A Conceptual Framework of RFID Adoption in Retail Using TOE Framework

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ABSTRACT

Motivated by the need to understand the underlying antecedents of RFID adoption in retail, this study proposes and tests a framework predicting RFID adoption intent. Based on the TOE (technology-organization-environment) framework, this research develops and validates the research framework to examine the influence of twelve contextual factors under four broad categories (technological, organizational, environmental, and value-chain) on RFID adoption in retail. A structured study instrument is developed to measure these variables and data are collected from 74 experts spread across different business associations through Delphi technique. Multivariate discriminant analysis (MDA) is used to develop the conceptual framework for RFID adoption. The results indicate that relative advantage, competitive pressure, catalyst agent, and value chain complexity are significant determinants of RFID adoption in retail. It suggests that environmental characteristics are very important to be considered in RFID adoption studies along with technological and value chain characteristics.

Keywords: Adoption, Delphi, Determinants, Retail, RFID, Technology-Organization-Environment (TOE)

1. INTRODUCTION

Despite extensive research on adoption and diffusion of innovation, adoption of emerging technologies with specific characteristics is still not well understood (Rogers, 1995). Adoption of electronic data interchange (EDI) is an example where generalizations of diffusion theory could not be directly applied and new models were developed to understand the adoption patterns by identifying adoption drivers (Chwelos et al., 2001; Sharma et al., 2008). There are many studies on technology adoption in the field of information systems (IS) at both individual and organizational level (Abu-Shanab & Ghaleb, 2012; Alshesri et al., 2013). In this study the focus is organizational adoption of technology. The unique characteristics offered by Radio Frequency Identification Technology (RFID) distinguishes it from other technologies such as internet and EDI and warrants further investigation specifically around its adoption. RFID is a wireless automatic identification and data capture (AIDC) technology (Ross et al., 2009) used to track and trace pallets and cases.

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RFID caught the attention of the media when giant retailers like Wal-Mart, Tesco, Target, and Albertsons announced that they were going to adopt RFID to streamline supply chain operations and demanded that their suppliers become RFID compliant. According to Das (2006), the retail sector is expected to comprise 44% of the global RFID market value for systems including tags by the year 2016. On the other hand, according to a survey sponsored by NCR (NPN, 2006) only 9% of participating retailers have an RFID implementation timeline as compared to 44% of participating manufacturers. About 60 percent of the retailers in this group are large retailers with more than $5 billion in annual revenues and they reported an increase in their spending as RFID technology is being introduced across different product lines However, only 29 percent of the retailers expect to have a RFID-enabled pilot store opened by the end of 2006 (Kilcourse, 2008). This strongly indicates that the retail sector is not adopting RFID technology as rapidly as expected.

While the emerging literature of RFID adoption and use has demonstrated the high operational and strategic value of this technology (Ngai et al., 2014), the implementation challenges, including infrastructure costs, environmental upheaval, top management leadership, second-order organizational learning, resource commitment, and organizational transformation have caused many potential adopters to back away from RFID. Most of the suppliers struggled to adopt and use RFID technology cost-effectively for competitive advantage (Ross et al., 2009). In addition, prior studies on RFID adoption have stressed the importance of adoption mandates particularly in the early stages of exploring the potential of the technology. The importance of these mandates diminishes over time as the perceived benefits and risks related to the technology are assessed (Wamba, 2012).

Thus the actual fact is that the adoption of RFID technology has been slower than predicted, mainly because the hype associated with any emerging information technology (IT) (Bendavid et al., 2013) gave researchers and practitioners unrealistic expectations. In reality, the widespread adoption of any given technological innovation is facilitated by changes in the "business perceptions of the business value—that are held by adopters and non-adopters" (Keating et al., 2010). Therefore, it is critical to deepen our understanding of the various factors determining the adoption of RFID technology by firms.

Many of the studies of organizational adoption of technology have drawn from the work of Tornatzky and Fleishcher's TOE (technology-organization-environment) framework (Tornatzky & Fleischer, 1990; Chwelos et al., 2001; Teo et al., 2004) who grouped factors influencing organizational adoption into technological, organizational, and environmental contexts. Technological context refers to innovation characteristics. The organizational context describes the organization and its characteristics, and the environmental context refers to the surrounding in which an organization conducts its business. It encompasses the industry and dealings with business partners, competitors, and government. Prior RFID adoption studies have not always investigated the three contexts in a comprehensive manner. Most of these have focused on a few factors instead (Brown & Russell, 2007). Additionally, most of the previous studies show the importance of technological factors; however the effects of organizational and environmental factors have been varied across different industrial contexts (Wang et al., 2010). Thus there is still more need to analyze the drivers of RFID adoption in different industrial contexts for a better understanding.

This study explores factors that drive RFID adoption, inspired by the TOE framework that draws from multiple theoretical bases. In addition to the basic constructs of the TOE framework, value chain factors are also studied since RFID technology is primarily used to streamline value chain. To the best of our knowledge, value chain factors have not been studied in prior studies. The value chain factors are critical for the retail sector because the retail sector is heavily dependent on its value chain

and cannot survive standalone. This makes this study novel and important. The fact that the retail sector is not adopting RFID technology as rapidly as expected suggests that the area of RFID adoption demands more empirical research that could shed some light on the uncertainty associated with the adoption decision. This study is one such attempt. Although research in RFID has been substantial in recent years, the majority of RFID research focuses on technical aspects or on descriptive studies on RFID impacts, benefits, and challenges (Soon & Gutierrez, 2010). Thus there is still a continued uncertainty associated with RFID adoption decision.

2. THEORETICAL FOUNDATION: TECHNOLOGY-ORGANIZATION-ENVIRONMENT (TOE) FRAMEWORK

While certain organizational factors along with perceived organizational benefits often enable technology adoption, the absence of enablers can present themselves as inhibitors of adoption. According to the stream of research on organizational technology adoption *technological, organizational, and environmental* factors are identified to be most relevant to the adoption of technologies in general and could be applicable to the RFID technology adoption as well.

(Tornatzky & Klein, 1982) examined the relationship between technological or innovation characteristics and adoption. The 10 characteristics that were found to be most frequently used were relative advantage, complexity, communicability, divisibility, cost, profitability, compatibility, social approval, trialability, and observability. Out of these 10 characteristics, relative advantage, complexity, compatibility, and cost were found to be consistently related to adoption studies. Recent IT adoption studies have also found these variables to be important in the context of adoption of various information technologies (Cooper & Zmud, 1990). One of the first challenges that can be identified in RFID or any new technology adoption is the cost of the physical implementation with regards to hardware and software. Adoption of such infrastructure is of significant cost to the organization. However such technologies also bring cost savings that implementing the technology might bring to an organization which corresponds to the relative advantage of the new technology compared to its predecessor technologies. The issue of complexity can refer to both the complexity of the technology implementation and the technology itself (Gallivan, 2001). Compatibility refers to the deviation from previous ideas, values, or technologies that the new technology supersedes.

The literature on organizational innovativeness explored the influence of organizational characteristics on adoption decisions (Damanpour, 1991). This perspective emerged as researchers recognized that decisions at the firm level are often too complex to be captured only by an individual's cognitive abilities (Tornatzky & Klein, 1982) and could not be directly addressed with traditional technology adoption and diffusion models (Rogers, 1995). Organizational factors identified in IT adoption studies are top management support, organizational size, existence of product champions, and availability of resources. Top management attitude and support ensures availability of adequate resources for implementing the innovation (Grover & Goslar, 1993). Studies suggest that providing sufficient resources and creating conducive environment for innovation adoption within an organization comes from the top management and is positively related to innovation adoption and diffusion process (Rogers, 1995; Premkumar & Roberts, 1999). The availability of organizational resources, such as financial, human, and physical was shown to be of significant importance in the adoption decision and implementation success (Depietro et al., 1990). Organizational size has repeatedly been found to influence innovation adoption (Gremillion, 1984). Also, organizations must be willing to make changes in business processes for benefits to accrue (Kinsella, 2003; Brown & Russell, 2007). Moreover there

must be a cultural willingness to move beyond conventional methods and to take risks to ensure innovation adoption (Hoske, 2004).

Organizational behavior and strategic management studies also suggest that organizational technology adoption decision-making was also influenced by contextual environmental factors. This shortcoming of enterprise adoption models led to the examination and integration of environmental factors in enterprise adoption research. Competitive pressures, vendor influence, and regulatory forces are all environmental factors that could impact an organization's decision to adopt an innovation. Thus, an understanding of the institutional environment in which businesses operate is extremely important. Factors that are external to an organization but influencing its functioning and decision making e.g. governmental push, technology standards development, legal environment, consumer readiness with increasing awareness, technological breakthroughs etc. have been characterized as environmental factors. (Tornatzky & Fleischer, 1990) identified competitive pressure, governmental regulations, and consumer readiness as environmental factors influencing innovation adoption.

