International Business Research

www.ccsenet.org/journal.html

Vol. 2, No. 1

January 2009

An Empirical Study on the Adoption of RFID Technology for Logistics Service Providers in China

Chieh-Yu Lin

Department of International Business

Chang Jung Christian University

396, Sec.1, Chang Jung Rd., Kway Jen, Tainan, 71101, Taiwan, R.O.C.

Tel: 886-6-278-5123 ext 2154 E-Mail: jylin@mail.cjcu.edu.tw

Yi-Hui Ho

Department of International Business

Chang Jung Christian University

396, Sec.1, Chang Jung Rd., Kway Jen, Tainan, 71101, Taiwan, R.O.C.

Tel: 886-6-278-5123 ext 2158 E-Mail: vicky@mail.cjcu.edu.tw

Abstract

The purpose of this paper is to study the influences of technological, organizational and environmental factors on the adoption of RFID technology for logistics service providers in China. While the growth of China's economy hinges to a large extent on the ability of the logistics industry to operate more efficiently and effectively in the global supply chain system, China's logistics companies should pay attention to adopt more efficient logistics technologies to provide better services for their customers. The data to study the factors affecting the adoption of RFID technology came from a questionnaire survey of logistics service providers in China, and 574 logistics companies were analyzed. According to the survey results, about fifty percents of logistics companies are interested in RFID technology, but less than ten percents have the experiences of using RFID technology. Explicitness and accumulation of technology, organizational encouragement for innovation, quality of human resources, and governmental support exhibit significant influences on the willingness to adopt RFID technology.

Keywords: RFID technology, Logistics service providers, Technology adoption, Innovation, China

1. Introduction

Due to the emergence of the concept of supply chain management, logistics management has become a strategic factor that provides a unique competitive advantage in the global market (Christopher, 1993). One of the keys to effective supply chain management is to make the logistics function more efficiently in the supply chain. Consequently, the logistics industry plays an important role in the supply chain (Bowersox, Closs & Cooper, 2002). The purpose of logistics is the supply of service or product to the demander or demanding unit at the right time, with the right quantity, in the right quality, with the right cost and at the right place. Logistics management is a kind of programming, implementing and controlling process dealing with the flow from the primitive occurring point to the final consumption point and the storage efficiency as well as the cost benefit of raw material, half-finished product, finished product and related information, for the purpose of satisfying the customer's requirement (Bowersox & Closs, 1996). The globalization of supply chain has prompted many firms to develop logistics as a part of their corporate strategy (McGinnis & Kohn, 2002). To deliver products quickly to customers, many companies seek to outsource their logistics activities to logistics service providers. This reflects the trend of using logistics companies to satisfy increasing need for logistics services (Lieb & Miller, 2002). More than two decades of economic reform and transition to market economy has brought China unprecedented economic growth. With the fast growth in China's economy and China's accession into WTO, the demand for logistics services has been growing significantly in China, and the logistics industry in China is set to take off. The total logistics value has grown by 29.9 percents year-on-year (Li & Fung Research Center, 2005). New modern facilities such as logistics parks, distribution centers and warehouses are being built at a record setting pace. Many logistics companies have invested extensively in information and logistics technologies. As China

continues to develop into a global manufacturing factory, China's logistics industry will play an important role in the global supply chain.

Over the past decade, many logistics service providers have acknowledged that their supply chains are not responsive enough. If they are willing to operate more efficiently and responsively, they must adopt technologies that will help manufacturers, warehouses, and retailers to communicate with each other more efficiently (Cohen, 2000). With the rapid growth of technologies, our economic society and life are changing significantly in the 21st century. How to capture company's competitive advantage has become the most important issue for mangers in the rapidly changing and uncertain business environments. An amount of research has shown that the adoption of technological innovations is the most important tool for enterprises to keep their competitive advantage. Recently, a body of evidence shows that logistics companies can increase their performance by employing new technologies. Many logistics companies began to improve their operation efficiency by continuous implementation of information or automation technologies according to their business characteristics (Mason-Jones & Towill, 1999; Sauvage, 2003). Nixon (2001) suggested that logistics companies should employed new information technologies to raise their service capability in the e-commerce age. Speakman (2002) proposed that logistics companies could increase their performance by employing new technologies. Sauvage (2003) found that technological effort is the key variable and means of differentiation between logistics companies. Chapman, Soosay and Kandampully (2003) suggested that logistics industry should pay more attention to innovation in logistics service and the innovation in logistics can be implemented through technology, knowledge and relationship networks. Therefore, it can be concluded that technological innovation is important for China's logistics industry. Most operations in China's logistics industry are labor-intensive, and rely on the input of a large number of service workers. Nowadays, in the age of knowledge-based economy, how China's logistics industry can be transformed from labor-intensiveness into knowledge-intensiveness, and how they can make full use of the market intelligence to create knowledge and further take advantage of the knowledge to innovate products, services as well as strategies to promote the competence of organizations, are the topics worth taking into deep consideration. Continuous technological advancement can assist China's logistics industry to revolutionize the way they operate and conduct their business.

