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Radio Frequency Identification (RFID) Adoption Drivers: A Radical Innovation Adoption Perspective

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ABSTRACT

This study addresses an IOS (interorganizational system) adoption literature gap by proposing an integrative model of RFID (Radio Frequency Identification) adoption and incorporating the effect of perceived radicalness of technology in IOS adoption decisions. Three technological factors (perceived benefit, perceived costs and compatibility), four inter-organizational pressure factors (competitive pressure, industry/regulatory pressure, net supply-chain exercised power and favorable transactional climate), three organizational readiness factors (top management support, financial readiness, IS infrastructure/capabilities) and three external environmental factors (standards stability, perceived consumer readiness and perceived stakeholder privacy) have been proposed as predictors of RFID adoption intent while perceived technology radicalness has been suggested as a potential moderator of the proposed relationships. The model was developed using existing IOS theories and constructs consistently found significant in IOS adoption studies. The model is supported using semi-structured interview data and news-report data. Testable hypotheses, methodology outline, and findings-implications discussion are presented.

Keywords

Adoption, RFID, interorganizational systems, radical innovations

INTRODUCTION

Despite extensive adoption and diffusion of innovation writings (Rogers, 1983), adoption of emerging technologies with unique characteristics is still not well understood. Adoption of special technologies with adopter interdependencies, heavy adopter knowledge burdening technologies, and EDI adoption are all instances where existing diffusion theory generalizations could not be directly applied. Various models in IOS literature have been developed to identify adoption drivers. However, an integrative adoption model incorporating drivers from multiple studies with tested predictive power is still needed. Similarly prior literature characterizes innovations dichotomously (i.e. product-process, administrative-technological and/or incremental-radical (Hage, 1980)), but little operationalization of these characterizations on continuous scales or testing them for mediating/moderating effects has been done at individual, organizational or inter-organizational levels. Plus, only partially explored, external environment factors may influence a new technology's diffusion and adoption due to the technology's unique features and characteristics.

This paper addresses an existing literature gap by proposing an integrative model based on drivers suggested in existing IOS adoption literature and which appear in initial data gathering to be relevant for RFID adoption. The model seeks to explain the adoption of RFID, an emerging technology. RFID possesses special features such as inter-organizational linkages similar to EDI and other existing IOS, but at a grander scale transcending tight linkages and processes as with EDI. Untested in IOS adoption literature, the model incorporates environmental factors believed to be important in RFID adoption due to its ubiquitous radical nature such as perceived consumer readiness, stakeholder privacy and standard stability. Finally, the model operationalizes perceived radicalness as a continuous construct moderating adoption intent and its' antecedents.

RFID

RFID automatically identifies objects using radio frequency and enhances data collection and handling through greater accuracy, speeds and visibility. Basic identification data is carried in transponders known as tags read by transceivers that decode and send data to attached computers for processing.

As RFID use grows in its technology adoption trajectory, firms have devised new ways of leveraging its technological capabilities. Providing item/good status information to interfacing existing computer systems is one-way firms leverage RFID. For example RFID is key in a recent UPS initiative to provide low-cost improved second-by-second package and

delivery vehicle monitoring. Similarly, leading retailers (i.e. WalMart, Target) and manufacturers (i.e. P&G, Gillette) have endorsed and are pilot-testing RFID. The technology not only has direct benefits for supply-chain members but also many unrealized indirect benefits.

RFID can be viewed as both an internal and interorganizational tool with corresponding differences in adoption drivers strengths depending upon anticipated inter and/or intra-organizational uses. However, we believe that internal organizational use adoption drivers are a subset of potential inter-organizational drivers. RFID combined with information management systems can create effective IOSs capable of providing visibility across supply-chains and delivering direct and indirect benefits to participating supply-chain partners. Hence, this study views RFID as an interorganizational system and uses existing literature models of adoption of other IOS (i.e. EDI e-business) as a basis for establishing a RFID adoption model

Thus, drawing on prior IOS research, this study proposes an RFID adoption model by focusing on the following issues: What major factors influence organizational RFID adoption? What are RFID adoption considerations and their corresponding weights assigned by different stakeholders (manufacturers and retailers) in supply-chains? Do differences (increase or decrease) in strengths of drivers exist based on the perceived radicalness of RFID technology by different adopting organizations?