The TOE framework is widely accepted since findings from innovation adoption studies are empirically supported and thus consistent with it (Cooper & Zmud, 1990; Thong, 1999). The framework has been used to study adoption of general IT innovation (Chau &and Tam, 1997; Zhu et al., 2006a; Zhu et al., 2006b; Lin et al., 2014) as well as specific IT innovation such as EDI (Kuan & Chau, 2001).

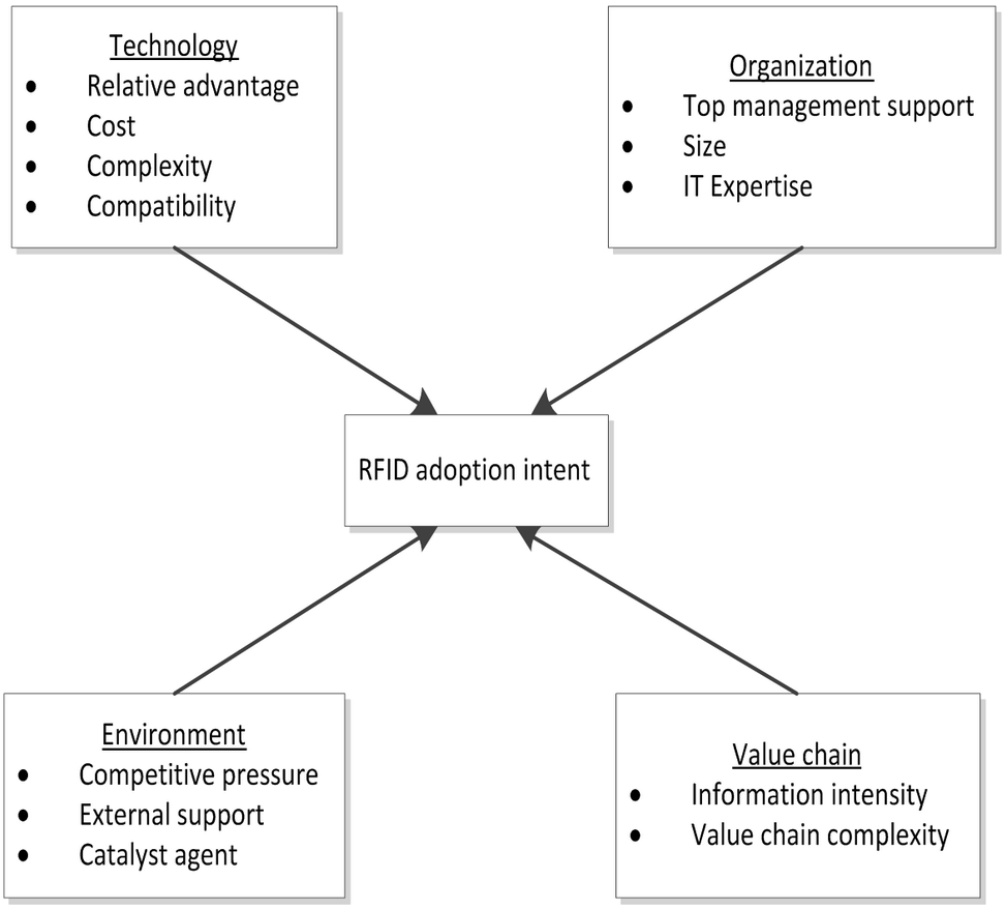
The TOE framework is adapted to make it particularly suitable to study RFID adoption process in retail organizations in this study. The goal is to develop a comprehensive RFID adoption conceptual framework. Based on the multiple theories perspective of TOE framework to explain enterprise adoption, there is also an opportunity to develop a single, integrated model that will provide a holistic view on the factors involved in this complex decision. Also, despite the plethora of enterprise adoption studies, only a very small percentage has examined disruptive organizational technologies like RFID. Given the growing importance of RFID technology it is thus critical to examine whether existing models apply, and if not, how they can be modified or extended.

3. RESEARCH FRAMEWORK AND HYPOTHESES

A wide range of factors has been found in the literature that facilitates or inhibits technology adoption. In this study a few factors that are believed to be important in understanding RFID adoption are investigated. The proposed research framework on RFID adoption identifies and evaluates the antecedents of RFID adoption intention. The dependent variable is retailer's RFID adoption intent. Intention to behavior is a suitable predictor of behavior since behavior is usually more difficult to measure reliably (Ajzen, 1991). Given the newness of RFID technology, intention which refers to a future behavior is more meaningful than behavior. The three contexts of technology, organization, and environment form the basis for developing the adoption framework and factors relevant to the adoption of RFID within each category are highlighted. A fourth category of value chain context is introduced in the model considering the unique characteristics of RFID and its applicability in a value chain.

The contextual factors are synthesized from innovation adoption research that includes work on different kinds of innovation in organizational context, general research on information systems implementation, and research on strategic information systems like inter-organizational systems (IOS) and are put into a testable model for RFID adoption. Please note that experts who support RFID adoption in retail represent actual retail adopters whereas experts who do not support such adoption represent non-adopters in this study. It is assumed that the behavior of actual adopters and non-adopters of RFID is similar to that of the experts. Thus this study will be discussed

Figure 1. Conceptual framework of RFID adoption



in terms of adopters and non-adopters from this point onwards.

The differences in profiles of adopters and non-adopters with respect to the four categories of contextual factors provide insight into the variables that are important to adoption. The adoption framework consists of twelve determinants or antecedents that are hypothesized to influence RFID adoption in retail. This study focuses on identifying factors that can predict RFID adoption and thus the relationships among the twelve factors are beyond the scope of this research. The proposed research framework is shown in Figure 1.

3.1. Technological Context

Technological factors represent characteristics of an innovation as defined by (Tornatzky & Fleischer, 1990). Several innovation characteristics have been studied as the basis for innovation diffusion research.

These characteristics that are found to be used most frequently are relative advantage, complexity, communicability, divisibility, cost, profitability, compatibility, social approval, trialability, and observability (Tornatzky & Klein, 1982). Of these characteristics relative advantage, compatibility, and complexity consistently predicted adoption (Grover, 1993). Cost is also found to be significant in

studies of innovation adoption and IT diffusion (Premkumar et al., 1994). Thus these three characteristics along with cost are included in the research framework. Specifically, these four characteristics have been suggested as being important for RFID adoption (Ranganathan & Jha, 2005; Sharma & Citurs, 2005; Brown & Russell, 2007).

3.1.1 Relative Advantage

Relative advantage is defined as the degree to which an innovation is perceived to be better than the idea it supersedes providing greater direct or indirect organizational benefits. Relative advantage has consistently been identified as a predictor of adoption intent in innovation diffusion literature (Premkumar & Roberts, 1999). It has also been considered as the most frequently cited facilitator of RFID adoption (Sharma & Citurs, 2005). Perceived RFID benefits include greater supply chain visibility, increased speed and efficiency of operations, reduced labor costs and improved security, and improved customer service (Kinsalla, 2003; Wu et al., 2006; Bhattacharya et al., 2008; 2010; 2012). RFID is expected to provide greater competitive advantages to companies (Ngai et al., 2008; Chao et al., 2007). Thus companies which perceive higher relative advantages in RFID technology are more likely to adopt it. The proposed hypothesis is thus:

H1: Technological factor relative advantage positively influences RFID adoption intent.

3.1.2. Cost

Perceived costs of innovations lead to lower intent to adopt despite the benefits that they provide. Thus benefits must exceed the cost of innovation adoption for decisions to adopt it. Thus cost relative to benefits is an important consideration for most innovation adoption decisions and it is true for RFID adoption as well. According to (Tornatzky & Klein, 1982) technologies that are low in cost are more likely to be adopted. (Premkumar et al., 1994) found cost to be an important variable in EDI adoption. RFID technology is a costly investment for companies involving costs of tags, hardware and software, data management and integration, and reengineering business processes that could inhibit its adoption. Cost has been proposed to be used as a predictor of RFID adoption in several studies (Sharma and Citurs, 2005; Brown & Russell, 2007). Thus companies which perceive higher cost relative to benefits in RFID technologies are less likely to adopt it. The proposed hypothesis is thus:

H2: Technological factor higher cost negatively influences RFID adoption intent.

