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Investigating the role of task-technology fit along with attractiveness of alternative technology to utilize RFID system in the organization

Suk Kyoung Kim, Min Jae Park, Eun Ji Ahn and Jae Jeung Rho
Korea Advanced Institute of Science and Technology (KAIST)

Abstract

In spite of exponential growth projections of RFID (Radio Frequency Identification) market value, many companies are reluctant to adopt RFID and RFID vendors are complaining that the business is not growing as fast as expected. The existing challenges and deep skepticism that RFID is facing remains around the return on investment, the incompleteness of RFID technology, and the lack of trust in the result of performance improvement. To fill these voids identified in previous research, from the perspective of business productivity and efficiency, this paper investigates what factors affect RFID-driven task performance, based on the extended Task-Technology Fit (TTF) model. To empirically evaluate the proposed model, a total of 63 usable responses were collected from companies in Korea, and the data is analyzed by Partial Least Squares (PLS). The results obtained pointed out the importance of the fit between the technology and users' tasks in achieving individual performance impact. Moreover, negative perceptions toward RFID have no direct effect on continuing RFID utilization. Knowing these factors, potential technology users are able to evaluate if it is reasonable to adopt RFID under certain conditions and at a certain point in time. Furthermore, they can attempt to actively influence these variables in order to reduce the failure probability of RFID deployments.

Keywords

RFID, task-technology fit, switching barrier theory, information technology, information sharing, barcodes, Korea

The dynamic nature of RFID technology could change its importance in the future

Introduction

Ubiquitous has emerged as the biggest trend in the information and communication industry of the 21st century. Specifically, there is a great deal of attention to Radio Frequency IDentification (RFID), which is being regarded as a core technology for implementing a ubiquitous world (Moon et al., 2012). RFID is an electric tagging technology that enables to automatically identify a person or object by using radio frequency transmission (Want, 2004). Although RFID was first utilized to identify friendly aircraft in World War 2, it has been recently gaining more and more popularity after its introduction by influential organizations such as Wal-Mart, Tesco, and the US Department of Defense (Xiao et al., 2007). The RFID market is expected to have explosive growth. In 2009, the value of the entire RFID market was around US$ 5.56 billion; by 2018 (IDTechEx, 2010), it is expected to become over five times larger

Corresponding author:
Min Jae Park, Department of Management Science, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro (373-1 Guseong-dong), Yuseong-gu, Daejeon, Republic of Korea.
Email: minj.park@kaist.ac.kr

and this rapid growth will be accelerated by falling RFID tag prices (IDTechEx, 2010). However, in spite of such an exponential growth projection, many companies are reluctant to adopt RFID and RFID vendors are complaining that the business is not growing as fast as expected (Wu et al., 2006). The existing challenges and deep skepticism that RFID is facing concern: a) the return on investment (ROI); b) the incompleteness of RFID technology; and c) the lack of trust in the results of business process innovation and performance improvement (Wu et al., 2006; Goodhue and Thompson, 1995). Moreover, barcode technology, the existing alternative technology, is considered a barrier to RFID adoption (Wu et al., 2006; Moon et al., 2012). Even though many people believe that in the future RFID will totally replace traditional optical barcode systems, the latter are still dominant. The barcode system is deeply entrenched and will not be replaced any time soon. This means that both barcodes and RFID will still have to coexist for a long time. The migration from barcodes to the RFID system will not only increase demands on system capabilities and compatibilities, but also increase the costs of maintenance and operation of both systems (Wu et al., 2006; Park et al., 2011).

To date, there is abundant published research on the technological side of RFID. However, there is very limited research on the strategies and applications of RFID. In the field of information systems research, a key concern has been to better understand the relationship between information technology and individual performance, and the managerial view of successful diffusion factors of RFID across diversity industries could be studied and investigated by past research. The adoption or utilization of a new system does not necessarily lead to higher performance. One of the main reasons is that new technology does not properly support employees' tasks at the operations and production levels (Goodhue and Thompson, 1995). From a business productivity and efficiency perspective, Task-Technology Fit (TTF) has been studied as a diagnostic tool for measuring the success of such IT adoption (Goodhue 1995).

However, TTF may not fully explain the impact of new emerging technology adoption on individual or group performance. Thus, based on the TTF model, this study employed the concepts of switching barriers to explain the influence of the existing substitutive technology and a theory of planned behavior to examine the motivation underlying behavioral intention toward individual performance or continuous utilization of RFID. To fill these voids identified in previous research, this paper studies what factors affect RFID-driven task performance based on the TTF model, from the perspective of business productivity and efficiency. Moreover, it is focused on how to influence the perceptions of RFID and competitive technology on the intentions to continuing RFID utilization in their organizations. Based on the studied factors, the extended TTF model is used and empirically tested. The extended TTF model helps us to evaluate whether RFID based systems and services are meeting user needs and determine if it is reasonable for them to adopt RFID into their organizations, under which conditions, and at which point in time.

Since 2004, a new growth engine, the RFID initiative, is being driven by the Korean government, including the Ministry of Information and Communication (MIC), the Ministry of Commerce, Industry and Energy (MOCIE), the Ministry of Science and Technology (MOST), and the Ministry of Construction and Transportation (MOCT). This initiative is expected to boost demand for new RFID technology applications from 2006 over the next several years. In order to enhance global competitiveness and become a leader in the IT market, MIC has declared RFID an important technology of the future and plans to aggressively pursue its development, along with a host of other new converging technologies. RFID applications are already being adopted and used in Korea in the areas of asset management, transportation ticketing, cargo and airline baggage tagging, etc. RFID pilot projects led by the Korean government were expected to turn into full projects from 2006. MIC has set aside an early stage-financing budget of approximately US$15 million for agencies that submit specific business plans on RFID applications from among agencies that were involved in pilot projects in 2004–2005. The demand for RFID equipment and solutions for new projects is forecast to increase by more than 10 times that of pilot projects. In addition to main government RFID projects, mobile RFID businesses with various applications, in which RFID and mobile/wireless technologies are combined, will also prompt strong interest and demand from the market as a new pilot project.

