

Full Length Research Paper

Measuring readiness for RFID adoption: Reflection from Iranian supply chain companies

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Accepted 20 December, 2010

In order to benefit from RFID adoption, entire RFID infrastructure must first be established and supply chain companies should conduct considerable up-front analyses to assess their readiness. The purpose of this study is to survey the readiness of supply chain companies in Iran for RFID adoption. Therefore, facilities, conditions and necessary readiness for the successful adoption of RFID systems in Iranian grocery supply chain companies have been investigated. The study involved survey data from 89 Iranian grocery supply chain companies. The findings reveals that grocery supply chain companies in Iran are overall not ready for RFID adoption and to adopt these systems successfully; in the first step, technological, organizational, and environmental problems and challenges of supply chain companies must be wiped out. This subject, besides Iranian grocery supply chain companies, could be also extended to other supply chain companies in Iran.

Key words: Radio frequency identification, Readiness for RFID adoption, Grocery supply chain.

INTRODUCTION

Radio frequency identification (RFID) is a small tag containing an integrated circuit chip and an antenna, and has the ability to respond to radio waves transmitted from the RFID reader in order to send, process, and store information. The RFID system consists of three basic components: a tag, a reader, and back office data processing equipment. The tag contains unique identification information of the item to which it is attached; the reader emits and receives radio waves to read the information stored in the tag, and the data-processing equipment processes all the collected data (Wu et al., 2006; Thornton, 2006; Sandip, 2005). At the present state of technology, simultaneous communication at a rate of 1,000 tags per second is possible, with an accuracy that exceeds 98% (Hunt et al., 2007).

RFID technology is considered as “the next big thing” in management (Wyld, 2006, Ashon and Ilyas, 2008) and was introduced as one of the top ten technology in the world in 2004 and 2005 (Janz et al., 2005). In recent

years, this technology has attracted much attention in developed countries, and at present own a unique development in industrial, business and supply chain applications, and large companies like Wal-Mart (the world's largest retailer) in America, Tesco in Europe and Toyota in Japan, and various government departments like the Department of Defense America (the world's largest supplier) use this tool increasingly to evolution management supply chain organizations. It is predicted that over the next five years, the RFID industry will experience explosive growth, both in terms of dollar sales and applications available. In 10 to 15 years RFID technology will be ubiquitous. (Hunt et al., 2007)

RFID technology can be increasingly used in Supply Chain Management (Kbajaj, 2006). Since this technology will be a new tool and will offer an unprecedented ability for supply chain members to coordinate their activities (Hunt et al., 2007). In supply chain management, product information that can be captured by the RFID system includes instance data (e.g., dates of manufacture and expiration), history data (e.g., departure and arrival times), product group data (e.g., description, dimensions, and selling units), and commercial entity data (e.g., address and telephone number) (Tajima, 2007). RFID in

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the supply chain create numerous benefits such as reduced shrinkage (Karkkainen, 2003; Twist, 2005), reduced material handling, improved information sharing, quality control, material handling, space utilization, asset management, reduce stock outs, after sales service (Tajima, 2007) increased data accuracy (Lapide, 2004; Lin et al., 2006) faster exception management (Lapide, 2004) production tracking (Karkkainen and Holmstro, 2002) supply and production continuity (Lu et al., 2006) customer service (Tajima, 2007; Jones et al., 2004b) and lower inventory (Prater et al., 2005; Smaros and Holmstro, 2000).

Although commercial applications of RFID date back to the 1960s, the use of RFID in supply chain management is relatively new. In 2003, the world's leading retailers, including Metro Group in Germany, Marks and Spencer in the United Kingdom, and Wal-Mart in the US, mandated the use of RFID in tracking supplies (Tajima, 2007). In 2004, the US DoD followed suit (Wyld, 2006). As of March 2005, RFID has been installed in 104 Wal-Mart stores, 36 Sam's Clubs, and three of Wal-Mart's distribution centers. For the DoD, 97% of pallets bound for Iraq have been shipped with RFID tags, and two depots have been accepting RFID-tagged shipments since February 2005. The largest area of adoption has been in the retail industry, and approximately 1500 RFID patents have been issued since 1997 (Tajima, 2007).

According to the literature, many countries have invested a fortune in RFID technology. For example, in 2007, RFID technology investment in East Asia was US\$2.7 billion of US\$4.96 billion spent globally. US\$1.9 billion of this was just in China, and the USA has invested even more than China. The US market for RFID technology retail supply chain will rise from 91.5 million US Dollars in 2003 to 1.3 billion US Dollars in 2008 (Zhang and Symonds, 2008). In the past 50 years, approximately 1.5 billion RFID tags have been sold worldwide. Sales for 2007 alone are expected to exceed 1 billion and as many as 1 trillion could be delivered by 2015 (Hunt et al., 2007). In addition with the backing of Walmart and DOD, RFID could become widely available at a similar, if not faster rate than bar codes. (Tajima, 2007). At the present time, Wal-Mart's top 100 suppliers alone could account for 1 billion tags sold annually and revenues for the RFID industry were expected to hit \$7.5 billion by 2006 and in the retailing sector, item-level tagging could begin in as early as five years. In short, the use of RFID technology is expected to grow significantly in the next five years, and it is predicted that someday RFID tags will be as pervasive as bar codes (Hunt et al., 2007).

RFID and its adoption is a global concern (Brown and Russell, 2007). The use of RFID has since been highlighted as one of the key issues facing CIOs (Loebbecke and Palmer, 2006). Research on the organizational and business implications of RFID is beginning to increase (Asif and Mandviwalla, 2005; Curtin et al., 2007). Although there has been much written about the benefits

of RFID for supply chain management (Tajima, 2007; Twist 2005), there is a considerable dearth of literature reporting the valuable benefits that RFID holds for marketing (Brady et al., 2006). The adoption of a RFID system along an entire supply chain will benefit multiple companies. But in order to achieve this goal, an entire RFID infrastructure must first be established (Ornauer et al., 2004, Brady et al., 2006) and readiness of supply chain companies for adoption of RFID systems must be assessed. Adopting RFID systems without careful planning most likely ends with cost overruns and failure. Like any other major innovation, RFID adoption requires considerable up-front analysis, development time, money, technological infrastructure and leadership support to be successful. Thus, managers should assess their companies' readiness for RFID systems before adopting this innovation. For the implementation of RFID, the execution of system concerning financial, economical, cultural and other dimensions- as well as technical and technological issues- must be investigated and analyzed; moreover, the suitability of the investment must be considered by indexes, qualitative and quantitative factors (Langen Walter, 2000).