3.1.3. Complexity

Complexity is defined as the degree to which an innovation is perceived as relatively difficult to understand and use. New technical skills are required to correctly use the innovation that tends to inhibit its adoption (Cooper & Zmud, 1990). Since complexity can be a deterrent to successful implementation followed by use of an innovation, it is usually negatively associated with adoption (Premkumar et al., 1994; Premkumar & Roberts, 1999). Although RFID provides several organizational benefits, the perceived characteristics of the technology is still complex. Managing and integrating large volumes of data generated by RFID system is difficult thus making the potential benefits of the technology unclear. This is one of the major inhibitors of RFID adoption and has been proposed in several RFID adoption studies (Sharma & Citurs, 2005; Brown & Russell, 2007). The diversity of RFID technology available in terms of multiple standards, operating frequencies, tag types and so on makes RFID implementation a very complicated task (Wang et al., 2010). Thus companies which perceive greater complexity in RFID technologies are less likely to adopt it. The proposed hypothesis is thus:

H3: Technological factor complexity negatively influences RFID adoption intent.

3.1.4. Compatibility

Compatibility refers to the degree to which an innovation is consistent with existing values, needs, and practices of the adopting organization (Rogers, 1995). It is an important determinant of innovation adoption because the new innovation can bring significant changes in existing work procedures. It has been widely used as a predictor of adoption in innovation diffusion research (Premkumar & Roberts, 1999). RFID systems bring significant changes in business processes in order to fully utilize its potentials. Companies need to integrate RFID systems with other applications and need to cooperate with value chain partners and thus they will not intend to adopt it if they do not believe that the technology is compatible with their existing practices and infrastructure. Compatibility has been suggested to be used as a predictor of RFID adoption in several studies (Sharma & Citurs, 2005; Brown & Russell, 2007; Wang et al., 2010). Thus companies which perceive greater compatibility in RFID technologies are more likely to adopt it. The proposed hypothesis is thus:

H4: Technological factor compatibility positively influences RFID adoption intent.

3.2. Organizational Context

Organizational factors represent organizational characteristics that influence innovation adoption decisions. Organizational factors identified in innovation adoption studies are top management support, organizational size, existence of product champions, and availability of resources (Premkumar & Ramamurthy, 1995). The organizational context being extremely relevant to innovation adoption process was shown by (Orlikowski, 1993). These characteristics are suggested to be important for RFID adoption as well (Sharma & Citurs, 2005; Brown & Russell, 2007; Wang et al., 2010). The organizational characteristics of top management support, size, and IT expertise are included in the research model.

3.2.1. Top Management Support

Top management support is crucial for innovation adoption decisions. The decisions made by the top management are likely to impact organizational growth and development because higher management level has greater influence upon strategic decisions (Carpenter et al., 2004). Top management support is defined as the degree to which the values of the management are in favor of the new innovation adoption thus creating a supportive climate and providing adequate resources for its adoption (Useem, 1993; Kwon & Zmud, 1987; Teo et al., 2004). Top management support is very critical for RFID adoption since RFID implementation requires adequate resources, process reengineering, and overcoming employee resistance to change (Hoske, 2004; Wang et al., 2010). Thus companies which receive greater top management commitment towards RFID technologies are more likely to adopt it. The proposed hypothesis is thus:

H5: Organizational factor top management support positively influences RFID adoption intent.

3.2.2. Size

Organizational size has been shown to impact innovation adoption by several studies (Premkumar & Roberts, 1999; Delone, 1981; Rogers, 1995). Large organizations typically have slack resources to experiment with a new innovation and then make an informed adoption decision (Premkumar & Roberts, 1999). Size has been suggested as an important predictor of RFID adoption in several studies (Brown & Russell, 2007; Wang et al., 2010). Thus companies which are larger in size are more likely to adopt RFID technology. The proposed hypothesis is thus:

H6: Organizational factor organizational size positively influences RFID adoption intent.

3.2.3. I.T Expertise

Technological resources represented by appropriate technology infrastructure and skilled people are critical for innovation adoption. Companies that do not have adequate IT expertise may be unaware of new technologies or may not be in a position to deploy them. IT expertise has been used as an important variable predicting adoption in innovation diffusion research (Premkumar & Roberts, 1999; Kwon & Zmud, 1987). It has been suggested to be used in RFID adoption studies as well since the presence of adequate IT expertise may reduce costs and efforts to integrate RFID technologies with existing systems (Sharma & Citurs, 2005; Brown & Russell, 2007). Thus companies which have greater IT expertise are more likely to adopt RFID technology. The proposed hypothesis is thus:

H7: Organizational factor IT expertise positively influences RFID adoption intent.

3.3. Environmental Context

Factors external to a firm but influencing a firm's functioning influences organizational adoption of new innovations. Tornatzky and Fleischer (1990) identified competitive pressure, governmental regulations, and consumer readiness as environmental factors influencing innovation adoption. Competitive pressure, external support, and existence of catalyst agents such as government influence and development of standards are some of the factors within the environment context that have been used in general innovation diffusion research and specific RFID adoption studies (Premkumar & Roberts, 1999; Ranganathan & Jha, 2005; Sharma & Citurs, 2005, Orlikowski, 1993; Brown & Russell, 2007). These three environmental factors are included in the research framework.

3.3.1. Competitive Pressure

Competitive pressure refers to the degree to which an innovation is adopted in the firm's industry. It is perceived to be positively influencing innovation adoption in an organization (Premkumar & Roberts, 1999; Kuan & Chau, 2001). RFID technologies provide several organizational benefits that lead to competitive advantage and is thus of immense interest to several firms particularly retailers. A firm without RFID technology may experience more pressure when more competitors have adopted it. Competitive pressure is suggested to be used as a predictor of RFID adoption in several studies (Brown & Russell, 2007; Sharma et al., 2008; Wang et al., 2010). Thus companies which experience greater competitive pressure are more likely to adopt RFID technology. The proposed hypothesis is thus:

H8: Environmental factor competitive pressure positively influences RFID adoption intent.

3.3.2. External Support

External support represents the availability of support for implementing and maintaining an innovation from outside of the firm. Vendor and third party service provider support and support from powerful business partners positively influences innovation adoption as organizations are more willing to invest even if they do not have internal expertise to handle it. External support has been used as a determinant of adoption in innovation diffusion research (Delone, 1981; Kwon & Zmud, 1987). It is suggested to be used as a predictor of RFID adoption in several studies (Brown & Russell, 2007; Wang et al., 2010). Thus, companies which experience greater external support are more likely to adopt RFID technology. The proposed hypothesis is thus:

H9: Environmental factor external support positively influences RFID adoption intent.

3.3.3. Catalyst agent

Catalyst agents external to organizations include vendors trying to sell a new innovation, government and industry bodies promoting its

adoption, and increased general awareness and thus acceptance and readiness with innovation maturity (Teo et al., 2004; Brown & Russell, 2007). Existence of such catalyst agents could positively influence RFID adoption decisions and has been suggested in literature (Brown & Russell, 2007; Sharma et al., 2008). Thus companies which experience greater external catalyst agents are more likely to adopt RFID technology. The proposed hypothesis is thus:

H10: Environmental factor catalyst agent positively influences RFID adoption intent.

3.4. Value Chain Context

Value chain context is critical for RFID adoption because the primary use of RFID is to streamline the value chain through improved visibility that could lead to savings for the adopting organization. Information intensity in the value chain and value chain complexity are the two variables in this group that are included in the research model.

3.4.1. Information Intensity

Information intensity refers to the degree to which information is present in a product or service thus requiring more information to order or use those (Wang et al., 2010). The more information intensive is a value chain, the more suitable it is for enhancement with new innovation (Grover, 1993; Porter & Miller, 1985; Ranganathan & Jha, 2005). It has been suggested to be a determinant factor in RFID adoption (Ranganathan & Jha, 2005; Wang et al., 2010). Thus companies which sell information intensive products or services are more likely to adopt RFID technology. The proposed hypothesis is thus:

H11: Value chain factor information intensity positively influences RFID adoption intent.

3.4.2. Value Chain Complexity

Value chain complexity refers to the degree of complexity in the value chain of the adopting organization in terms of dealing with too many value chain partners and tremendous uncertainty. It is an extension of the concept of system complexity inhibiting adoption of new technologies (Grover & Gosler, 1993). It has been suggested to be a significant predictor of RFID adoption (Ranganathan & Jha, 2005). Thus companies which conduct businesses in complex value chain environments are more likely to adopt RFID technology. The proposed hypothesis is thus:

H12: Value chain factor value chain complexity positively influences RFID adoption intent.

4. RESEARCH METHODOLOGY

This section discusses the research methodology employed for developing the conceptual framework of RFID adoption. Data is collected through Delphi technique to accomplish research goals. The purpose of this study is to investigate antecedents of RFID adoption in retail. A statistical method of multivariate discriminant analysis (MDA) is used to identify the significant antecedents and their relative importance. Construct measures, and validity and reliability of the study instrument are discussed next.