The next section provides previous literature and the theoretical foundation for this research. The third section describes the research model and hypotheses. Section four reveals the data analysis procedure for this study and the concluding section provides a discussion of the findings and the implications of this research.

Literature review

RFID technology adoption and diffusion in business applications

Much of the literature on RFID adoption and diffusion is based on well-known frameworks that originated from other areas of research such as innovation or information systems. There are several well-known theories, frameworks, and approaches that are generally applied, such as diffusion of innovation (Lin, 2009; Sharma et al., 2008; Wen et al., 2004), technology acceptance model (TAM) (Hossain and Prybutok, 2008), technology, organization and environment (TOE) (Schmitt and Michahelles, 2007), as well as other IT adoption theories. In addition Diffusion of Innovation (DOI) theory by Rogers (1983) is the most referred theory in IT adoption due to its well-developed concepts and the large number of empirical results available. Slettemeås (2009) observed that most existing RFID research has been dominated by organizational, behavioral, and information systems perspectives. Among the literature available, a few conceptual and empirical research studies have dealt with RFID adoption. As described by Rogers and many other works, in terms of adoption and diffusion patterns, any IT generally does not follow a linear path, but rather an S-shaped curve, as described by several works such as Corrocher and Ordanini (2002), Guo and Chen (2007), and Schmitt and Michahelles (2007).

Among the benefits that have been attributed to RFID in the context of business applications are improved coordination in supply chains (Lee and Ozer, 2007), increased visibility and responsiveness (Wamba and Ygal, 2008), as well as improved safety and security of supply chains (Inaba, 2008:191–210). However, the benefits are opposed by the costs for RFID, the costs for the necessary infrastructure as well as the risks associated with embedding RFID in the business context. Most notably, it has been argued that RFID puts the privacy of consumers at risk (Juels, 2006). Despite the description of RFID benefits and potential RFID applications in the literature, organizations are still striving to determine whether and how they can benefit from RFID. This seems to be attributable to a lack of understanding of the benefits of RFID on a basic level. Fleisch and Tellkamp (2003) state that ''so far there is only limited knowledge on the impact of RFID on business processes and how applications based on these technologies can create value for companies''. Similarly, Basole (2004) advocates the development of a suitable framework for identifying functional and process areas that can benefit from mobile technologies.

The benefits of RFID in a business context have commonly been studied within a narrow scope. The applications and benefits of RFID are either assessed in a specific company, a certain industry, or in particular business processes (Boushka et al., 2002). Consequently, the results of these studies can only be transferred to organizations that operate in the domain covered by the particular study. Some researchers have adopted a broader view by examining the business impacts of ubiquitous technology (UT) on a conceptual level (Yoo and Lyytinen, 2003). Strassner and Schoch (2002) found identification, monitoring, tracking, and notification to be the main capabilities of RFID from which benefits can be accrued. However, the conceptual frameworks developed by this stream of research are not detailed enough to be directly applicable. While Yoo and Lyytinen (2003) suggest that although complementary organizational assets and practices combined with RFID usage affect business process performance, no specific assets and practices that actually complement RFID usage are identified.

Comparison between RFID technology and barcode

RFID is expected to replace the barcode currently used for the identification of goods. Consequently, barcodes and RFID are indeed quite similar; both are auto-ID technologies intended to provide rapid and reliable item identification and tracking capabilities. The primary difference between the two technologies is the way in which they read objects. With bar coding, the reading device scans a printed label with an optical laser or imaging technology. However, with RFID, the reading device scans, or interrogates, a tag using RF signals. Thus, referring to RFID as radio bar codes is a disservice to the technology, confusing its basics (Wyld, 2006; Hossain et al., 2011).

There are five primary advantages that RFID has over barcodes: a) Each RFID tag can have an unique code that ultimately allows every tagged item to be individually accounted for; b) RFID allows for information to be read by radio waves from a tag, without requiring line-of-sight scanning or human intervention; c) RFID allows for virtually simultaneous and instantaneous reading of multiple tags; d) RFID tags can hold far greater amounts of information, which can be updated; e) RFID tags are far more durable. The specific differences between barcode technology

Table 1. Comparison between RFID and barcode.

Characteristics	RFID	Barcode
Reading Capability	Wireless line of sight not necessary	Optical-line of sight required
Reading Speed	RFID can read multiple tags in a single pass	Barcode can read a single label per pass
Durability	Pretty robust and not as sensitive to dirt, smearing as barcodes and are not easily broken, and thus can be used in harsh environments such as snow, fog, ice, etc.	Labels tend to be damaged in harsh processes. Etching directly onto part has increased durability
Amount of Information	RFID tags are capable of storing several thousand characters	One 1D barcode can store 20 alphanumeric characters
Flexibility of Information	To update information, many RFID tags can have their memories updated with new information through wireless communication.	To update information, a barcode label must be replaced with a new barcode label.
Security	RFID tags have manufacturer installed identification codes that cannot be changed, thus making counterfeiting difficult.	2D barcodes provide encryption capability.
Cost per label or tag	RFID tags cost from $0.25-$0.50, up to $250	Barcode labels typically cost less than $0.01
Standards	RFID lacks complete standardization, especially in the global environment	Bar coding is standardized and widely accepted.
State of Infrastructure	RFID is minimal. Users would have to invest in additional equipment to support RFID.	The infrastructure to support barcodes is in wide existence.

and RFID are summarized in Table 1 (Reik et al., 2004:12–13).