LITERATURE REVIEW AND HYPOTHESES

IS Inter-organizational System Adoption Literature

Existing IOS adoption literature is based on multiple theoretical frameworks. Tornatzky and Fleischer's (1990) technology-organization-environment framework, which was developed to study general technological innovation adoption, has been widely utilized for studies in e-business (Zhu et al., 2002). Their framework identifies three aspects of firms' contexts (technological, organizational, and environmental) that influence their adoption and implementation processes. Iacovou et al., (1995) proposed an EDI adoption model in which technological factor (perceived benefits), organizational factor (organizational readiness) and environmental factor (external pressure) were suggested as EDI adoption influencers. Chwelos et al., (2002) expanded Iacovou et al.'s (1995) work, by testing an EDI adoption model, which categorized adoption influences into technological factors (perceived benefits), organizational factors (organizational readiness) and interorganizational factors (external pressure, trading partner readiness). Premkumar and Ramamurthy, (1995) suggest that technological factor (internal need), organizational factor (top management [TM] support) and interorganizational factors (competitive pressure and exercised power) influence a firm's adoption decision mode. This paper outlines four-types of adoption influences for RFID technologies, which are categorized as technological, interorganizational-pressure, organizational-readiness, and external-environmental factors and one moderating influence, perceived-radicalness.

Technological Factors

Technological factors, as defined by Tornatzky and Fleischer (1990), relate to perceived characteristics of a technology. Most past studies used innovation diffusion theory as the basis for IOS adoption research. Relative advantage (Rogers 1983) or perceived benefit (Iacovou et al. 1995) have been previously found to be key innovation adoption determinants. Perceived innovation characteristics like complexity, compatibility, (Tornatzky and Klein 1982), costs and communicability (Premkumar and Ramamurthy 1995) were identified for example as important EDI adoption predictors. Consistently cited as important adoption factors, perceived benefits, compatibility and perceived costs were the technological factors selected as facilitators and inhibitors of adoption intent in this study

H1A: Technological factors perceived benefits and compatibility will have significant positive relationships with adoption intent.

H1B: Technological factor perceived costs will have a significant negative relationship with adoption intent.

Inter-organizational Pressure Factors

Issues focusing on actions of other organizations influencing IOS adoption are characterized as inter-organizational pressure factors. For example external pressure has been identified as an intent to adopt driver in EDI studies along with its sub-constructs (i.e. competitive pressure, industry pressure, enacted supply-chain partner power and supply-chain partner dependence) based on resource dependence arguments (Chwelos et al., 2001). Socio-political factor such as exercised power of supply-chain partners was observed to be an important EDI adoption driver. A favorable transactional climate between supply-chain partners on the "Cooperation-conflict continuum" is important in IOS adoption (Premkumar and Ramamurthy, 1995). In this study, competitive pressure, industry/regulatory pressure, net exercised supply-chain power, and favorable transactional climate are suggested as RFID adoption drivers.

H2: All inter-organizational pressure factors will have significant positive relationships with adoption intent.

Organizational Readiness Factors

Internal organizational characteristics and properties have been identified as organizational factors (Chwelos et al., 2001) influencing IOS adoption. Organizational readiness, availability of financial and technological resources (people, technology, expertise) of a firm has been found to be a driver in EDI adoption (Iacovou et al. 1995). Some studies include IT sophistication (Chwelos et al. 2001) as a separate construct incorporating TM support, expertise, and infrastructure. Presence of TM support, a champion within an organization, and organizational compatibility are some key organizational factors previously researched (Premkumar and Ramamurthy 1995) having been found important in IOS adoption. This study suggests TM support, financial readiness, infrastructure presence and capabilities as organizational factors driving RFID adoption.

H3: All organizational readiness factors will have significant positive relationships with adoption intent

External Environmental Factors

Factors external to a firm but influencing its functioning and decision-making (i.e. governmental influences, technology standards development, legal environment, consumer readiness, stakeholders' privacy concerns, technological breakthroughs) have been characterized as environmental factors. Some of these factors (i.e. competitive and industry pressure) have been classified under the environment context (Tornatzky and Fleischer, 1990), whereas Chwelos et al.'s (2001) interorganizational factors address some of these influences. Governmental control and regulations (Tornatzky and Fleischer, 1990) and consumer readiness (Zhu et al., 2002) have also been studied as environmental factors. However, here due to the ubiquitous and radical nature of RFID external environment factors like standard stability (data, software/hardware and regulatory), perceived stakeholder privacy and perceived consumer readiness are viewed as important environmental influences on a firm's RFID adoption decision.

H4: All external environmental factors will have significant positive relationship with adoption intent.