Consequently, in this article, the researchers tried to access these purposes. They have first identified factors that can be used to assess the supply chain companies' readiness for RFID adoption. Later, they used these factors to develop a survey instrument and administered it to the grocery supply chain companies in Iran to assess their RFID adoption readiness. This article intended to reveal the results of this study.

Literature review

The RFID technology itself is not novel; however its application in supply chains can be considered innovative (Srivastava, 2004). The adoption of innovations often has been investigated in IS research (Patterson et al., 2003; Ranganathan et al., 2004). In particular, SCM is regarded as an important business area for IS application (Bowersox and Daugherty, 1995). Research on IS adoption has been carried out using several theoretical lenses. One major research approach is based on Innovations Diffusion Theory (Madlberger, 2009). IDT has been widely used to predict and explain the adoption of innovation in various domains (Rogers, 2003). The IDT provides well-developed concepts and a large number of empirical results which are useful for the study of technology evaluation, adoption and implementation. Therefore, it is not surprising that innovation diffusion has become a very popular reference theory for current research of information and communication technologies (Schmitt and Michahelles, 2009). Based on this theory a frequently used framework is the technology-organization-environment framework (Madlberger, 2009). Most of the accomplished researches about the adoption

of RFID have used this framework, for example: (Madlberger, 2009; Zhang and Symonds, 2008; Brown and Russell, 2007; Tsai et al., 2010; Schmitt and Michahelles, 2009; Wu and Subramaniam, 2009) and in this research, also the aforementioned framework has been used.

Moreover, the majority of published work concerning RFID has hailed from Europe and North America (Brown and Russell, 2007). For example, Wyld et al. (2005), Vijayaraman and Osyk (2006), Lee and Shim (2007) have been reported some cases about the adoption of RFID in North America. Similarly, in Europe, China, Australia, Taiwan, New Zealand, and South Africa the same researches have been reported (Madlberger, 2009; Tsai et al., 2010; Deng and Chen, 2009; Jones et al., 2004a; Lai et al., 2005; Loebbecke and Palmer, 2006; Luo et al., 2007; Brown and Russell, 2007; Zhang and Symonds, 2008).

Also, different researches in different fields such as transportation industry (Vijayaraman and Osyk, 2006; Seymour et al., 2007), air lines customer service (Wyld et al., 2005), pharmaceutical supply chain (Lee and Chung, 2006) have been carried out. Sharma et al. (2008) believe that the effective factors on RFID adoption are top management support, costs, external pressure, stability of standards, and existent IS-infrastructure. Strucker and Gille (2008), have done a research on 153 German companies, and determined the effective factors on the adoption of RFID technology as organization size, integration, costs/benefits, performance of the system, security/privacy. Whitaker et al. (2007), have done a research on 398 American companies, and determined the effective factors on the implementation of RFID technology as existing IT-infrastructure, organization size, mandates, investments depending on expected ROI, and expected ROI depending on the existence of a standard. Also, concerning the supply chain management, some researches such as Brown and Russell (2007), Huyskens and Loebbecke (2007), Huber et al. (2007), Jones et al. (2005), Jones et al. (2004), Bhattacharya et al. (2007), Koh et al. (2006), Lin et al. (2006) have done studies about the adoption and implementation of RFID technology, in respect of different factors. But, there is not any noteworthy study in this field in Iran.

Despite its advantages, RFID adoption in Iran is still in its infancy stages. In Iran the same as other countries, the starting point for the application of RFID had been automotive industry. At present, Iran Khodro Company is applying this system in managing its manufactured automobiles' parking. Additionally; Commerce Ministry of Iran is applying RFID technology in a project in shipments. In this project, 2.4 gigahertz labels are being stick on the containers. IRIB has also applied RFID technology for monitoring the entrance and exit of organizational equipment into and out of its warehouses.

Other organizations such as urban Bus System Company and Subway System Company have had a special attention to RFID. In contrary, the Iranian supply chain companies have not paid any attention to the aforementioned technology and seemingly have a long way to adopt that technology.

Motives such as initial costs, infrastructure requirements, and uncertainty about the functionality as well as past unsuccessful experiences about use of technology in supply chain ground a challenge for Iranian managers about implementing RFID systems in their companies. However, researchers believe that companies will soon adopt innovation easily because technological innovations have been easily transferred and adopted by companies in the country, and Iran has a population that is relatively younger, more dynamic, and open to innovations.

Purpose

The main purpose of the article is to report the results of a study that intended to answer the question: 'Are the grocery supply chain companies in Iran ready for RFID adoption?' The study examines the readiness of the implementation and adoption of RFID in the Iranian grocery supply chain companies.

The research questions of the study have been formulated as:

1. How do managers of the Iran grocery supply chain companies perceive their readiness for RFID adoption?
2. Do managers' demographic characteristics (gender, age, education, and major) differentiate their perception of organizational readiness for RFID adoption?

METHODOLOGY

The data collection method used for this study was a survey designed to seek input from managers who are able to judge their companies' readiness for RFID adoption. Following are the information about the participants and the survey instrument used in the study.

Participants

The target population for this study was Iranian supply chain companies in general. The Iranian supply chain companies is a large and diverse group that includes banks, petroleum companies, clothing and grocery companies, etc. The study targeted specific parts of the supply chain companies, namely the grocery and food production companies. They were therefore selected as targets for this Iran study. The IT executives or, senior managers in these companies were chosen as the respondents who can provide data about their companies' readiness for RFID adoption.