Although RFID is still evolving, governments and companies are already exploring several applications. Barcode and RFID will most likely coexist on product and shipping labels for at least the next decade. Indeed, some of the most creative and cost-beneficial applications may come from combining RFID and barcodes together. RFID tags/labels may be used to identify large groups of items. Barcodes remain as the tracking device for individual items. Previous research has identified several generic classes of less expensive applications that could emerge in the near to the medium term (Smith and Konsynski, 2005). As the adoption of RFID technology is moving from mandatory to voluntary, firms are looking for tools, frameworks and methodologies to enable them to evaluate the real impact of RFID technology on their business processes (Linda and Samuel, 2007). Also, in the business academic world, most recent works are focused on RFID adoption and the necessity of the research on the impact of RFID on individuals, organizations and markets is proposed by a burgeoning area and is still scarce (Wamba and Bendavid, 2008).

Theoretical background and related work

From the perspective of business productivity and efficiency, this paper studies what factors affect RFID-driven task performance based on the TTF model. Moreover, how users' perception of RFID technology and alternative technology on intention to continuance of RFID utilization in their organizations was investigated. Based on the studied factors the extended TTF model was proposed and empirically evaluated. The extended TTF model helped us to evaluate whether RFID based systems and services in a given organization are meeting user needs and determine whether it is reasonable to adopt RFID into their organizations, under which conditions, and at which point in time.

Task-Technology Fit model. Information technology is regarded as a decisive instrument to enhance organizational or individual performance. The impact of information technology adoption on performance has been the domain of MIS research (Goodhue and Thompson 1995; Seddon 1997). Many studies related that different areas have been flourishing and there are two main streams: utilization-focused research and fit-focused research. In the field of utilization-focused research, the Technology Acceptance Model (TAM) is the most popularly accepted model to explain why people accept or reject new technology among researchers. According to TAM, the perceived usefulness and perceived ease of use influence the intention to use a system and then system usage behavior is determined by the intention (Wang et al., 2003). However, despite its popularity, TAM has several weaknesses that obstruct the understanding of IT utilization. First, by including the assumption that the usage behavior is volitional, which is to say, voluntary, TAM does not fully explain the specific influences of technological and usage context factors that may alter the user's acceptance (Mark and Diane, 1999; Moon and Kim, 2001). Secondly, TAM has overlooked that more utilization of IT does not necessarily lead to higher performance (Goodhue and Thompson, 1995).

The fit perspective is focused on complementary streams to the limitations. 'Fit' means the degree to which the functionality of the technology matches the requirements of the task. Thus it has been proposed that only when there is a good fit between its capabilities and the task demands of users, could technology have a positive impact on performance (Goodhue, 1986). However, this approach also has some limitations. The models focusing on fit alone do not give sufficient attention to the fact that the information technology must be utilized before it can deliver performance impacts (Goodhue and Thompson, 1995).

The TTF model was developed to compensate for the weaknesses of both the utilization-focused research and fit-focused research. Since Goodhue and Thompson (1995) proposed this model, it has been applied to various areas of information technology and provided a theoretical basis by empirically verifying the casual relationship between information technology and performance. The essence of this model is that if the information technology is used and has a good fit with the tasks it supports, positive performance will be derived. Research on the TTF model is still actively evolving and especially being extended and integrated with the other models to increase its predictive or explanatory power.

Switching Barrier theory. Switching barrier refers to the difficulty in switching from the old to the new service or system (Jones et al. 2000). According to switching barrier theory, the reason why customers who are not satisfied with an existing situation repeat former purchase behavior and maintain the status quo is that they perceive high switching costs. That is, the switching costs could be explained by economical, social and psychological costs and measured by the attractiveness of alternatives, interpersonal relationship, and perceived switching cost (Dick and Basu, 1994; Fornell, 1992; Lee and Cunningham, 2001).

'Interpersonal relationship' refers to the strength of the personal bonds that are developed between customers and their service provider (Jones et al., 2000). This relation is evolved by repeated interactions such as trust, care, and communications between a customer and a service provider. 'Perceived switching cost' is the degree to which individuals believe that switching service providers would incur certain costs. The costs could be time, money, effort, or any other form of psychological cost associated with the change of service provider (Jones et al., 2000). 'Alternative attractiveness' is conceptualized as the client's estimate of the likely satisfaction available from an alternative relationship (Ping, 1993). If consumers perceive a lack of an attractive alternative, they are most likely to retain the existing relationship (Inman, 1997; Lemon et al., 2002; Jones et al., 2000).

Theory of Planned Behavior. The theory of planned behavior (TPB), that is the successful theoretical framework of the theory of reasoned action (TRA), has proved to be, in a wide range of behavioral disciplines, a successful model to empirically predict and understand behavior in a variety of situations (Shifter and Ajzen, 1985). The theory of planned behavior constitutes a general model for explaining users' behavior according to the relationship between beliefs, attitude, and behavior. In particular, it is an extension of the theory of reasoned action, which focuses on those cases where users have no complete control over their choice, but are somehow conditioned by non-motivating factors related to the availability of certain requirements and resources (Fishbein and Ajzen, 1975:181–205). The theory of planned behavior considers intention as the best behavior indicator, or foresight, since it shows the efforts that users are willing to make to carry out a specific action. This model identifies three kinds of variables determining or explaining behavior intention: attitude towards behavior, subjective norm and perceived behavioral control.