Perceived Radicalness

Hage (1980) identified radicalness as one of the "most critical dimensions" of an innovation, however it remains largely unexplored in IOS adoption literature. Radical technologies appear more complex to adopters, generate greater resource requirement uncertainty, and have lower adoption likelihoods (Gopalakrishnan and Damanpour, 1994). A technology's degree of perceived radicalness may influence its adoption by individuals/organizations. Etlie et al. (1984) define an innovation as radical if it is new and introduces significant change. Consistent with Ellie et al and Lyytinen-Rose's (2003) disruptive IT innovation, this study defines radicalness of technology with two sub-dimensions i.e. 1) degree of new knowledge required for its adoption and 2) the extent of changes it brings about in existing practices and infrastructure.

For RFID adoption, besides direct user operational benefits, very prominent is modifying and altering business processes to leverage RFID's indirect benefits. RFID adoption may be perceived as radical because it may 1) require learning new skills and infrastructure, 2) provide unforeseen strategic benefits, 3) bring about internal organizational structure and functioning changes and 4) alter supply-chain partner interactions. Hence, the proposed adoption drivers are likely to be more significant the more radically perceived the technology.

H5: Perceived radicalness will moderate relationships between technological, organizational readiness, inter-organizational pressure, external environment factors and adoption intent such that relationships will be stronger in hypothesized directions.

RESEARCH MODEL

In the research model (see Figure 1), drawing on existing models, three technological factors (perceived benefit, compatibility and perceived costs), four inter-organizational factors (competitive pressure, industry/regulatory pressure, net exercised supply-chain power and favorable transaction climate), three organizational factors (top-management support, IS infrastructure/capabilities, financial readiness) and three external environment factors (standard stability, perceived stakeholder privacy, perceived consumer readiness) have been suggested as predictors of RFID adoption intent. We propose new constructs: standard stability, perceived stakeholder privacy and perceived consumer readiness to capture the effect of external environmental factors such as adoption and stability of RFID data and software standards, adoption and stability of legal standards for decision right allocation and intellectual property, consumer readiness and stakeholders' privacy concerns. To address existing limitations in incremental vs radical innovation and IOS adoption literatures, we are operationalizing perceived radicalness as a continuous construct suggesting it moderates relationships between core constructs and adoption intent.