The study sample was limited to 89 grocery and food production supply chain companies throughout Iran. With this in mind, a survey instrument was distributed to each of those directors. Data were gathered over the period July 2009 – October 2009.

Although it cannot be claimed that the respondents of this study represent all supply chain companies in Iran, this section of the

Table1. The respondents' age and major distribution.

Age range	Frequency	Percent	Education course	Frequency	Percent
24 and younger	3	37/3	Computer	27	30/34
25-34	21	59/23	Accountancy	16	17/98
35-44	28	46/31	Management	21	23/60
45-54	32	96/35	Industrial engineering	10	11/24
55 and older	5	62/5	Others	15	16/84
Total	89	100		89	100

study provides some indication about the status of human resources of supply chain companies in the country. For instance, the study revealed that majority of the managers or experts working in supply chain companies in Iran are male (92%) and older than 35 years old (Table 1).

The collected data show that 17.97% (16 persons) have associate degree, 55.06% (49 persons) have bachelor degree and 26.97% (24 persons) have masters. It is obvious that educated and post educated persons make 82% of the statistical population.

Instrumentation

A two-section survey entitled, 'RFID adoption Readiness Survey' has been developed to assess the RFID adoption readiness of grocery supply chain companies in Iran. The first section consisted of 8 items to gather data about demographic characteristics, such as gender, age, education level, education course and position in the company who takes the survey. The second section included 42 items to assess respondents' self-report perceptions of their companies' readiness for RFID adoption. A 5-point Likert scale was used for each item, anchored by a little to very much at the other. Each question has two segments: current situation and optimal situation in implementing and adoption of RFID technology in Iranian grocery supply chain companies.

DeVellis (2003) indicates that the first step in the development of an instrument is clearly determining what it is the researcher wants to measure. The variables –or factors- that the researchers of this study want to measure are identified after detailed analyses of the available RFID adoption instruments, and developed by adapting and amalgamating measures from several sources (Baek and Lee, 2001; Premkumar and Roberts, 1999; Teo et al., 2004; Brown and Russell, 2007), combined with the cultural characteristics of supply chain companies in Iran and personal experiences of the researchers. As a result, thirteen major factors that can help organizations measure how ready they are for RFID adoption have been determined. Everett M. Rogers' innovation diffusion theory (IDT) provides a theoretical background for these factors. The three contexts of technology, organization, and environment will form the basis for developing a comprehensive research framework, and factors relevant to readiness of the RFID adoption within each category will be highlighted. Here, the factors and related dimensions have been elaborated.

Technological factors

Technological factors are one of the factors that can be effectively used to adapt a technological innovation in an organization (Rogers, 2003). The technological context refers to technologies that are already applied prior to the innovation in question but also to the innovation itself (Madlberger, 2009). perceived benefit(or relative advantage) (Shih et al, 2008; Lee and Shim, 2007; Sharma

et al., 2008; Bhattacharya, 2007; Vijayaraman and Osyk,2006) Compatibility (Luo et al, 2007; Asif and Mandviwalla, 2005) Complexity(Brown and Bakhru, 2007; Riggins and Slaughter, 2006; Seymour et al., 2007; Koh et al, 2006; Lee and Chung, 2006), Costs' Payments (Financial capability) (Sharma et al., 2008; Straker andGille,2008; Shih et al, 2008; Huber et al., 2007; Sharma et al., 2007; Brown and Bakhru, 2007; Riggins and Slaughter, 2006; Bhattacharya et al., 2007; Chao et al.,2007; Luo et al, 2007; Wu et al., 2006; Vijayaraman and Osyk, 2006; Lee and Chung, 2006; Jones et al., 2005; Wyld et al., 2005; Asif and Mandviwalla, 2005; Lai et al., 2005; Jones et al., 2004a) are the most significant technological factors in implementation and adoption of RFID technology.

Perceived benefit

The relative advantage (or perceived benefit) of a technology is a key influence on its adoption (Looi, 2005) since if a company or organization can not perceive the advantages of technology, it could be dropped behind of the rival companies and its costs will be increased; consequently, weakened in the generation of competitive advantages and in the long run eliminated from the field of competition. Therefore, one of the important factors in the adoption and implementation of RFID technology is the perception of its advantages in supply chain and in relation to barcodes.

RFID technology has three fundamental advantages which have generated many advantages in comparison to barcodes. The first fundamental characteristic of RFID is being wireless, which provides RFID four advantages over bar codes. First, because no physical contact is required between tags and readers, the tags can be read through layers of packaging materials without undoing the packaging (Tajima, 2007). Second, because no line of sight is needed, product positioning associated with bar code scanning is no longer required, and contents of mixed pallets can be identified by reading multiple tags simultaneously (Kabachinski, 2005). Third, by not requiring product positioning or scanning in sequence, RFID can generally support more automated material handling than bar codes (McFarlane and Sheffi, 2004). Fourth, RFID is relatively more robust in a harsh and dirty environment (e.g., in the dust, rain, snow and heat) than bar codes (Tajima, 2007). These four advantages enable automation of many processes related to material inspection and handling. In addition to improving the efficiency of existing material handling processes, RFID-enabled process automation would also improve the accuracy of the physical count of items, which provides a tighter control over inventory and helps reduce the occurrence of shrinkage and stock outs.

The second characteristic of RFID is being able to provide a unique identifier to an object. An RFID tag has a higher data capacity than a bar code, and depending on the type of chips, RFID tags can store more than identification information, and the information can be rewritten by users (Sheffi, 2004). From this data capacity perspective, RFID is able to provide a more advanced

record keeping and retrieval capability than bar codes can, and through this capability, RFID enables closed-loop tracking of individual items and assets. Closed-loop tracking could be applied in many different ways, from production monitoring to quality control, equipment maintenance, asset tracking, and after sales services such as retrieving warranty details (Tajima, 2007). Finally, the third characteristic of RFID is the ability to trace and track objects. By combining RFID use with other technologies, such as global positioning system (GPS), RFID could someday enable wireless, real-time tracking of any individual items anywhere in the world to provide complete visibility in the supply chain. This supply chain visibility is the most commonly mentioned advantage of RFID over bar codes in the literature (Jogleker and Rosenthal, 2005).