Major differences between TAM and TPB are that TAM focuses on perceived benefits, while TPB enables positive as well as negative beliefs (Horst et al., 2007). Introducing a new technology involves both benefits and risks to the end-user, and before deciding to adopt the technology the individual may want to weigh risks and benefits. Perceived risk has been formally defined as a combination of uncertainty plus seriousness of outcome involved (Featherman and Pavlou, 2002). The magnitude of the perceived

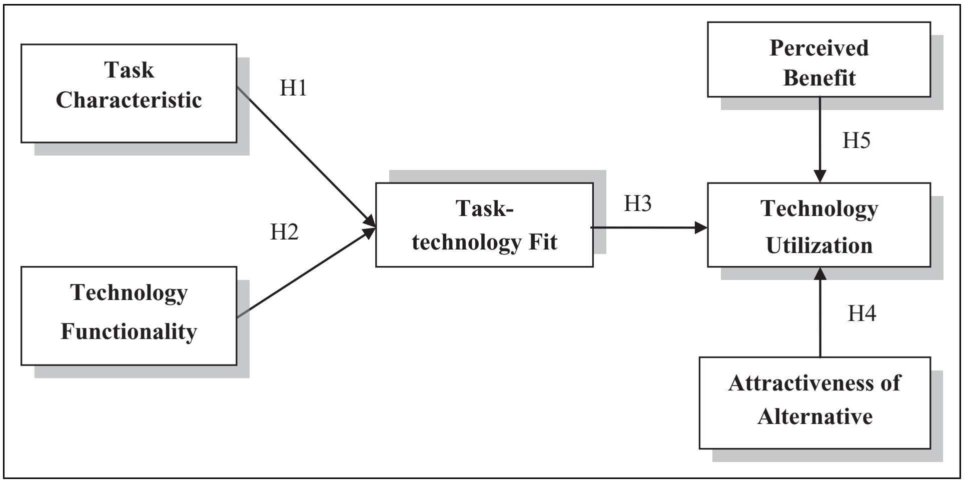

Figure 1. Research model.

risk is inversely related to the perceived benefit. A larger perception of risk will reduce the perceived benefit of the technology (Koh et al., 2006). The perception of a risk depends on the individual's perception to be able to control the consequences of the risk.

Research model

As previously stated, the purpose of this study is to propose and validate the TTF model, extended with selected core concepts from switching barrier theory and the theory of planned behavior, which may be suitable for investigating factors affecting RFID-driven task performance. The final research model used is shown in Figure 1.

In this study, task characteristic is analyzed along the dimensions of task interdependence, time-criticality, user mobility, and location dependency. Also, in order to measure RFID technology functionality, this research utilizes multiple reading simultaneously, high speed reading processes, mass memory, and various applications as measurement items. Task-technology fit is the degree to which a technology assists an individual in performing his or her portfolio of tasks. Specifically, TTF is the correspondence between task requirements, individual abilities, and the functionality of the technology (Goodhue and Thompson, 1995). Goodhue (1995) emphasized that task-technology fit would be most appropriately measured by assessing the user's beliefs of how satisfactorily systems meet task needs, regardless of how the user might feel about the systems. Because the construct 'TTF' is defined as the degree of worker's perception that the RFID capabilities match with the task requirements, this study uses the following measurement items: service satisfaction, technology satisfaction, and overall satisfaction.

Utilization is the behavior of employing the technology in completing tasks (Goodhue and Thompson, 1995). Measures such as the frequency of use or the diversity of applications employed (Davis, 1989) have been used. In order to measure utilization of RFID systems, this study used the following measurement items: attitude of reutilization, and recommendation to another person. Perceived benefit relates to satisfaction through the accomplishment of a portfolio of tasks by an individual. Higher perceived benefit implies some mix of improved efficiency, improved effectiveness, and/or higher quality (Goodhue and Thompson, 1995). Ideally, when RFID becomes fully implemented in distribution centers, it may eliminate the need for barcode scanning and manual counting at receiving docks. This has the potential to greatly reduce the labor hours needed, the amount of human error inherent in the current barcode scanning methods, and employee theft (Vijayaraman and Osyk, 2006). Thus, in this study, perceived benefit was analyzed along the dimensions of improved efficiency, improved effectiveness, and higher quality.

In the process of technological development, the adoption of a new system or service implies that individuals will eventually switch from the old system to the new one. According to Switching Barrier Theory, individuals are less likely to adopt a new system or service if they perceive a high switching cost. Jones et al. (2000) classified the switching barriers into three groups: attractiveness of alternatives, interpersonal relationship, and perceived switching

Table 2. The measurement items of each constructor.

Construct	Operational Definition	Measurement Items	Reference
Task Characteristic	The degree of worker's perception regarding actions carried out by RFID in turning inputs into outputs	*Task interdependence *Time-criticality *User mobility *Location dependency	Palsson(2007) Goodhue and Thompson (1995)
Technology Functionality	The degree of worker's perception regarding RFID characteristics used by individuals in carrying out their tasks.	*Multiple reading simultaneously *High speed reading processes *Mass memory *Various applications	Xiao(2007) Koh et al. (2006) Goodhue and Thompson (1995)
Task-technology Fit	The degree of worker's perception that the RFID capabilities match with the task requirements.	*Service satisfaction *Technology satisfaction *Overall satisfaction	Goodhue and Thompson (1995) Goodhue (1995) Vessey(1985)
Technology Utilization	The degree of worker's willingness to continuously use RFID in completing tasks.	*Attitude of reutilization *Recommendation to another person	Davis (1989) Goodhue and Thompson (1995) Goodhue (1995)
Perceived Benefit	The degree of worker's expectation of gains associated with utilization of RFID.	*Improved efficiency *Improved effectiveness *Higher quality	Goodhue and Thompson (1995) Vijayaraman and Osyk (2006) Goodhue (1995)
Attractiveness of Alternative	The degree of worker's perceived reputation, image, and service quality of Barcode.	*Cost reduction *Relative Benefit *Better quality of performance	Jones et al.(2000) IGD (2004)

