710**									
ES	0.454	**0.752**								
CPX	0.476	0.492	**0.896**							
CPT	0.563	0.518	0.829	**0.790**						
CST	-0.293	-0.252	-0.401	-0.38	**0.837**					
STD	0.24	0.12	0.199	0.259	0.123	**0.811**				

OR	0.24	0.462	0.536	0.514	-0.274	0.063	**0.788**			
MF	0.465	0.453	0.605	0.636	-0.458	0.156	0.464	**0.827**		
EXP	0.423	0.275	0.274	0.292	-0.072	0.268	0.134	0.373	**0.694**	
ADP	0.622	0.429	0.546	0.617	-0.321	0.219	0.374	0.637	0.359	**0.740**

Bold diagonal elements are the square root of AVE

Table 4. Test of Hypotheses

Hypothesis	*Path Coefficient*	*t-value*	*Result*
H1a: EP to adoption (+)	0.34	4.44**	Supported
H1b: ES to adoption (+)	0.004	0.08	Not Supported
H1c: Uncertainty to adoption (-)	0.05	0.84	Not supported
H2a: Complexity to adoption (-)	0.008	0.08	Not Supported
H2b: Compatibility to adoption (+)	0.18	1.72*	Supported
H2c: Cost to adoption (-)	0.02	0.28	Not Supported
H2d: Standard to adoption (+)	0.03	0.48	Not Supported
H3a: Resource to adoption (+)	0.04	0.48	Not Supported
H3b: Management to adoption (+)	0.34	4.2**	Supported
Expectation to adoption (+)	0.02	0.35	Not Supported

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

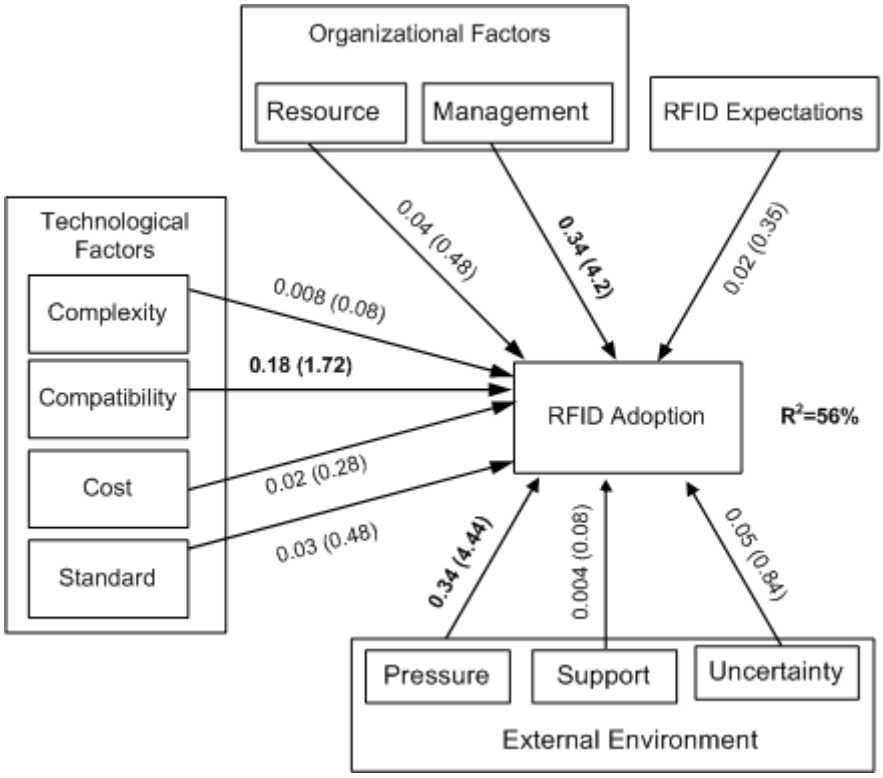

Figure 1. The mandatory adoption model for RFID