There are many advantages for the adoption of RFID technology in the supply chain which calls for the companies' endeavor for the recognition of these advantages and examining their capabilities in applying them.

Compatibility

Compatibility has been shown an important factor in innovation literature to explain the usage of a new technology by organizations. (Schmitt and Michahelles, 2009) Compatibility has been defined as the degree to which a technology is perceived to be consistent with an organization's strategic intent, infrastructure, practices, and needs (Baek and Lee, 2001; Rogers, 2003; Teo et al., 2004). For RFID adoption and implementation to be successful, it is necessary that organizations develop a flexible IT infrastructure that will be able to accommodate RFID systems (Janz et al., 2005). RFID hardware, software, and data resources need to mesh and integrate seamlessly with existing IS resources (Janz et al., 2005; Loebbecke and Palmer, 2006). Therefore, technology compatibility is one of the outstanding issues of RFID technology adoption in the companies and the readiness of the companies must be scrutinized before its adoption.

Complexity

The complexity of an innovation is a very important factor regarding the decision to adopt a new technology (Schmitt and Michahelles, 2009). The degree of complexity indicates how difficult it is to understand, implement, and to use the innovation or new technology (Rogers, 2003). Whilst the relative ease of use of RFID positively influences its adoption, the idiosyncrasies associated with its implementation raise concerns amongst IT personnel (Janz et al., 2005). It is certainly more complex than barcodes to implement (Asif and Mandviwalla, 2005; Fitzek, 2003).

The higher the complexity of an innovation the higher are the doubts regarding the possibility of a successful implementation within an organization (Schmitt and Michahelles, 2009). Therefore, if the technology is perceived as too complex organizations could delay the adoption of RFID (Bradford and Florin, 2003). Therefore, the perception of the complexity of the innovation for the adoption of RFID technology is an effective factor on its adoption and the companies must scrutinize the innovation before the adoption of the aforementioned technology, so some questions were designed about in the questionnaire.

Financial capability

Costs are an inhibitor of technology use. Prior IT adoption studies could also validate this relation (Schmitt and Michahelles, 2009). The costs associated with a new technology therefore have a major bearing on the decision as to whether organizations choose to adopt it or not. In this respect RFID technology is no exception

(Sharma and Citurs, 2005). Six types of costs associated with RFID are the tag costs, the cost of applying the tag to products, the cost of purchasing and installing readers, systems integration costs, the cost of training and re-organization, and the cost of implementing adoption solutions (Smith and Konsynski, 2003). Kinsella (2003) identify hardware, software, integration, and process changes as the major costs. Additionally, one of the important issues about the costs of RFID technology is the related costs of RFID tags and the costs referring to expenses for RFID transponders as well as implementation, integration, operating, and maintenance costs for the whole system (Schmitt and Michahelles, 2009).

Thus, the financial readiness of the organization for the payment of the RFID technology adoption costs is an a significant factor which must be taken into consideration .For instance, the study carried out in 2004 by Texas Technology company showed that the costs of RFID technology implementation in a small warehouse and excluding the tag's expenses was up to \$147000 (Hunt et al., 2007). The adoption costs of this technology is to some extent high ; therefore , some questions designed in the questionnaire about the capability of cost's payments in Iranian supply chain companies for the adoption of RFID technology.

Organizational factors

One of the outstanding factors of new technologies adoption, and hence especially RFID technology is organizational factors. The organizational context describes the organization and its characteristics, e.g. firm size or management structure (Madlberger, 2009). Some researchers have carried out some studies in this field and designated certain factors such as:

Management support (Sharma et al., 2008) information technology experiences (Sharma et al., 2008; Strucker and Gille, 2008; Whitaker et al., 2007; Brown and Bakhr, 2007; Luo et al, 2007; Wu et al., 2006) organization size (Strucker and Gille, 2008; Whitaker et al., 2007; Huyskens and Loebbecke, 2007; Vijayaraman and Osyk, 2006; Quaadgras, 2005) technical know-how (Huber et al., 2007; Huyskens and Loebbecke, 2007; Brown and Bakhr, 2007; Leimeister et al., 2007; Koh et al, 2006; Lee and Chung, 2006; Asif and Mandviwalla, 2005) and inter organizational readiness (Asif and Mandviwalla, 2005; Sharma and Citurs, 2005). These factors are discussed in the following lines.

Management support

Management support has been shown as important for the adoption and diffusion of new technologies into an organization (Teo et al., 2004). Especially for RFID, where strategic benefits may be realized through improved partner coordination, higher transparency, and the need for new processes, signals need to be send out within a company and the supply chain about the importance of the adoption of RFID and the commitment of the top management (Sharma et al , 2008; Bradford and Florin, 2003). Loebbecke and Palmer (2006) furthermore note that with RFID, success depends on the management challenges associated with implementation being addressed. These include having to address business process changes, and overcoming resistance to change (Hoske, 2004). For this reasons, several questions about the management support of the RFID adoption are included in the readiness instrument.

IT experiences

According to Rogers (2003), past experiences in a system about an innovation may also affect the adoption of a new one. Past experiences of employees, as well as managers, about an

innovation in any or similar previous management procedures in a company may be influential on results of an RFID adoption. RFID projects require skilled IT expertise in order for the implementation challenges to be addressed (Ranganathan and Jha, 2005; Sharma and Citurs, 2005).

The organizations and companies which have higher experience in technology, its implementation and adoption, have better readiness in the adoption of RFID technology as well as better infrastructure and relative condition for the acquisition of RFID technology. Therefore, the study of this issue is accentuated in the Iranian supply chain companies and accordingly, some questions were designed in the readiness questionnaire.