cost. According to Jones et al. (2000), 'interpersonal relationship' refers to the strength of personal bonds that are developed between customers and their service provider. And 'perceived switching cost' is the degree to which an individual believes that switching a service provider would incur certain cost to him/her. Furthermore, 'attractiveness of alternatives' refers to the perceived reputation, image, and service quality of a competing alternative solution. There is a perspective that sees barcode as likely to remain the dominant technology where large volumes of lower priced goods are concerned. The Institute of Grocery Distribution (IGD) (2004) identifies that while RFID does bring many advantages, barcodes still have three main strengths: cost, reliability, and the benefit of established technology. Thus, in order to measure attractiveness of alternative, this research used measurement items such as cost reduction, relative benefit, and higher quality of results. Table 2 summarizes measurement items of each constructor to validate the research model.

Hypothesis development

Hypotheses related to Task Technology Fit theory

The TTF model argues that the use of a technology may result in different outcomes, depending upon its configuration and the task for which it is used (Goodhue and Thompson, 1995). TTF models have five key constructs: a) task characteristics, b) technology characteristics, c) which combine to affect the TTF, which affects the outcome d) performance and e) utilization. Tasks are broadly defined as the actions carried out in turning inputs to outputs in order to satisfy information needs. Technology includes a wide range of IT, such as hardware, software, data, etc. Numerous empirical tests have shown that the TTF model is a robust theoretical foundation for explaining IT utilization and the impact of IT in work performance. These applied models are extended by adding some external factors to the original TTF model to better reflect a wide variety of IT context, such as Enterprise Resource Planning (ERP), Knowledge Management

System (KMS), Personal Digital Assistant (PDA), etc. (D'Ambra and Wilson, 2004; Pagani, 2006; Moon and Kim, 2007), and the results provide that task characteristics, technology characteristics and TTF are important predictors of performance or utilization. Based on these findings, this research adopted TTF models as the basis in the context of RFID.

Hypothesis 1: There is a positive relationship between task characteristic and TTF.
Hypothesis 2: There is a positive relationship between technology functionality and TTF.
Hypothesis 3: There is a positive relationship between TTF and RFID technology utilization.

Hypothesis related to Switching Barrier Theory

In the process of technology development, the adoption of a new system or service implies that individuals will eventually switch from the old to the new system. To explain these issues, the field of marketing research gives attention to switching barrier theory. Switching barrier is classified into three groups: attractiveness of alternatives, interpersonal relationships, and perceived switching cost. Under the RFID context, because the service and system provider is the same for both services, this study could not examine interpersonal relationships and perceived switching cost. However, attractiveness of alternatives could be adopted in the study since RFID is perceived as an alternative to barcode. Barcode may have a negative impact on the attitude toward RFID, as well as continuous utilization of RFID, because workers who are attracted to the barcode may have a negative attitude toward RFID, and thus result in negative willingness to continuously utilize RFID.

Hypothesis 4: There is a negative relationship between attractiveness of alternative and RFID technology utilization.

Hypothesis related to Theory of Planned Behavior

According to the Theory of Planned Behavior, a behavior intention is determined by relevant internal belief such as expected benefit/risk, enhanced value, compatibility, adoptive experience, etc. Especially, it has been found that perceptions of technology or service, from both benefit and risk aspects, have influenced traditional technology adoption or utilization (Wilkie and Pessemier, 1973). When perceived benefit is higher, user's decision to utilize or diffuse is higher and positively influences user's decision to purchase a product or adopt IT. Therefore, workers' perception of the beneficial aspects of RFID could be expected to affect their intention of continuous usage of RFID.

Hypothesis 5: There is a positive relationship between perceived benefit and RFID technology utilization.

Research methodology

Data collection

This study used representative random sampling and questionnaire to collect data related to the hypotheses. Representative sampling is statistical sampling in which a researcher attempts to select individuals who are representative of a larger population. As a research tool, statistical sampling is extremely valuable because it allows researchers to study a population without studying every individual within that population. In order to obtain a representative sample, researchers must first identify the population being sampled; then, they find a way to randomly select people from the identified population so that they can survey these individuals to obtain the data required to answer the research questions.

In this study, the questionnaire data was obtained from a representative random sampling of the people who were engaged in an organization that was actually implementing an RFID system and really used or managed an RFID system. The organization was derived from companies that participated in the RFID project supported by the Ministry of Information and Communication of the Republic of Korea in 2007. The details of the related projects are summarized in Table 3. All respondents were directly employed by the four institutions listed in column 2 of Table 3, which means that the survey target is the participants engaged in four projects in Table 3 and this study took samples from all these four institutions.

To make the survey more convenient and to increase the response rate, it was well distributed in both hardcopy and electronic format and a survey was conducted from 26 November to 10 December 2007. A total of 69 questionnaires were fully answered and returned out of the 80 served. Samples with characteristics of duplication or inconsistency were excluded. After these processes for ensuring data quality, 63 responses were deemed eligible for analysis. The demographic profiles of the respondents are presented in Table 4.