Delphi method is used for this research work. Delphi is a well-established scientific research method widely used in Information Science (IS) research and is well suited for this study considering the novelty of RFID technology. It allows capturing expert opinions from multiple fields of associations and job associations thus providing more enriching data.

4.1. Delphi Technique

Delphi 'technique' is the primary method used for this work. The Delphi 'technique' combines judgments from a panel of independent experts.

Table 1. Expert characteristics

Expert Characteristics	Statistics
Sector	Consultants: (23; 31.1%) Academics: (17; 23%) Retail: (16; 21.6%) Service Providers: (18; 24.3%)
Management Level	Top Management: 28 (37.8%) IT management: 8 (10.8%) Executives: 19 (25.7%) Research: 19 (25.7%)
RFID knowledge Level	Very Good: (44; 59.5%) Know All: (26; 35.1%)
RFID Experience Level	> 5 Years: (29; 39.7%) 3-5 Years: (22; 30.1%) 1-3 Years: 14; 19.2 6 Months: (8; 11%)

This method is relevant when well-established theory is not yet available, but where experts have relevant judgments. It is based on the premise that aggregation reduces the error of individual responses (Brown 1968; Linstone & Turoff 1975). The Delphi technique dates to 1959 and was developed by Dalkey, Helmer, Rescher, Gordon and others of the Rand Corporation. According to Dalkey (1969) the Delphi method has three primary features: anonymity, controlled feedback and iteration, and formal group judgment. Each respondent submit independent answers to the relevant questions in the interview/questionnaire. The results of a given round of responses are summarized and reported to the group who are then asked to reassess their replies in light of the feedback. Finally, the group's answer is presented as an aggregation given the final set of individual answers.

4.2. Candidate Selection

In order to reduce bias from a group composed of candidates of similar backgrounds candidates from different sectors such as consulting, academia (faculty researchers), retail, and third party service providers were obtained. This allowed achieving a broad overview and eliminating inherent bias in each sector. A total of 74 expert candidates, including consultants (23; 31.1%) academics (17; 23%) retail practitioners (16; 21.6%), and third-party service providers (18; 24.3%) participated in this research. It is also attempted to obtain the opinions of experts across the spectrum of management levels. Among the expert candidates, 28 (37.8%) hold top management positions, 8 (10.8%) hold IT management positions, 19 (25.7%) are executives, and 19 (25.7%) hold research positions. About (44; 59.5%) of the experts claimed that they have very good knowledge about RFID and (26; 35.1%) claimed that they know all about RFID. Finally (29; 39.7%) out of the 74 candidates have greater than five years of involvement with RFID projects, (22; 30.1%) have 3-5 years of involvement, 14; 19.2%) have 1-3 years of involvement, and (8; 11%) about six months of involvement with RFID projects. Table 1 below provides the summary of the expert characteristics.

4.3. Research Process

The Delphi study was conducted online in two stages. After the questionnaire was developed it was sent to around 240 experts in electronic format through email. The web address of the questionnaire was provided in the email. The experts were identified through personal contacts. The researchers were contacted based on their active published research on RFID re-

lated topics in reputed journals and conference proceedings. Consultants, executives in Retail, and third party service providers were identified through linked-in association and through personal contact (such as alumni working in different retail organizations, consulting firms, and other RFID service providing companies). Two weeks later an email reminder was sent to request to respond to the questionnaire. After another two weeks around 80 responses were received, out of which 74 were deemed usable. The response rate is 30.84% which is a significantly high number and could be explained by the use of personal contacts and personalized methods to contact the candidates. The questionnaire was only sent to individuals who were considered as experts by a team of faculty and graduate researchers after careful scrutiny. However the candidate pool cannot be considered biased because the personal contact was only used so that experts could be short listed. There was no prior knowledge about the inclination of the expert opinions. Additionally experts from multiple fields of associations and job association also allowed controlling any bias.

In this study two iterations of the Delphi study are used. Not much new information is gained after the second round and thus no follow up rounds were conducted. According to Altschuld (1993) two iterations are usually enough to obtain good estimate of the distribution and consensus view of participants and often not enough new information is gained to warrant the cost of more rounds.

After the first round of data collection, summary statistics of the results along with their individual responses were sent to each expert. The summary statistics showed the rating average and the standard deviation of all responses for each question. The experts were allowed to review their own opinion in light of the average results from all experts and make changes if they wanted to. They were allowed to provide additional comments however it was not required. Very few changes were made by the experts in light of the feedback which was not statistically significant and thus no new knowledge was created. No further iteration of the Delphi study was hence conducted.

4.4. Construct Measures

All constructs in this study employs multiple item scales. The majority of the items are written in the form of statements with which the respondent is to disagree or agree on a 5-point Likert scale. The principle construct measures are based on existing instruments. Items are modified to fit the context of RFID when necessary. New items were constructed from statements in relevant literature after a thorough and extensive review.

The adoption of RFID technology is measured according to the perceived intent to adopt RFID technology by retailers. Intent to adopt a new technology is positively associated with the actual adoption behavior (Ajzen, 1985; Davis, 1989). This study assumes that retailers will be more likely to adopt RFID technology if they are perceived to have strong intent. The dependent variable of retailer's RFID adoption intent is recoded as a dichotomous variable measuring whether the experts disagree or agree with retailers RFID adoption intent. The construct was originally operationalized via a five-point Likert scale which was later recoded as disagree and agree.

Table 6 in Appendix A summarizes the measurement items of the independent variables. The exact questionnaire including the relevant questions is provided in Appendix B. The exact wording of the statements of the items are adapted from previous studies (Grover, 1993; Premkumar & Roberts, 1999; Ranganathan & Jha, 2005; Brown & Russell, 2007; Sharma & Citurs, 2008; Bhattacharya et al, 2008; 2010)

4.5. Instrument Validation

Cronbach's alpha is applied to test reliability of the constructs. The results in table 2 indicate that all the constructs have adequate alpha values (> 0.6) which is acceptable for exploratory research (Premkumar & Roberts, 1999), except catalyst agent. However, the alpha value for catalyst agent is 0.520 (close to 0.6) which is

acceptable. It could be explained by the use of few items for measuring catalyst agent. Some more relevant items need to be added in future.

Content validity is established through an extensive process of literature search and refinement followed by strict scrutiny for appropriate mapping of the constructs by a team of researchers.

Factor analysis is used to evaluate construct validity. Although the questionnaire developed for this study has been adapted from previous studies, new items are included. Thus, construct validity is examined using principal component analysis (PCA) with varimax rotation rather than confirmatory. The items loaded on twelve factors that directly mapped with the theorized constructs. Cross loadings of items on other factors is minimal, except in a few instances. After clarifying the spurious factors that emerged from the factor analysis using independent factor analysis of certain constructs, twelve meaningful constructs remained in the research framework. Items measuring the catalyst agent construct are created from statements in literature and have not been validated in prior research. From the reliability and validity tests of the instrument it is obvious that the items measuring the construct of catalyst agent need to be further refined for future research. It is believed that other items need to be added to measure the construct completely. Results of factor analysis of the twelve independent variables are provided in Table 6 in Appendix A.

5. DATA ANALYSIS RESULTS

Multivariate discriminant analysis (MDA) is used to identify each predictor's contribution to a linear function that best discriminates between two or multiple groups. It provides a statistical method to classify the RFID adopter and non-adopter and also allows determining which of the independent variables would contribute to RFID adoption. The objective is to maximize between-group variances compared to within-group variances based on a series of discriminant scores generated by a linear combination of independent variables, so that the discriminant function separates the groups well.

The composite scores of the twelve factors are first calculated by averaging the original items scores. Table 3 shows the twelve factors of the RFID adoption model represented by the rating average (mean) of the expert's responses, standard deviation, and the 90% lower bounds of the confidence intervals (One sample t test results). The twelve factors are then taken as independent variables and the perceived retailer's intent to adopt RFID as the dependent variable; and consequently the method of multivariate discriminant analysis (MDA) is employed to determine their relationship. To test the model all twelve independent variables are entered in one step to generate the discriminant function. However, discriminant analysis assumes homogeneity of co-variances which is examined with Box's test of equality of co-variances.

The null hypothesis for Box's test is that the variances of the independent variables among categories of the categorical dependent variable are not homogeneous. The value of Box's M, F-value, and the level of significance of the test are 116.536, 1.000, and 0.480 respectively. Since the significance level 0.480 is greater than cut off value of 0.10 (Cannot reject the null hypothesis of equal population co-variance matrices at 0.10 significance level), homogeneity of co-variance is accepted and thus discriminant analysis can be performed. A check on multi-collinearity is also performed looking at the pooled within-groups correlation matrix. When assessing the correlation matrix for multi-collinearity a rule of thumb is that no r (correlation value) > 0.90 and not several r > 0.80. Table 7 in Appendix A provides the pooled correlation matrices. Since, all correlation values are < 0.658 and thus there is no support for the existence of multi-collinearity in these independent variables. So discriminant analysis can be performed (Premkumar & Roberts, 1999).