Organization size

The size of an organization has been consistently recognized as an accelerator for the adoption of innovations (Schmitt and Michahelles, 2009). Larger companies tend to have greater financial resources which are necessary to test, pilot, and then to decide whether or not to adopt RFID (Brown and Russel, 2007). They are more likely to achieve economies of scale and are more capable of bearing high risk associated with early stage investment (Schmitt and Michahelles, 2009). In the case of inter-organizational technologies, such as RFID, the larger companies can use their power and influence to ensure that suppliers adopt and implement whatever technology and standards they require (Jones et al., 2005; Ranganathan and Jha, 2005). It seems that larger companies have better readiness and conditions for the adoption of RFID technology, therefore, some questions in the readiness questionnaire were designed for it.

Technical know-how

The factor technical know-how describes the existing knowledge within an organization (Schmitt and Michahelles, 2009). Companies that already have the knowledge about a technology have the ability to better evaluate the benefits, disadvantages, costs, and requirements that have to be taken into account for an adoption. Organizations without technological know-how possibly perceive the innovation as too complex (Premkumar and Roberts, 1999). Furthermore, companies with more knowledge about the technological innovation are more likely to implement an aggressive technology adoption strategy (Lee and Shim, 2007). For this reasons, several questions about the technical know-how factor for RFID adoption readiness of the RFID adoption are included in the instrument.

Inter organizational readiness

Asif and Mandviwalla (2005) note that inter organizational readiness is an important variable for RFID adoption. Organizations must be prepared to make business process changes (Kinsella, 2003). Moreover, a cultural willingness to move beyond traditional methods needs to be developed to ensure implementation (Hoske, 2004). Employees who think that they do not have the necessary qualification for the control and operation of a new technology may fear the loss of their jobs. As a result of these worries they could come up with an intense resistance regarding the implementation (Seymour et al., 2007). A research study conducted by Rosen and Weils (1998) shows that around 58-65 percent of any organization's employees is generally uncomfortable with new technology and is even technophobic to some degree. According to Rosen and Weils (1998) 'If employers don't take into consideration that there will be company resisters and technophobes for whom they have done nothing to help, then they are going to suffer reduced worker

productivity, lower job satisfaction, their profits and their efficiency are going to decrease company wise, and there will be more mistakes and errors with higher employee absenteeism'. An RFID adoption may suffer due to technophobia, as well. Especially in case of the RFID technology which probably will substitute manual scanning processes those oppositions have to be expected (Schmitt and Michahelles, 2009). Hence, identification of employees' attitudes toward use of technology and inter organizational readiness is also taken into account in the process of developing the RFID adoption assessment instrument.

Environmental factors

The environment represents the organization's surrounding and encompasses the industry, competitors, and public administration (Madlberger, 2009). The most effective and important environmental factors on the RFID technology adoption are:

Competitive pressure (Premkumar and Roberts, 1999; Bradford and Florin, 2003), external support (Brown and Russell, 2007), change agents (Brown and Russell, 2007) and certainty (Ranganathan and Jha, 2005; Sharma and Citurs, 2005; Teo et al., 2004)

Competitive pressure

Competitive pressure is able to influence the decision making of an organization regarding the adoption of a new technology. Examples are the competitive environment (that is, competitors decision to adopt) or mandates by supply chain partners (Sharma et al., 2008; Rogers, 2003; Chwelos et al., 2001). Several other major supply chains have been reported as piloting and implementing RFID systems too (Fitzek, 2003; Jones M. et al., 2005; Loebbecke and Palmer, 2006, Brown and Russell, 2007). It seems that the existence of a competitive environment with out economical and political abuses in the adoption of RFID technology is an important factor in its adoption. Moreover, the accessibility of RFID technology suppliers, controlling policies and sanctions are effective on the adoption and implementation of the FRID technology, since the implementation, adoption and expansion of new technologies like RFID technology needs suitable environment for the investment and competition in a healthy atmosphere to acquire competitive advantages.

External support

Many companies may not have the internal IT expertise to pilot and implement RFID projects, and would tend to rely on the availability of external support. This availability may vary from country to country, affecting the rate at which RFID is adopted across regions (Brown and Russell, 2007). The supportive laws and regulations and governmental back-up in the adoption of new technologies, especially RFID technology, have a noteworthy impact, so by considering the issue, some questions were designed about the readiness.

Change agents

Change agents external to organizations could include vendors trying to sell a technology, or government and industry bodies with an interest in promoting the adoption of a technology (Teo et al., 2004; Brown and Russell, 2007). Much hype has been written in the media about RFID (Janz et al., 2005). Moreover, since most of the companies are purchasing RFID systems from outside resources, existence of enough RFID vendors and/or consultants can be

considered as another predictor of whether or not RFID systems will be adopted rapidly.

Certainty

Certainty originates from information, know-how, or the ability to predict developments and situations (Rogers, 2003). Companies are often uncertain regarding the demand for their products, the loyalty of their customers or general developments in the market environment (Papastathopoulou et al, 2007). Accordingly, some questions were designed for the adoption of RFID technology.

Additionally, after identifying factors and creating questions and designing questionnaire a cover sheet that comprised definitions of RFID, the directions, a description of the study, and an introduction to the researchers has been added to the instrument.