Table 3. Project summary of the survey samples.

Title	Institution	Description
National Goods Management System	Public Procurement System.	RFID system has been adopted for the 800,000 goods management at 16 government institutions to effectively manage the entire life cycle of the goods from acquisition to disposal.
Integrated U-medicine System	Ministry of Health and Welfare.	The RFID based system is developed for sharing information on medicine, which manages information that results during the production, distribution and consumption of medicines in an integrated manner providing information on medicine and so forth through medicine traceability and verification, service to verify authenticity, linkage with the participating companies' legacy systems.
Air Baggage Management System	Korea Airports Corporation.	The RFID system is developed for the end-to-end process ranging from transport, processing, and delivery and all other baggage processing activities, targeting 11 airports in Korea.
Integrated Food Management System	Korea Food Industry Association	RFID tags are attached onto foodstuffs' raw and subsidiary ingredients and finished products to develop RFID based safe food information management system that can track and manage entire processes ranging from production, logistics, and distribution.

Table 4. Profile of sample respondents.

Demographic Factor	Characteristic	Frequency (%)
Gender	Male	46 (73%)
	Female	17 (27%)
	Total	**63 (100%)**
Position	Leader	5 (8%)
	Senior	21 (33%)
	Junior	17 (27%)
	Assistant	20 (31%)
	Total	**63 (100%)**
Project	National Goods Management System	13 (21%)
	Integrated U-medicine System	7 (11%)
	Air Baggage Management System	18 (29%)
	Integrated food management System	25 (40%)
	Total	**63 (100%)**

Statistical analysis method

The questionnaire had multiple items and each item was measured based on a seven-point Likert scale that ranged from 'strongly disagree' to 'strongly agree'. All items with their descriptive statistics are presented in the Appendix. Data analysis was performed using Partial Least Squares (PLS) method and other statistical methods using SPSS 10.0. The use of PLS has been increasing in information systems (IS) fields (Chin et al., 2003; Pavlou et al., 2007). PLS, a component-based structural equation modelling technique, is similar to regression, but simultaneously models paths among variables (Chin et al., 2003). PLS is regarded as a structural equation model (SEM) method, but there is an important difference with other analytical programs – that is, covariance-based SEM methods. Most covariance-based SEM methods use common factor analysis to analyze the relations between latent variable and measurement items, but PLS uses principal component analysis. PLS method is useful for establishing management strategies to predict how much impact various variables have on achieving management goals (Chin, 1998:295–336; Gefen et al., 2000).

Results of analysis

Reliability test and construct validity test

The reliability test was performed by Cronbach's Alpha and Composite Reliability (CR). Table 5 shows

Table 5. Results of reliability test.

Construct	No. of items	Cronbach's Alpha	Composite Reliability
Task Characteristic (Task)	4	0.7077	0.765
Technology Functionality (Tech)	4	0.8409	0.894
Task-technology Fit (TTF)	3	0.9274	0.954
Attractiveness of Alternative (AA)	3	0.9058	0.941
Perceived Benefit (PB)	3	0.8908	0.935
Technology Utilization (UL)	2	0.8864	0.946

Table 6. Individual item's factor loading and construct's composite reliability value.

Measurement items		Factor Loading	CR	AVE
Task Characteristic (Task)	Task1	0.6902	0.765	0.617
	Task2	0.7285		
	Task3	0.7123		
	Task4	0.6644		
Technology Functionality (Tech)	Tech1	0.6651	0.894	0.680
	Thch2	0.9226		
	Tech3	0.8241		
	Tech4	0.8655		
Task-technology Fit (TTF)	TTF1	0.9127	0.954	0.875
	TTF2	0.9456		
	TTF3	0.9437		
Attractiveness of Alternative (AA)	AA1	0.9613	0.941	0.842
	AA2	0.9674		
	AA3	0.8717		
Perceived Benefit (PB)	PB1	0.8828	0.935	0.828
	PB2	0.9145		
	PB3	0.9322		
Technology Utilization(UL)	UL1	0.9465	0.946	0.898
	UL2	0.9487		

that there was no significant defect in internal consistency. All constructs passed the reliability test since Cronbach's Alpha value was higher than .70. CR greater than .70 implies that a construct retains both internal consistency and convergent validity.

To test validity, CR, Factor Loading (FL) and Average Variance Extracted (AVE) were checked. AVE measures the percentage of variance captured by a construct by indicating the ratio of the sum of the variance captured by the construct and measurement variance. It is acceptable that individual item factor loading is greater than .60 and AVE exceeds .50.

Test of convergent validity. Table 6 represents individual item factor loadings, each construct's CR and all AVE loadings are significant at .01. Because the CRs of all constructs in Table 6 are higher than .70, six constructs maintain convergent validity. Regarding factor loading, all items exceed the cut-off value of .60. Therefore strong convergent validity was demonstrated.

Test of discriminant validity. To examine discriminant validity, this study made a cross loading matrix. The cross loading matrix represents the correlation between the construct score and the measurement items, suggesting that measurement items load highly on other items. Table 7 shows that cross loadings of each item are compared across all latent variables. Each item is highly assigned to respective latent variable, thus discriminant validity is identified. The square root of AVE could be used to examine discriminate validity. Diagonal elements should be larger than entries in corresponding rows and columns. The correlations among all constructs are under .70, thus

Table 7. Correlation of the latent variables and square root of the AVE.