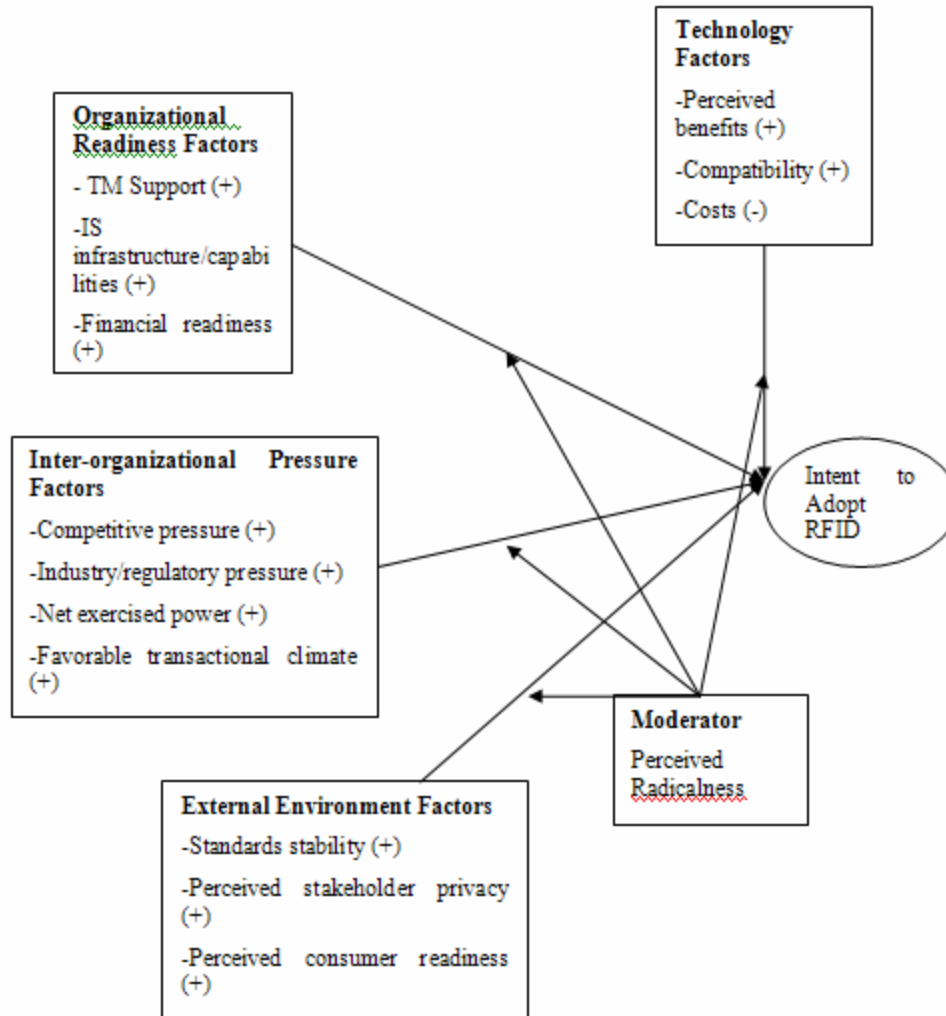


Figure 1. Research Model

RESEARCH METHODOLOGY

Model Development

This paper’s model drew on prior IOS adoption literature and was developed using semi-structured interviews on RFID technologies adoption of executives from manufacturing, retailing or supply-chain partner organizations. In addition business press articles discussing firms and their thoughts on adoption of RFID technologies in the near future and reports on RFID technology related websites have been presented as additional supporting evidence of model components. Business press contextual data has been incorporated and reviewed in a manner consistent with Slaughter and Ang’s (1995) approach. Table 1 presents construct occurrence frequencies from multiple news-reports on 16 firms and semi-structured interviews as support for the model.

Model Testing

Proposed model empirical testing would be executed by collecting RFID technologies adoption survey data from executives in organizations that are manufacturers, retailer or supply-chain partners. A three-version questionnaire was developed for group (manufacturers, retailers, supply-chain partners) relevance. Questionnaire items were drawn from previous studies with slight modification for the three versions for different supply-chain position perspectives (i.e. context, language network position). Responses from multiple individuals (CIO, CTO, project managers, etc) will be averaged for each firm to eliminate individual biases.

Item content validity was assessed by going through each item and comparing it with prior literature items and subsequently utilizing a second independent evaluator for deriving inter-rater reliability. The initial questionnaires were pilot-tested with email web-based survey respondents at two firms. Minor revisions to pilot-questionnaire items will reflect changes based on exploratory factor analysis, which will ultimately be followed by confirmatory factor analysis done through structural equation modeling. Final model analysis will incorporate SEPATH method in Statistica and confirmed by Lisrel 8.51 and construct measures of internal reliability will be computed using Cronbach's alpha.

Table 1. Frequency and occurrence percentage of relevant constructs in news-reports and interviews

CONSTRUCTS	FREQUENCY OCCURRENCE	% OCCURRED
Technology		
Perceived Benefit	16	88.9%
Perceived cost	9	50%
Organizational		
TM Support	1	5.5%
IS Infrastructure	3	16.7%
Financial Readiness	3	16.7%
Diffusion Champion Present	5	27.8%
Organizational Readiness	2	11.1%
Interorganizational		
Competitive Pressure	0	0%
Exercised Supply-chain Partner Power	11	61.1%
Industry/Regulatory Pressure	1	5.5%
Favorable Partner Transactional Climate	0	0%
Environmental		
Tag Cost Reductions	3	16.7%
Data Standards Adoption	6	33.3%
Software Standards Adoption	6	33.3%
Intellectual Property Standards Adoption	7	38.9%
Consumer Privacy Concerns Addressed	2	11.1%
Consumer Readiness	0	0%

DISCUSSION AND CONCLUSION

As evident from Table 1, most model suggested constructs have been mentioned several times in news-reports and semi-structured interviews. The highest occurrence frequency is the construct perceived benefit (88.9%) followed by exercised supply-chain partner power (61.1%) and perceived costs (50%). Also 38.9% responses favor intellectual property and ownership standards adoption, and 33.3% responses favor data and software standards adoption, 27.8% responses favor diffusion champion presence and TM support. 16.7% responses favor tag cost reductions and suggest external environment factors as an important RFID adoption driver. Industry/regulatory pressure has been mentioned in 5.5% cases explicitly. Some constructs although not directly mentioned (i.e. competitive pressure, favorable transactional climate, consumer readiness) in news-reports or semi-structured interviews have been previously found important in the IOS adoption literature.

In this study, organizational, technological, interorganizational and environmental factors were observed to play a role in intentions of organizations to adopt RFID. This study should be viewed as an attempt to unearth factors and their relationships involved in organizational RFID adoption. Quotes from news-reports and semi-structured interviews provide evidence to support the model. It also provides some insights into relative importance of constructs.

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