Data analysis method

In this study, both methods of "descriptive analysis" and "inferential analysis" were used. The test used in the inferential analysis method is as it follows: in the descriptive level, by the application of statistical frequency, percentage, mean and Standard deviation, the properties of the population have been described and analyzed and in the inferential level, the following tests have been applied:

Binominal test

The hypotheses or the research questions are investigated by the qualitative scale, and by the application of binominal test. In this test, the following hypotheses are tested:

$$\begin{cases} H_0 : \bar{P} \leq P_0 \\ H_1 : \bar{P} > P_0 \end{cases}$$

To study the readiness of Iranian grocery supply chain companies for the adoption of RFID technology, binominal test have been applied. Therefore, the difference between the current situation and the optimal situation has been used, i.e., the current situation of each statement has been subtracted from its optimal situation). Therefore, the responses of the readiness of Iranian grocery supply chain companies to adopt RFID technology were categorized into two groups: the first group -more than zero - which means lack of readiness according to the statement and the second group -equal or less than zero- which means readiness of the company according to the statement.

$$\begin{cases} H_0 : \mu_d \leq 0 \\ H_1 : \mu_d > 0 \end{cases}$$

In this test the statistics test has been defined as:

$$Z = \frac{(\bar{P} - P_0)}{\sqrt{\frac{P_0(1 - P_0)}{n}}}$$

Critical quantity

The space under the H0 and H1 curves, in normal distribution, is under the influence of statistical hypotheses in the first phase. The space under the curve, based on the type of the test for H₀ and H₁,

is a space equal to 100 α percent. Naturally, critical quantity must be derived from the standard table of Z according to α value.

Decision making

In this phase the statistics test value is compared with the critical quantity. If the statistics test, places in the region of H₀, it could be said that sufficient incremental evidences, in the set significance level, are existing for the approval of H₀; otherwise, the H₀ hypothesis will be rejected (Azar and Momeni, 1997).

Friedman's test

This test is applied at the time that the statistical data are at least ordinal type and could be ordered by ordinal concept in two direction ranking. By the application of this test, the variables of the study could be ranked (Sedghiayi and Ebrahimi, 2001). The

Freedman statistics test χ^2 is defined as following:

$$\chi^2 = \frac{12}{nk(k+1)} \sum_{j=1}^k R_j^2 - 3n(k+1)$$

Where,

n: Number of cases or respondents, k: Number of the variables that will be ranked and R: total of the attributed ranks to the variables by the respondents. This test has been applied for the ranking of effective factors for the successful adoption of RFID systems in Iranian grocery supply chain companies.

Reliability and validity of the survey instrument

In this research, to ensure the validity of the data gathering tools a questionnaire was designed and given to experts, faculty members and ten manager of supply chain companies and necessary changes were made according to their comments and recommendations. So, the questions that had a standard deviation score of higher than 0.1 during two stages where experts answered the questionnaire were eliminated, the questionnaire was revised and only the questions with the standard deviation of less than 0.1 were maintained in the questionnaire.

Cronbach's Alpha coefficient was used to evaluate the reliability of the questionnaire; Cronbach's alpha is actually for calculating the internal coordination of measurement devices such as questionnaire or test that measure various. Considering the fact that Cronbach's Alpha coefficient for this questionnaire is equal to 0.84, it could be said that it is high in reliability.

RESULTS AND DISCUSSIONS

The reporting of results and discussion is organized into two sections. The first section reports results for the first research question, 'How do managers of the Iranian grocery supply chain companies perceive their organizational readiness for RFID adoption?'; while the second section summarizes results for the second research question, 'Do managers' demographic characteristics (gender, age, and education) differentiate their perception of organizational readiness for RFID adoption?'

Table 2. Statistic and ranking of technological factors.

Current situation			Factors and questions		Optimal situation			
Rank	M. Rank	S.D	M		M	S.D	M. Rank	Rank
2	2/47	0/43	2/22	Perceived benefit	4/12	0/40	2/58	2
		0/81	2/21	The identification of RFID technology benefits in comparison with barcodes by the company	4/10	0/62		
		0/88	2/27	The identification of assets observation benefits with RFID technology	4/06	0/66		
		0/81	2/09	The identification of operational costs omission benefits of the company with RFID technology	4/08	0/76		
		0/81	2/26	The identification of in-time information creation benefits with the adoption of RFID technology	4/18	0/78		
		0/77	2/29	The identification of efficiency creation benefits in the company with the adoption of RFID technology	4/18	0/70		
2	2/47	0/53	2/29	Financial capability	4/06	0/45	2/49	3
		0/90	2/42	The capabilities of necessary fund absorption for the adoption and implementation of RFID technology	3/91	0/67		
		0/77	2/22	The capabilities of necessary fund absorption for the back-up and maintenance costs of RFID technology	4/06	0/70		
		0/90	2/26	The capabilities of necessary fund absorption for the training of the employees to be able to apply RFID technology	4/19	0/75		
		0/85	2/24	The capabilities of necessary fund absorption for the purchase of equipment ,hardware and software of RFID technology	4/09	0/79		
3	2/38	0/62	2/17	Complexity	3/91	0/61	2/18	4
		0/74	2/02	The capability of company's current systems integration with RFID technology	3/87	0/83		
		0/74	2/32	The essential skill for the adoption and implementation of RFID technology	3/94	0/71		
1	2/69	0/43	2/30	Compatibility	4/11	0/36	2/74	1
		0/79	2/13	The compatibility of the company for the hardware and software investment with RFID technology	4/15	0/66		
		0/73	2/19	The compatibility of company's information and communication systems with RFID technology	4/13	0/71		
		0/78	2/43	Lack of employees' resistance for the adoption and implementation of RFID technology	4/09	0/82		
		0/86	2/42	The adaptability culture for the application of RFID technology among the staff and experts of the company	3/99	0/76		
		0/77	2/38	The adaptability culture for the application of RFID technology among the managers of the company	4/18	0/70		

Managers' perception of their companies' readiness for RFID adoption

The first research question concerned how the managers of the Iranians grocery supply chain companies perceived their organizational readiness for RFID adoption. In order to decide whether or not grocery supply chain companies in Iran are ready for RFID adoption, the participants' self-

reports were used.

Mean and variance have been used for the evaluation of the questionnaire questions and Friedman's Test has been used for the determination of the significance and rank of the factors. In Table 2, the results of technological factors and the questions of each factor in the current and optimal situation; as well as the mean and mean rank of each factor for the adoption of RFID technology have

Table 3. Binominal test result for technological factors.