	Tech	TTF	AA	Task	UL	PB
Tech	**0.825**					
TTF	0.519	**0.935**				
AA	−0.314	−0.105	**0.918**			
Task	0.176	0.328	0.098	**0.742**		
UL	0.463	0.659	−0.106	0.327	**0.948**	
PB	0.581	0.639	−0.281	0.102	0.642	**0.910**

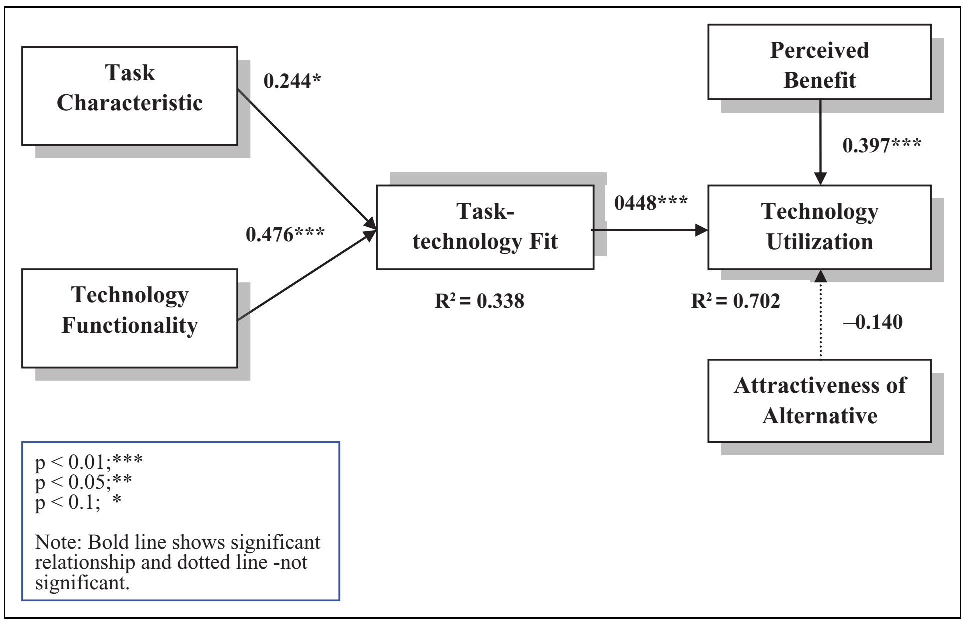

Figure 2. The results of structure model analysis.

suggesting that all constructs are distinct from each other. Moreover, Table 7 shows correlations of the latent variables and square root of the AVE.

Assessment of structural model

The final step is to explore the path significance of each causal relationship or hypothesis and examine the variance explained by each path in the proposed research model. The model is assessed as shown in Figure 2 and Table 8. All of the hypothesized causal relationships are significant at $p = 0.05$ except the link for "AA-UL". Hypotheses 1 to 3 tested the general causal relationship shown in conventional TTF. As expected, all hypotheses are supported at $p = 0.05$. Hypothesis 4 examined the impact of attractiveness of alternative on RFID technology utilization. In more detail, in this study this hypothesis tested the role of attractiveness of alternative technology, 'barcode' as a predictor of intention to continuous utilization of RFID. However, its impact on continuous utilization of RFID technology is not significant. Hypothesis 5 examined the influence of RFID perception on the intention toward continuous utilization. The result indicates that perceived benefit of RFID has a significantly positive effect on this intention.

Implications

Empirically tested results provide useful implications for organizations to consider RFID adoption. Firstly, RFID-driven task characteristics, RFID technology functionality, relative benefit and attractiveness of barcode, and benefit of RFID are recognized, which provides empirical evidence to support various anecdotal claims of companies which have tried to adopt RFID technology. Knowing these factors, potential users are able to understand the critical success factors to adopt RFID technology. Also they can attempt to actively influence these variables in order to reduce

Table 8. The results of hypothesis test

Hypothesis		Significance
H1	There is a positive relationship between task characteristic and TTF.	**Accepted**
H2	There is a positive relationship between technology functionality and TTF.	**Accepted**
H3	There is a positive relationship between TTF and RFID technology utilization.	**Accepted**
H4	There is a negative relationship between attractiveness of alternative and RFID technology utilization.	**Rejected**
H5	There is a positive relationship between perceived benefit and RFID technology utilization.	**Accepted**

the failure probability of RFID deployments. Secondly, one of the surprising findings of the study is that negative factors associated with RFID technology did not influence the continuance intention toward RFID. That is, the loyalty of users toward barcode is not high enough for them to continue using barcode. This implies that barcode users can easily switch to RFID if necessary. It also means that perceived risks like switching cost do not influence the intention toward continuous utilization of RFID. The result found in the studies of Koh et al. (2006) argued that risk factors such as increased managerial cost and complexity of technology associated with RFID adoption and utilization did not fit into the comprehensive RFID implementation model. They argued that it is premature to do offer any conclusive explanation for their findings. Finally, regarding research on IT utilization, earlier researchers were limited to the TAM framework. However, by providing a new framework that is extended with TTF, we explore various accessibilities.

Conclusions

The primary purpose of this study was to examine which factors influence RFID-driven task performance based on a TTF model, and how intention toward continuous utilization is influenced by the perceptions of RFID and the technology it may substitute, namely, the barcode. This research started from the doubts that the promising RFID technology could not necessarily deliver improved business productivity and efficiency. Moreover, the conventional constructs addressed in TTF may not be good enough to explain the intention toward continuous utilization of RFID, because conventional TTF does not consider the relationship between technologies and the user's cognitive perspectives under the usage of the information system are mandatory. In this regard, this study identified the significant factors that affect the performance of the members of organizations implementing RFID systems and investigated how the perceptions of RFID and barcode influence the intention to make continuous utilization of RFID.