Discriminant model is generated for perceived RFID adoption intent of retailers. The value of Wilk's Lambda, chi-square value, and the level of significance is shown in table 4. The model is significant with p-value = 0.003

Table 2. Reliability of measurement items

Variables	No. of Items	Alpha-Value
Relative advantage	6	0.834
Cost	3	0.780
Complexity	4	0.864
Compatibility	2	0.830
Top management support	4	0.825
Size	1	N/A
IT expertise	3	0.665
Competitive pressure	2	0.789
External support	4	0.755
Catalyst agent	4	0.520
Information intensity	4	0.820
Value chain complexity	2	0.816

at 0.10 significance level. The standardized discriminant coefficients and discriminant loadings for the variables are also provided in table 4. Univariate statistics in terms of group-wise means and F-value significance on equality of means are provided for comparative analysis. Discriminant loadings (Structural correlation), measuring the simple linear correlation between each predictor variables and the extracted discriminant function, is used to determine the significance of the variables. The general guideline is that the values above 0.3 are satisfactory and acceptable (Hair et al., 1983).

The significant variables thus are relative advantage, competitive pressure, catalyst agent, and value chain complexity that discriminate between adopter and non-adopters. The univariate significance levels corresponding to the F statistics given in table 4 also indicate that these variables are significant independently as well.

Classificatory test is done to determine the ability of the model to classify accurately. The classification result is used to assess how well the discriminant function works, and if it works equally well for each group of the dependent variable. Classification result is provided in table 8 in Appendix A. The classificatory ability of the discriminant model is 84.7% for original grouped cases and 78% for cross-validated grouped cases.

Looking at the discriminant coefficients given in table 4 it is observed that the four significant variables relative advantage, competitive pressure, catalyst agent, and value chain complexity positively influence.

RFID adoption. Remaining antecedents IT expertise, top management support, information intensity, cost, external support, compatibility, size, and complexity are found not be significant. IT expertise, top management support, information intensity are expected to be significant antecedents. Thus, the results were in contradiction to what was expected and the argument for the insignificance could be that the variables came out to be insignificant in the presence of other stronger antecedents. However, the discriminant loadings for the factors of IT expertise, top management support, and information intensity are close to the cut off value of 0.3 as observed from table 4. The univariate significance levels corresponding to the F statistics for IT expertise and top management support given in table 4 indicate that these variables are significant independently. Table 5 presents the results of the discriminant model (all variables entered together) in a summarized form.

Table 3. Means and standard deviations of the independent variables

Independent Variables	Rating Average (Mean)	Std. Deviation	($H_{\mu i}$: $\mu_i > 3$) 90% Lower Bound
Relative advantage	4.16	0.551	4.077
Cost	2.73	0.948	2.587
Complexity	2.50	0.798	2.380
Compatibility	2.42	0.890	2.286
Top management support	2.75	0.735	2.639
Size	3.38	1.150	3.207
IT expertise	3.75	0.687	3.647
Competitive pressure	2.76	1.005	2.609
External support	3.43	0.665	3.330
Catalyst agent	3.13	0.567	3.045
Information intensity	2.75	0.783	2.632
Value chain complexity	3.02	0.950	2.877

6. DISCUSSION

Results of the analysis indicates that technological variable relative advantage, environmental variables competitive pressure and catalyst agent, and value chain variable value chain complexity are the significant variables to discriminate between the RFID adopters from non-adopters thereby providing strong support for hypotheses 1, 8, 10, and 12. Thus, the empirical results indicate that there are significant determinants in each context except the organizational context. This is contrary to what was expected. The results imply that the determinants of RFID adoption in retail should include not only the technological characteristics but also factors related to external environment and the value chain context. Unexpectedly, the same could not be verified for the organizational characteristics. In the next section, each determinant affecting RFID adoption in retail is discussed in detail. The non-significant variables are also discussed in the following section.

6.1. Exploring the Significant Variables

6.1.1. Relative Advantage

The summary table 5 indicates that relative advantage which is a technological characteristic is a significant variable to discriminate RFID adopters from non-adopters as expected. This is consistent with the results of prior studies that have found it to be a significant antecedent for initiating many innovations including RFID (Premkumar & Roberts, 1999; Grover, 1993; Lee & Shim, 2007; Roh et al., 2009; Tsai et al., 2010). Firms adopt technology only if there is a perceived need for it to exploit a business opportunity to gain competitive advantage. Some of the benefits of RFID technology are improved inventory management, improved visibility, improved security from theft and fraud, greater data accuracy, and improved customer service levels (Wamba et al., 2009; Wang et al., 2010; Bhattacharya et al., 2008; 2010; Bhattacharya, 2012). Relative advantage coming out to be a significant antecedent indicates that RFID technology has a high level of relative advantage. This also shows RFID adopters have higher

perceived relative advantage levels of RFID as compared to non-adopters. This implies that adopters believe that adopting RFID is beneficial for retailers.

6.1.2. Competitive Pressure

The summary table 5 indicates that competitive pressure which is an environmental characteristic is a significant variable to discriminate RFID adopters from non-adopters as expected. It is thus an environmental characteristic that stimulates RFID adoption by retailers. This is consistent with the results of previous RFID adoption studies that have found it to be a significant antecedent for initiating RFID adoption (Brown & Russell, 2007; Wamba et al., 2009; Wang et al., 2010). RFID adopters perceive significantly higher competitive pressure for RFID adoption than non-adopters.

Many large retailers mandating their top suppliers to tag their products at pallet or case level is influencing other retailers to jump into RFID adoption to stay in business. It is becoming more of a strategic necessity for other retailers who are still not actively pursuing RFID adoption. When competitor retailers use RFID that provides them competitive advantage, other retailers will feel pressure and be more receptive to RFID. This implies that RFID adopters feel higher perceived competitive pressure as compared to non-adopters.

6.1.3. Catalyst Agent

The summary table 5 indicates that an external catalyst agent which is an environmental characteristic is a significant variable to discriminate RFID adopters from non-adopters as expected. It is thus an environmental stimulator of RFID adoption by retailers. This is consistent with the results of previous RFID adoption studies that have found it to be a significant antecedent for initiating RFID adoption (Brown & Russell, 2007; Wamba et al., 2009; Wang et al., 2010). These catalyst agents are EPC global initiatives for RFID standardization, government influence in the form of mandates such as FDA (Food and drugs administration) and DOD (US department of defense) requirements pushing for case, pallet, or item level RFID tagging, and perceived consumer readiness for RFID tagging of products through increased awareness about the technology. Consistency and interoperability between value chain partners achieved through global RFID standard initiatives can allow firms to leverage cross-industry benefits.

6.1.4. Value Chain Complexity

Value chain complexity which is a value chain characteristic is a significant variable to discriminate RFID adopters from non-adopters. This implies that the more complex is the value chain of operation in terms of dealing with too many value chain partners or uncertainty while doing business, the more likely it is that the retailers will adopt RFID technology. To my best knowledge, the variable of value chain complexity has not been investigated in previous RFID adoption studies. Traditionally, it is assumed that RFID implementation could get very complex and tedious in real world complicated value chain scenario involving multiple relationships. However, from this study it is observed that RFID benefits relative to the cost might be more balanced in a complex value chain situation and thus justifies RFID adoption.

This implies that influence of value chain complexity discriminates between the two groups of RFID adopters and non-adopters. More empirical research on RFID adoption is needed to further validate the efficacy of the value chain complexity variable.

6.2. Exploring the Non-Significant Variables

6.2.1. Technological Characteristics: Cost, Complexity, and Compatibility

Technological factors cost, complexity, and compatibility are found not to be significantly determining RFID adoption in retail. High cost issues and complexity of RFID technology are expected to be significant inhibitors of RFID adoption whereas compatibility with previous technologies and current business values and ob-

Table 4. Discriminant analysis – RFID adoption

Wilk's Lambda = 0.559, Chi-Square = 29.62, DF = 12, Sig = 0.003					
Variables	**Discriminant Coefficients**	**Discriminant Loadings**	**Univariate Analysis Group Mean (S.D) Adopter**	**Non-adopter**	**Sig**
Relative advantage	0.705	0.600	4.34 (0.45)	3.50 (0.62)	0.000
Competitive pressure	0.691	0.526	3.02 (0.95)	2.06 (0.87)	0.001
Catalyst agent	0.183	0.482	3.25 (0.53)	2.75 (0.55)	0.002
Value chain complexity	0.057	0.344	3.17 (0.96)	2.53 (0.92)	0.025
IT expertise	0.220	0.289	3.89 (0.60)	3.54 (0.66)	0.058
Top management support	0.387	0.252	2.87 (0.76)	2.51 (0.55)	0.097
Information intensity	-0.116	0.212	2.78 (0.78)	2.47 (0.71)	0.162
Cost	0.068	-0.116	2.56 (0.85)	2.77 (1.02)	0.441
External support	-0.280	0.091	3.49 (0,70)	3.37 (0.57)	0.545
Compatibility	0.041	-0.069	2.29 (0.88)	2.40 (0.78)	0.646
Size	-0.340	-0.018	3.39 (1.16)	3.44 (1.21)	0.903
Complexity	-0.054	0.009	2.44 (0.85)	2.42 (0.65)	0.952

jectives is expected to be positively influencing adoption. However, based on the results of this study, these technological characteristics do not successfully discriminate between RFID adopters and non-adopters. This is contrary to what is observed in previous RFID adoption studies (Brown & Russell, 2007; Wang et al., 2010).