Technological factors	Group	Category	N	Observed Prop.	Test prop.	Asymp. Sig. (2-tailed)
Perceived benefit	1	<= 0	1	0.01	0.50	0.000a
	2	> 0	88	0.99		
Compatibility	1	<= 0	0	0.00	0.50	0.000a
	2	> 0	89	1.00		
Complexity	1	<= 0	1	0.01	0.50	0.000a
	2	> 0	88	0.99		
Financial capability	1	<= 0	1	0.01	0.50	0.000a
	2	> 0	88	0.99		

been shown according to the respondents.

The ranking of the technological factors in the current situation shows that at the moment the compatibility factor has the least readiness in technological dimension (mean rank 3) and after that, in order, we have financial capability factors, perceived benefit and complexity. Concerning the optimal situation, the importance of the factors among the Iranian grocery supply chain companies has been stated; in technological factors, the compatibility has the most importance and after this factor in order we have perceived benefit, financial capability and complexity.

In Table 3 the results of binominal test - about the technological factors- have been shown. According to Table 3, the statistics of the test have binominal sentences distribution and the validity of all tests are less than 0.05 (Sig =0.000). Therefore, it could be said that, concerning all the technological factors such as perceived benefit, compatibility and financial capability, the Iranian grocery supply chain companies have not enough readiness for the adoption of RFID technology.

In Table 4 the result of organizational factors' study and the questions of each factor in current and optimal situations, as well as rank and mean of each factor for the adoption of RFID technology have been presented according to the respondents.

As it could be seen, in current situation, organization size has better condition in comparison to other organizational factors. After the aforementioned factor, in order, are technical know-how, IT experience, management support and inter organizational readiness. The technical know-how has the lowest rank among the organizational factors. It means that the Iranian grocery supply chain companies have the least readiness in technical know-how for the adoption of RFID technology among the organizational factors. In optimal situation, management support has the best rank and is the most important factor among the organizational factors. Among these factors, technical know-how has the lowest rank and in fact is the least important factor among the organizational factors.

In Table 5 the results of binominal test have been shown. As it could be seen the validity of all tests are less than 0.05 (Sig = 0.000). Therefore, it could be said that,

concerning all the organizational factors such as management support, IT experience, organization size, technical know-how and inter organizational readiness, the Iranian grocery supply chain companies have not enough readiness for the adoption of RFID technology.

In Table 6 the result of environmental factors' study and the questions of each factor in current and optimal situations, as well as rank and mean of each factor for the adoption of RFID technology have been presented according to the respondents.

As it could be seen, in current situation and among the environmental factors, certainty has the best situation. After this factor, in order, are change agents and external support. Among the environmental factors, competitive pressure has the lowest rank. It means, the Iranian grocery supply chain companies have the least readiness in competitive pressure for the adoption of RFID technology in environmental factors. In optimal situation for the adoption RFID technology, according to the respondents, external support had been the most important factor among the environmental factors. After this variables are competitive pressure and change agents. It is noteworthy to mention that the certainty factor has the lowest rank, and in fact, is the least important factor among the environmental factors.

In Table 7 the results of binominal test - about the environmental factors- have been shown. As it could be seen the validity of all tests are less than 0.05 (Sig = 0.000). Therefore, it could be said that, concerning all the environmental factors such as, competitive pressure, external support, change agents and certainty, the Iranian grocery supply chain companies have not enough readiness for the adoption of RFID technology.

Relationship between managers' demographic characteristics and their perception of readiness

The second question of the study examines the differences that occur in the overall score for RFID adoption readiness due to respondent managers' demographic characteristics such as gender, age, education level, and major. An independent sample t-test analysis has been conducted to see of gender makes any

Table 4. Statistic and ranking of organizational factors.

Current situation				Factors and questions	Optimal situation			
Rank	M. Rank	S.D	M		M	S.D	M. Rank	Rank
2	3/07	0/58	2/12	IT experiences	4/09	0/36	2/88	4
		0/95	2/36	Sufficient experience in the field of IT technology for the implementation of RFID technology	4/11	0/70		
		0/86	2/11	Sufficient experience in the field of IT technology for the backing up and support of RFID technology	4/04	0/72		
		0/84	1/90	Knowledge and familiarity of company's staff with RFID technology	4/12	0/78		
3	3/04	0/45	2/19	Management support	4/25	0/41	3/23	1
		0/84	2/10	Top management support and back up for RFID technology	4/24	0/67		
		0/75	2/27	Agreeable attitude of the top management towards RFID technology	4/22	0/72		
		0/76	2/11	Acceptance of financial risk by the top management for the adoption of RFID technology	4/33	0/78		
		0/82	2/26	Attitude of the top management towards adoption objectives of RFID technology	4/22	0/72		
1	3/30	0/83	2/26	Organization size	4/26	0/75	3/15	2
		0/83	2/26	The necessity of RFID technology adoption in respect of the organization size	4/26	0/75		
4	2/90	0/66	2/05	Inter organizational readiness	4/16	0/58	2/94	3
		0/87	2/02	The readiness of the staff and experts of the company for the adoption and handling of RFID technology	4/10	0/84		
		0/83	2/08	The readiness of the company's managers for the adoption and handling of RFID technology	4/22	0/73		
5	2/68	0/60	1/92	Technical know-how	4/06	0/56	2/79	5
		0/80	2/02	Perception of technical know-how knowledge of RFID adoption and implementation by the staff and experts of the company	4/02	0/77		
		0/86	2/01	Perception of technical know-how knowledge of RFID adoption and implementation by the company's managers	4/10	0/75		
		0/78	1/73	Perception of technical know-how knowledge of RFID adoption and implementation by the company's suppliers	4/07	0/78		

difference in the participant managers' perception about their companies' readiness for RFID adoption. The results of this analysis are summarized in Table 8. According to the results, although males' mean score is ($M_f = 2.27$) higher than females' score ($M_m = 2.16$), the difference between female and male scores is not statistically significant.