Even though the findings of this study seem to be comparable to past research literature, the dynamic nature of technology could change its importance in the future. The immaturity of the technology was a limiting factor for this study and as such the interpretations of results of this study are explored. Many more rigorous studies must be conducted in order to ascertain the importance and relationship of these constructs, as a number of issues remain to be addressed. First, the investigation of factors affecting RFID-driven task performance is relatively new to IS researchers. The discussed findings and their implications were obtained from one single study that examined a particular technology and targeted a specific user group in Korea. Thus, continued research is needed to generalize the findings and for the discussion to include other groups. Furthermore, there is a need to search for additional variables to improve the ability to predict performance improvement of RFID technology. Also, the model proposed in this study is cross-sectional. In other words, it measures perceptions at a single point in time, but perceptions change over time as individuals gain experience. The changes in perceptions have implications for researchers and practitioners interested in predicting RFID post-adoption behavior and improvement of business productivity over time. Additional limitations faced include the small sample size and the assessment of key constructs based primarily on respondents' self-reported perceptions. The small sample size provides less statistical power. Thus, one fruitful direction for future research would be to replicate this study with a larger sample, with a variety of industrial contexts and in a variety of countries.

Appendix A. Measurement items and descriptive statistics.

Construct	Measurement items	Related questionnaire items	Mean (Standard deviation)
Task Characteristic	Task interdependence	I feel the task utilizing RFID technology is required cooperation with other employees or departments having task interdependence.	4.61 (0.89)
	Time-criticality	I feel the task utilizing RFID technology is required time criticality.	4.12 (1.18)
	Mobility	I feel the task utilizing RFID technology is required mobility.	3.89 (1.29)
	Location dependency	I feel the task utilizing RFID technology is usually location dependent.	4.14 (0.96)
Technology Functionality	Multiple reading simultaneously	In the perspective of multiple reading simultaneously, I agree the RFID is the appropriate technology when implementing tasks.	4.14 (1.23)
	High speed reading processes	In the perspective of high speed reading process, I agree the RFID is the appropriate technology when implementing tasks.	3.86 (0.91)
	Mass memory	In the perspective of mass memory, I agree the RFID is the appropriate technology when implementing tasks.	3.59 (0.80)
	Various applications	I feel RFID has enough potential to adopt in diversity tasks.	4.38 (0.72)
Task-technology Fit	Service satisfaction	When implementing tasks, I am usually satisfied with the service level that RFID technology provides.	4.24 (0.62)
	Technology satisfaction	When implementing tasks, I am usually satisfied with the technological function level that RFID technology provides.	4.13 (0.75)
	Overall satisfaction	When implementing tasks, I am usually satisfied with the technological function level that RFID technology provides.	4.49 (1.02)
Technology utilization	Attitude of reutilization	I have an intention toward continuous utilization of RFID technology on my tasks.	4.52 (0.96)
	Recommendation to another person	I want to recommend RFID technology to other people to improve their own tasks efficiently.	4.13 (0.85)
Perceived benefit	Improved efficiency	I feel RFID technology have a positive effect on my task in the perspective of efficiency improvement.	5.08 (0.88)
	Improved Effectiveness	I feel RFID technology have a positive effect on my task in the perspective of effectiveness improvement.	4.89 (0.94)
	Higher quality	I feel RFID technology have a positive effect on my task in the perspective of quality improvement.	4.73 (1.07)
Attractiveness of alternative	Cost reduction	In the perspective of cost reduction, barcode is better than RFID.	3.42 (1.33)
	Relative benefit	In the perspective of benefit on task, barcode is better than RFID.	3.19 (0.96)
	Better quality of performance	In the perspective of task performance, barcode is better than RFID.	3.66 (1.19)

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About the authors

Suk Kyoung Kim is PhD candidate in the Department of Management Science at the Korea Advanced Institute of Science and Technology (KAIST), and has worked for the

National Information Agency (NIA). Her research interests include social media, e-government and m-government and ICT development in developing countries. Contact: Department of Management Science, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro (373-1 Guseong-dong), Yuseong-gu, Daejeon, Republic of Korea. Tel: +82-42-350-6391. Fax: +82-42-350-6339. Email: bigcandy@kaist.ac.kr

Min Jae Park is a researcher in Auto-ID Lab Korea and a PhD candidate in the Department of Management Science at the Korea Advanced Institute of Science and Technology (KAIST). His research interests include e-government, supply chain management, innovation by technologies like RFID/USN, and data mining for the public sector. Contact: Tel: +82-42-350-6391. Fax: +82-42-350-6339. Email: minj.park@kaist.ac.kr

Eun Ji Ahn is a researcher in Auto-ID Lab Korea and obtained her BS in Management Science at the Korea Advanced Institute of Science and Technology (KAIST). Her research interests include IoT business model development, supply chain management, innovation by technologies like RFID/USN. Contact: Tel: +82-42-350-6391. Fax: +82-42-350-6339. Email: eunji.ahn@kaist.ac.kr

Jae Jeung Rho is currently the director of Global Information & Telecommunication Technology Program and an Associate Professor of Management Science at the Korea Advanced Institute of Science and Technology (KAIST). He obtained his BS in mechanical engineering from Seoul National University (SNU) and an MS from Texas A&M University, United States and PhD in industrial engineering from University of Houston, United States. He is also the director of Business Division in Auto-ID Lab Korea. His teaching and research interests include supply chain management, application of RFID/USN, EPC sensor networks and applications of mobile technology in developing countries. Tel: +82-42-350-6844. Fax: +82-42-350-6339. Email: jjrho@kaist.ac.kr