It may be that decreasing cost of RFID tags and increasing maturity of RFID technology and services is contributing to these factors being insignificant in RFID adoption decisions. Unexpectedly compatibility factor also came out to be insignificant in this study. This could imply that firms which are starting fresh with RFID technology rather than those which have already invested a huge amount on previous technologies are more likely to adopt it. Firms that already made huge investments on older technologies need to upgrade their existing infrastructures, values, and objectives which might be a huge barrier for them. This also implies that the firms should look beyond the technological constraints to make RFID adoption a success. This study shows that the environmental and value chain characteristics should be emphasized rather than technological characteristics alone while making adoption decisions contrary to popular beliefs.

6.2.2. Organizational Characteristics: Top Management Support, Organizational Size, and IT Expertise

Unexpectedly, the organizational characteristics of top management support, organizational size, and IT expertise do not significantly impact RFID adoption in retail. This is consistent with prior RFID adoption studies (Leimeister et al., 2009; Wang et al., 2010). Top management support has been found to be critical in most prior studies on technology adoption (Premkumar et al., 1997). The contrasting result in this study may be due to the presence of more influential environmental characteristics. One possible explanation for the insignificance of top management support for RFID adoption is that most retailers are influenced by factors that are relevant to the external business environment or value chain in which the business operates rather than by the internal decision maker's perspectives. Competitive pressure arising from most big retailers mandating their suppliers and the perceived benefits of RFID providing competitive advantage might be driving RFID adoption more significantly as compared to internal perceptions of top management. Another possible explanation could be relative newness of RFID technology that might contribute to lesser degree of commitment from top management who prefer to rather wait and watch how well RFID technology develops and better learn how to implement it appropriately thus taking fewer risks. Again this implies the need for more empirical investigation of RFID adoption.

Organizational size also emerged as an insignificant factor influencing RFID adoption. This is contrary to what is expected since it is easier for larger firms to invest on new technologies since they have more slack resources and have greater capabilities to take risks. However, in this study the effect of organizational size is not significant. One possible explanation for this could be that it is simpler for smaller organizations to implement the technology given lesser degree of complexity in their value chain and lower cost of required hardware and software.

IT expertise also emerged to be insignificant in determining RFID adoption. This implies that existing IT expertise may not be sufficient for successful RFID adoption. A possible explanation for this could be again due to relative immaturity of RFID technology. Even if the firms acquire sufficient IT expertise they are still uncertain about the exact requirements for successful RFID adoption. Also being extremely familiar and used to older technologies might actually raise a potential barrier in adopting a new technology thus creating some resistance. This situation is most likely to change with technological advancements and increasing working knowledge about RFID technology. As previously discussed in the results section, please note that both top management support and IT expertise were close to the critical cut off value of 0.3 (Structural loading). Thus the alternative explanation for the insignificance could be that the influence of these variables might have been overshadowed due to the presence of other stronger variables and thus these variables must be explored in future research.

6.2.3. Environmental Characteristic: External Support

The environmental characteristic external support is not found to be significant for determining RFID adoption in retail. The evidence about the significance of external support has been diverse in technology adoption studies (Premkumar & Roberts, 1999). Brown and Russell (2007) found that external support is crucial and determines RFID adoption. External support is expected to be very important for RFID adoption since very few firms have complete in-house expertise to deal with the wide array of issues associated with RFID implementation followed by maintenance. The only plausible explanation for the insignificance of this variable is that an overwhelming influence of other significant variables on the RFID adoption decision has overshadowed the effect of external support on RFID adoption. For example, the environmental factors of competitive pressure and catalyst agents might be too strong and thus undermine

Table 5. Summary results of discriminant analysis

Variables	Hypotheses	Results
Relative advantage	H1: Technological factor relative advantage positively influences RFID adoption intent	**Accepted**
Cost	H2: Technological factor higher cost negatively influences RFID adoption intent	Rejected
Complexity	H3: Technological factor complexity negatively influences RFID adoption intent	Rejected
Compatibility	H4: Technological factor compatibility positively influences RFID adoption intent.	Rejected
Top management support	H5: Organizational factor top management support positively influences RFID adoption intent	Rejected
Size	H6: Organizational factor organizational size positively influences RFID adoption intent.	Rejected
IT expertise	H7: Organizational factor IT expertise positively influences RFID adoption intent	Rejected
Competitive pressure	H8: Environmental factor competitive pressure positively influences RFID adoption intent	**Accepted**
External support	H9: Environmental factor external support positively influences RFID adoption intent	Rejected
Catalyst agent	H10: Environmental factor catalyst agent positively influences RFID adoption intent	**Accepted**
Information intensity	H11: Value chain factor information intensity positively influences RFID adoption intent	Rejected
Value chain complexity	H12: Value chain factor supply chain complexity positively influences RFID adoption intent	**Accepted**

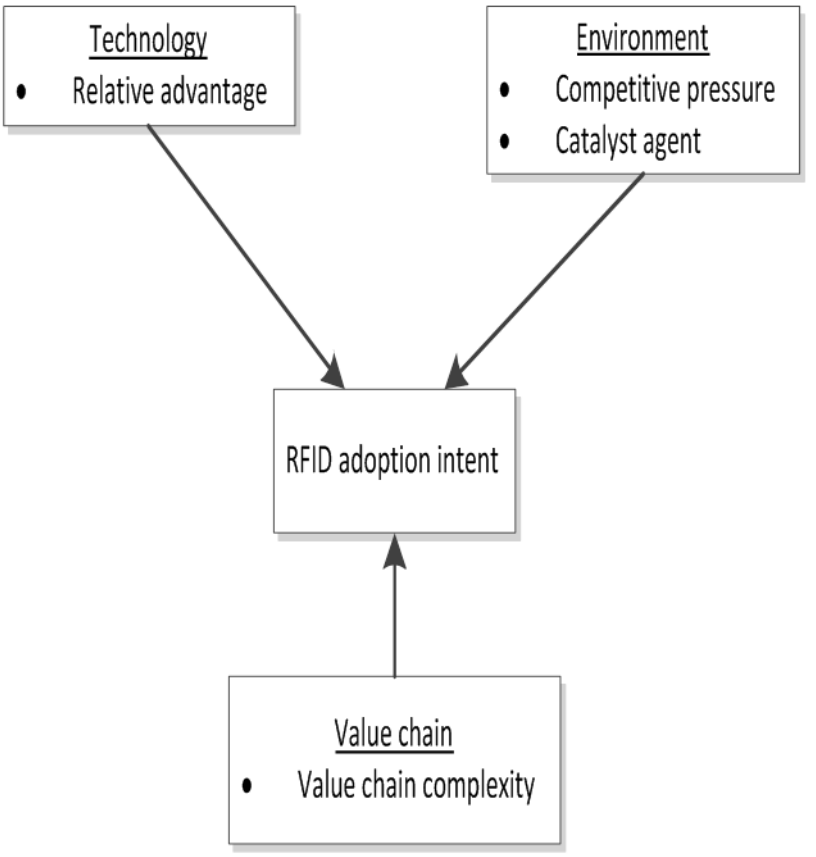
the effect of the external support factor. Or on the other hand, the level of availability of external support from vendors or third party service providers might be same for both adopters and non-adopters. Thus, external support is not a significant variable to discriminate between adopters and non-adopters.

From table 4, it is also observed that technological characteristic complexity and organizational characteristic IT expertise are not significant. This implies that both adopters and non-adopters of RFID technology perceive it to be a not so complex technology, have sufficient in house IT expertise and thus does not need external support from vendors, third party service providers, or business partners. This is a welcoming trend, if the argument is true. However, a relatively slow RFID adoption rate in retail tells a different story. Thus more research is required to determine the exact reason for this result.