A series of one-way between-groups analyses of variance (ANOVA) were performed to observe if the overall responses of the participant managers differ according to their age groups, education levels and

major. There was no significant effect of the age groups, education levels, and major on overall scores.

Conclusions

This study using survey data indicates that the companies surveyed, are, overall, not ready for RFID adoption, and they need to improve themselves, in order to be able to successfully implement and adopt RFID. In fact because of the low knowledge of the Iranian grocery supply chain companies, and their disability in

Table 5. Binominal test result for organizational factors.

Organizational factors	Group	Category	N	Observed Prop.	Test prop.	Asymp. Sig. (2-tailed)
Management support	1	<= 0	0	0.00	0.50	0.000a
	2	> 0	89	1.00		
IT experiences	1	<= 0	1	0.01	0.50	0.000a
	2	> 0	88	0.99		
Organization size	1	<= 0	8	0.09	0.50	0.000a
	2	> 0	81	0.91		
Technical know-how	1	<= 0	0	0.00	0.50	0.000a
	2	> 0	89	1.00		
Inter organizational readiness	1	<= 0	0	0.00	0.50	0.000a
	2	> 0	89	1.00		

Table 6. Statistic and ranking of environmental factors.

Current situation				Factors and questions	Optimal situation			
Rank	M. Rank	S.D	M		M	S.D	M. Rank	Rank
4	2/34	0/87	1/99	Competitive pressure	4/17	0/71	2/54	2
		0/87	1/99	The accessibility of the suppliers ,sellers, and experts of RFID technology	4/17	0/71		
3	2/40	0/84	2/04	External support	4/25	0/82	2/72	1
		0/84	2/04	Supportive regulations and laws and existence of governmental supports for the RFID adoption	4/25	0/82		
2	2/49	0/61	2/17	Change agents	4/13	0/50	2/44	3
		0/76	2/25	Iranian industry and organizational culture and environment and their impact on RFID technology	4/10	0/69		
		0/86	2/08	Informative media and prevailing information exchange in the country about the RFID technology	4/16	0/75		
1	2/76	0/88	2/34	Certainty	4/04	0/66	2/30	4
		0/88	2/34	Public trust(people and customers of the company) to RFID technology	4/04	0/66		

understanding the benefits of RFID technology adoption as the decreasing tool of organizational costs and the promoter of competitive advantages such as the observation of supply chain and process efficiency increase, these companies can not understand the benefits of new technologies. Moreover, the understanding and compatibility capabilities of Iranian grocery supply chain companies have been extremely decreased due to the primary adoption of new technologies which makes some difficulties for the employees, difficulties in implementation, adoption of new technologies and innovations for the IT personnel, complexity in implementation of RFID technology in comparison to barcodes, limited flexibility of IT structure and low level of integration and adaptability. On the other hand, because of the relevant

implementation and adoption costs of FRID technology, the Iranian managers are not really eager to apply this technology and consequently follow the previous technologies, unless they reach to an agreeable level of financial capability or to be put under pressure by their suppliers. Therefore, based on the aforementioned reasons the Iranian grocery supply chain companies do not have suitable readiness for the adoption of RFID technology, in respect of technological factors.

In Iranian grocery supply chain companies the knowledge of managers in IT fields is really low and the experts of these companies are not eager to update their knowledge of IT, so they will not have enough knowledge of IT to apply new technologies. Since there are numerous managerial challenges before Iranian grocery

Table 7. Binominal test result for Environmental factors.

Environmental factors	Group	Category	N	Observed prop.	Test prop.	Asymp. Sig. (2-tailed)
Competitive pressure	1	<= 0	10	0.11	0.50	0.000 ^a
	2	> 0	79	0.89		
External support	1	<= 0	7	0.08	0.50	0.000 ^a
	2	> 0	82	0.92		
Change agents	1	<= 0	1	0.01	0.50	0.000 ^a
	2	> 0	88	0.99		
Certainty	1	<= 0	10	0.11	0.50	0.000 ^a
	2	> 0	79	0.89		

Table 8. T-test results for gender.

Gender	N	M	SD	D.f	Sig
Female	7	2/16	0/24	87	0/92
Male	82	2/27	0/18		

supply chain managers, we cannot see the commitment of management for the adoption of new technologies. Additionally, lacking power and influence in Iranian companies and in a suitable competitive market, the size of the Iranian grocery supply chain companies is not suitable. The Iranian grocery supply chain companies have not inter organizational readiness for the adoption of RFID technology, since; they do not have experts who update their information and technical knowledge to be able to give appropriate consultation to the management and govern the new technologies' risk and institutionalize technology adoption culture within the company. In fact, Iranian expert and manager are drowned so much in the routines which have lost their ability in updating their knowledge. Accordingly, this study showed that the Iranian grocery supply chain companies do not have suitable readiness for the adoption of RFID technology, in respect of organizational factors.

On the other hand ,in a macrocosmic view ,it is noteworthy to accentuate that Iran is facing ,day in and day out , new problems such as inflation, unemployment, sanction, lack of suitable competitive market, difficulties in export and import, political ,economic and cultural problems, lack of public culture in adoption of new technologies, lack of security in investment atmosphere, lack of governmental support in the adoption of new technologies, extreme bureaucracy, shortages in broadcastings, authoritarianism in mass media, and so on which all hand in hand led to lack of suitable condition in dimensions of competitive pressure ,external support, change agents, and certainty.

The study confirmed that the personal characteristics

(gender, age, education level, and major of the participant managers) have no effect on their overall perception for the organizational readiness.

Finally in this study, the RFID adoption factors are categorized into three groups of technological, organizational and environmental which indeed none of them had suitable condition for the implementation and adoption of the RFID in Iranian grocery supply chain companies.

To adopt these systems successfully; in the first step, technological, organizational, and environmental problems and challenges of supply chain companies must be wiped out. Since there is a deep similarity between the structure of the Iranian grocery supply chain companies with other supply chain companies in Iran, the results of this study could be also generalized to other Iranian supply chain companies.

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