6.2.4. Value Chain Characteristic: Information Intensity

The value chain characteristic information intensity also emerged to be insignificant in determining RFID adoption in retail. Previous research on technology adoption has diverse findings when it comes to the effect of information intensity driving adoption. Some studies reported that information intensity positively influences technology adoption whereas others reported that it negatively influences technology adoption. The result from this study is inconsistent with prior RFID adoption study (Wang et al., 2010) who reported that information intensive environment negatively influences RFID adop-

Figure 2. RFID adoption model results summary



tion. The explanation for the insignificance of information intensity in this study could be due to the presence of other significant factors which overshadowed its effect. Another argument would be that traditional retail environment may not be as information intensive as some other businesses and thus it is not very crucial when it comes to adoption decision. Figure 2 shows the adoption model result summary.

7. CONCLUSION AND FUTURE RESEARCH

This study identifies key determinants of RFID adoption in retail. The key findings are as follows:

1. RFID adoption in retail depends on technological, environmental, and value chain contexts.
2. Four variables (Relative advantage, competitive pressure, catalyst agent, and value chain complexity) are found to be significant determinants of RFID adoption in retail.
3. All four variables are successful facilitators of RFID adoption in retail.
4. Environmental characteristics are very important to be considered in RFID adoption studies along with technological and value chain characteristics.
5. Organizational characteristics top management support and IT expertise are close to being significant, however their effects

are overshadowed in the presence of much stronger environmental characteristics that influence RFID adoption. This could explain slower RFID adoption rate than originally expected. Thus, no arguments could be made for organizational characteristics influencing RFID adoption in this study which is in sharp contrast with other RFID adoption studies.

This study verifies the applicability of TOE framework for RFID adoption studies and extends the framework by adding another dimension of value chain context to it that makes it more suitable for RFID research since the technology is primarily used to streamline value chain activities.

This study finds two significant facilitators of RFID adoption (Catalyst agent and value chain complexity) which are rarely investigated in previous RFID adoption studies.

Compared to previous research, this study uses a large and diverse pool of experts to develop the conceptual framework of RFID adoption.

The managerial implication of these findings suggests that environmental factors along with value chain specific factors and technological factors can positively influence wide spread adoption of RFID technology. These findings are specific to the retail sector and we believe that putting relevant information and knowledge into the context of a particular business domain is very important. The theoretical implication of this research is the developed research model that could be used as a platform for future research to better understand RFID adoption for retail and the framework could be extended for other sectors. The model links the research on RFID adoption to existing research in the area of diffusion of innovation.

The research model should be further refined and revised by putting it through more rigorous empirical investigation. For future research, we plan on improving the research model by conducting a detailed case study in a specific retail organization that has adopted RFID for handling their operations. Conducting a detailed case study or conducting multi organization case studies will allow us to improve the model and provide insights to better guide decision makers to make more informed RFID adoption choices. Furthermore, we plan on conducting a longitudinal study to investigate the influence of these variables across different levels of adoption through diffusion and use. We plan on following up with the experts for insights particularly for the contrasting results about organizational factors that we identified in this study. We also plan to extend the model and test for its applicability for other industries like healthcare and automotive.

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APPENDIX A

Table 6. Measurement items of adoption independent variables

Variables	Measurement Items
Relative advantage	RA1. RFID allows for improved inventory management RA2. RFID provides better information accuracy for better decision making and collaboration RA3. RFID provides improved visibility RA4. RFID allows for improved customer service levels and sales RA5. RFID provides improved operational efficiency RA6. RFID provides improved security against theft and counterfeiting
Cost	C1. The costs of adopting RFID technology are far greater than the benefits C2. The cost of maintenance and support of RFID technology is very high C3. The amount of money and time invested in training employees to use RFID technology is very high
Complexity	CX1. The skills required to use RFID technology are too complex for employees CX2. Integrating RFID technology in current retail work practices is very difficult CX3. Integrating RFID systems with existing IT systems is very complex CX4. Massive amounts of data generated by RFID is very difficult to manage
Compatibility	CM1. Implementing the changes caused by RFID adoption is not compatible with most retailer business approaches and objectives CM2. RFID is not compatible with retailers' experience with similar technology
Top management support	TS1. Top management in retail enthusiastically supports the adoption of RFID technology TS2. Top management in retail allocates adequate resources for adoption of RFID technology TS3. Top management in retail is aware of the benefits from RFID TS4. Top management in retail actively encourages employees to use RFID technology in their daily tasks
Size	S1. Organization size positively influences RFID adoption in retail
IT expertise	IE1. Greater IT expertise in an organization positively influences RFID adoption in retail IE2. Greater strategic IT planning positively influences RFID adoption in retail IE3. Most big retailers have a sophisticated database and telecommunication facility
Competitive pressure	CP1. Retailers will lose customers to competitors if they do not adopt RFID technology CP2. It is a strategic necessity to use RFID to compete in marketplace
External support	ES1. There are third party service providers that provide technical support for effective use of RFID technology ES2. There are agencies who provide training on RFID technology ES3. Technology vendors actively market RFID technology by providing incentives for adoption ES4. Technology vendors promote RFID technology by offering free training sessions
Catalyst agent	CA1. Vendors are trying very hard to sell RFID technology to retailers CA2. Government is promoting RFID adoption by retailers through specific mandates CA3. EPC global initiative for standardization is promoting RFID adoption in retail CA4. Perceived consumer readiness for RFID technology is positively influencing RFID adoption in retail
Information intensity	II1. The product/service in retail generally requires a lot of information to sell II2. The product/service in retail is complicated or complex to understand II3. The ordering of product/service in retail is generally a complex process II4. The products in retail industry are characterized by a long cycle time from order to delivered product
Value chain complexity	VC1. Typically retailers deal with too many value chain partners for doing business VC2. Typically retailers deal with a lot of uncertainty while doing business with value chain partners

Table 7. Factor loadings for constructs

Constructs	Items	Loadings	Eigen-Value	% Variance Explained
Factor 1 Complexity Compatibility Cost	CX2	0.852	6.782	17.85
	CX3	0.828		
	CX1	0.758		
	CM2	0.741		
	CM1	0.727		
	CX4	0.726		
	C3	0.575		
	C2	0.481		
Factor 2 Relative advantage	RA1	0.878	6.613	16.22
	RA3	0.857		
	RA2	0.825		
	RA4	0.609		
	RA5	0.577		
Factor 3 Top management support	TS2	0.880	2.848	7.49
	TS1	0.848		
	TS3	0.774		
	TS4	0.586		
Factor 4 Information intensity	II2	0.816	2.588	6.81
	II4	0.801		
	II3	0.797		
	II1	0.433		
Factor 5 External support	ES3	0.832	2.136	5.62
	ES4	0.662		
	ES2	0.657		
	ES1	0.626		
Factor 6 IT Expertise	IE2	0.844	1.894	4.98
	IE1	0.839		
Factor 7 Competitive pressure	CP2	0.862	1.772	4.68
	CP1	0.813		
Factor 8 IT Expertise Cost	IE3	0.847	1.718	4.52
	C1	0.638		
Factor 9 Relative advantage Catalyst agent	RA6	0.769	1.383	3.64
	CA4	0.628		
Factor 10 Value chain complexity Catalyst agent	VC1	0.712	1.104	2.90
	VC2	0.623		
	CA2	0.361		
	CA3	0.472		
Factor 11 Size	S1	0.758	1.078	2.84
Factor 12 Catalyst agent	CA1	0.74	1.012	2.68

Table 8. Pooled within-groups matrices to test multi-collinearity

		RRA	CC	CCX	CCM	TTS	SS	IIE	CCP	EES	CCA	III	VVC
Corr.	Relative advantage	11.000	--.398	--.231	--.172	--.097	..120	..243	..005	..338	..187	..125	..217
	Cost	--.398	11.000	..540	..514	..303	--.128	.209	-.272	--.330	..046	..110	--.047
	Complexity	--.231	..540	1.000	..657	..290	..151	..240	--.049	-.240	..293	..361	..055
	Compatibility	--.172	..514	..657	11.000	..273	--.023	..122	--.296	--.084	..385	..206	..110
	Top management support	--.097	..303	..290	..273	11.000	..151	..043	--.176	--.178	..218	..082	..006
	Size	.120	--.128	..151	--.023	..151	11.000	..268	..164	--.090	..081	..273	..280
	IT Expertise	..243	..209	..240	..122	..043	..268	11.000	..002	..127	..121	..318	..255
	Competitive pressure	..005	--.272	--.049	--.296	--.176	..164	..002	11.000	..176	..224	..219	..293
	External support	..338	--.330	--.240	--.084	--.178	--.090	..127	..176	11.000	..181	..039	..093
	Catalyst agent	.1.87	..046	..293	..385	..218	..081	..121	..224	..181	11.000	..352	..308
	Information intensity	..125	..110	..361	..206	..082	..273	..318	..219	..039	..352	11.000	..517
	Value chain complexity	..217	-.047	.055	..110	..006	..280	..255	..293	..093	..308	..517	11.000

Table 9. Classification result of RFID adoption model

		Retailers RFID Adoption Intent	Predicted Group Membership		Total
			Disagree	Agree	
Original	Count	Disagree	9	7	16
		Agree	2	41	43
	%	Disagree	56.3	43.8	100.0
		Agree	4.7	95.3	100.0
Cross-validated[a]	Count	Disagree	8	8	16
		Agree	5	38	43
	%	Disagree	50.0	50.0	100.0
		Agree	11.6	88.4	100.0
a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.					
b. 84.7% of original grouped cases correctly classified.					
c. 78.0% of cross-validated grouped cases correctly classified.					

APPENDIX B

Delphi Study Instrument

Your participation in this Delphi study is vital to understanding the impact of RFID on Retail sector. We are investigating key adoption issues specifically for retail such as adoption drivers, benefits, business processes, value chain activities, challenges, and major trends in this research. A summary of the results will be made available to everyone who completes the questionnaire giving you an opportunity to change your opinions if you choose to. Finally a complete research report with detailed comparative analysis between content analysis and Delphi study results will be made available to everyone who participates in this study as an acknowledgment for their valuable inputs and time. Please take a moment to take this online survey which should take no longer than 15-20 minutes. Below is our consent form. Completion of the survey implies that you have read the information in this form and consent to take part in the research.

Implied Informed Consent Form for Social Science Research

The XXX University
Title of Project: Exploratory Study of Impact of RFID on Retail Sector

1. **Purpose of the Study:** The purpose of this research study is to explore how Radio Frequency Identification (RFID) technology impacts retail sector. Also of interest is to understand key RFID adoption issues in retail sector.
2. **Procedures to be Followed:** You will be asked to participate in a Delphi study. You will be required to answer 19 questions on a survey. The combined results will be sent to you giving you an opportunity to change your opinions if you wish to.
3. **Duration:** It will take about 15-20 minutes to complete the survey. If you wish to change your opinions during the second round you may do so within 5-10 minutes.

4. Statement of Confidentiality: Your participation in this research is confidential. No one other than investigators will have access to your responses. Your data will be stored with a participant number, not a personal identifier such as a name. All presentations of this research will report your data using this anonymous code; in most cases your data will appear only as part of a group summary. Your name will not appear in professional presentations or publications. All data will be stored in a password protected computer. Only the principal investigator will have access to the password protected computer. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, XXX University's Social Science Institutional Review Board and XXX University's Office for Research Protections. Your confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the internet by any third parties.

5. Right to Ask Questions: Please contact XXX with questions or concerns about this study.

6. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and return of the survey implies that you have read the information in this form and consent to take part in the research. Please keep this form for your records for future reference.

This informed consent form was reviewed and approved by the Office for Research Protections (IRB#32286) at XXX University.

Do you consent to take part in this research?

- I agree
- I do not agree

Participant Information

1. Please select the item that best describes your field of business association.
   - Academia
   - Consulting
   - Third party service providers
   - Retail
   - Other (Please specify)
2. Please indicate what best describes your position.
   - Top management
   - IT management
   - Executive staff
   - Research
   - Other (Please specify)
3. Are you familiar with RFID (Radio Frequency Identification) and its uses?
   - I know all about RFID
   - I have good knowledge about RFID
   - I have some knowledge of what it is
   - I have only heard about it
   - I am not familiar with it at all
   - Other (Please specify)
4. How long have you been involved with RFID projects?
   - 6 months - 1 year
   - 1 - 3 years
   - 3 - 5 years
   - Greater than 5 years

5. Your email address. Please note that email address will be used for the purpose of acknowledgement and to provide summary results of the questionnaire only. All email/surveys will be treated in confidence.

Technological Adoption Factors

Instructions: Please think about consumer products like grocery, fresh produce and sea food, dvds and games, furniture, tableware, accessories (jewellery, watches, eye wear etc.), health and beauty products, alcohol and cigarettes, electronics etc. that could be tagged by RFID when you express your opinions. Based on your individual perception along with industry or professional experience please answer the following questions.

The statements are scaled from 1 to 5, with 1 being 'strongly disagree' and 5 being 'strongly agree'. Read each statement carefully, then using the following scale, decide the extent to which it actually applies to you. Attempt all statements.

Strongly disagree = 1
Disagree = 2
More-or-less agree = 3
Agree = 4
Strongly agree = 5

6. Does relative advantage influence RFID adoption in retail? How true is each of this statement?
   - RFID allows for improved inventory management
   - RFID provides better information accuracy for better decision making and collaboration
   - RFID provides improved visibility
   - RFID allows for improved customer service levels and sales
   - RFID provides improved operational efficiency
   - RFID provides improved security against theft and counterfeiting
   - Other Comments (Please specify)
7. Does cost influence RFID adoption in retail? How true is each of this statement?
   - The costs of adopting RFID technology are far greater than the benefits
   - The cost of maintenance and support of RFID technology is very high
   - The amount of money and time invested in training employees to use RFID technology is very high
   - Other Comments (Please specify)
8. Does complexity influence RFID adoption in retail? How true is each of this statement?
   - The skills required to use RFID technology are too complex for employees
   - Integrating RFID technology in current retail work practices is very difficult
   - Integrating RFID systems with existing IT systems is very complex
   - Massive amounts of data generated by RFID is very difficult to manage
   - Other Comments (Please specify)
9. Does compatibility influence RFID adoption in retail? How true is each of this statement?
   - Implementing the changes caused by RFID adoption is not compatible with most retailer business approaches and objectives
   - RFID is not compatible with retailer's experience with similar auto-ID technology
   - Other Comments (Please specify)

Organizational Adoption Factors

10. Does top management support influence RFID adoption in retail? How true is each of this statement?

- Top management enthusiastically supports the adoption of RFID technology
- Top management allocates adequate resources to adoption of RFID technology
- Top management is aware of the benefits from RFID
- Top management actively encourages employees to use RFID technology in their daily tasks
- Other Comments (Please specify)

11. Does organizational size influence RFID adoption in retail?
    - Organization size positively influences RFID adoption in retail
    - Other Comments (Please specify)
12. Does existing IT expertise influence RFID adoption in retail? How true is each of this statement?
    - Greater IT expertise in an organization positively influences RFID adoption in retail
    - Greater strategic IT planning positively influences RFID adoption in retail
    - Most retailers have a sophisticated database and telecommunication facility
    - Other Comments (Please specify)

Environmental Adoption Factors

13. Does competitive pressure influence RFID adoption in retail? How true is each of this statement?
    - Retailers will lose customers to competitors if they do not adopt RFID technology
    - It is a strategic necessity to use RFID to compete in marketplace
    - Other Comments (Please specify)
14. Does external support influence RFID adoption in retail? How true is each of this statement?
    - There are third party service providers that provide technical support for effective use of RFID technology
    - There are agencies who provide training on RFID technology
    - Technology vendors actively market RFID technology by providing incentives for adoption
    - Technology vendors promote RFID technology by offering free training sessions
    - Other Comments (Please specify)
15. Do catalyst agents influence RFID adoption in retail? How true is each of this statement?
    - Vendors are trying very hard to sell RFID technology to retailers
    - Government is promoting RFID adoption by retailers through specific mandates
    - EPC global initiative for standardization is promoting RFID adoption in retail
    - Perceived consumer readiness for RFID technology is positively influencing RFID adoption in retail
    - Other Comments (Please specify)

Value Chain Adoption Factors

16. Does information intensity of retail value chain influence RFID adoption? How true is each of this statement?
    - The product/service in retail generally requires a lot of information to sell
    - The product/service in retail is complicated or complex to understand
    - The ordering of product/service in retail is generally a complex process
    - The products in retail industry are characterized by a long cycle time from order to delivered product
    - Other Comments (Please specify)
17. Does complexity in retail value chain influence RFID adoption? How true is each of this statement?
    - Typically retailers deal with too many value chain partners for doing business

- Typically retailers deal with a lot of uncertainty while doing business with value chain partners
- Other Comments (Please specify)

Adoption Intent

18. In the light of technological, organizational, environmental, and value chain factors influencing RFID adoption, please express your opinion about retailers' RFID technology adoption intent.
    - Most retailers would intend to adopt RFID technology
19. Any additional comments?

Thank you for participating in this research. We will send you the compiled results giving you an option to change your opinion if you choose to. Finally we will send you the finished research report comprising a detailed analysis between of the findings from the results at the end of the study.

Please submit to complete.