Among many logistics technologies, radio frequency identification (RFID) technology has been taken as an important application in logistics operations and supply chain management (Srivastava, 2004; Angeles, 2005; Smith, 2005). Federal Express, Dell, Proctor and Gamble, the US Department of Defense, and the European retailer Metro Group have begun to utilize RFID technology in their supply chain systems (RFID Journal, 2004). Moreover, much like Wal-Mart did with electronic data interchange (EDI) and bar code development, Wal-Mart has been beginning to drive the adoption of RFID technology, which will mean significant changes in the way supply chains are managed. Wal-Mart has announced that they would require all of their larger suppliers to implement RFID on every box and pallet shipped to Wal-Mart by 2005 (Boyle, 2003). RFID technology is one type of auto-identification technology that uses radio waves to identify individual physical objects. An RFID tag consists of two main components: an antenna and a chip containing an electronic product code. RFID technology is compact and robust, and has been used for in many applications including the manufacturing and distribution of physical goods. It can help item level identification, which is useful for easily and efficiently identifying each item within the entire supply chain (Davis & Luehlfing, 2004). Due to the application of radio frequency, we can interact with the product items without physical contact, and as a result, increase our handling efficiencies. In summary, RFID technology provides a tool for real-time data communication and can close the information gaps in the supply chain, especially in retailing and logistics; therefore RFID technology allows for better control of supply chain due to effective information sharing and real-time data communication (Yao & Carlson, 1999; Angeles, 2005; Prater, Frazier & Reyes, 2005).

However, while a body of research has been conducted on the application of RFID technology, what has been missing is a discussion of the drivers or influencing factors that lead various industries to consider RFID (Prater, Frazier & Reyes, 2005). Although RFID technology has garnered a great deal of research interest, most research has primarily focused on the specifics of the technology, or its impact on general supply chain issues, such as its general promise of cost and time savings (Donovan, 2003; Kärkkäinen, 2003; Kunii, 2003; Niemeyer & Pak, 2003; Davis & Luehlefing, 2004; Srivastava, 2004; Angeles, 2005; Smith, 2005). Some studies argued that the key factor for widespread usage of RFID technology is its cost (Donovan, 2003). However, it is still not clear whether other technological factors and organizational and environmental context will affect the adoption of RFID technology. Therefore, this paper will investigate the adoption of RFID technology in China's logistics industry. The main purpose of this paper is to conduct questionnaire surveys in China to explore the factors that affect RFID technology adoption by logistics service providers from the perspective of technology, organization and environment. An understanding of the influencing factors is essential in order for practitioners to best implement a new technology, and for researchers to best understand what issues need to be addressed.

The next section introduces the theoretical foundations of the determinants of adopting RFID technology. The third section gives a description of the research methodology, while the fourth section focuses on the analysis of the results and the discussion of the findings. The final section gives research conclusions.

2. **Determinants of Technology Adoption**

Companies achieve competitive advantage through acts of innovation. They approach innovation in its broadest sense, including both new technologies and new ways of doing things (Porter, 1990). Betz (1997) assumed that innovation is to introduce a new or improved product, process, or service into the marketplace. Afuah (1998) proposed that innovation is the use of new technical and administrative knowledge to offer a new product or service to customers. The product or service is new in that its cost is lower, its attributes are improved, it now has attributes it never had before, or it never existed in that market before. Innovation is any practices that are new to organizations, including equipments, products, services, processes, policies and projects (Kimberly & Evanisko, 1981; Damanpour, 1991). Past research has argued that distinguishing types of innovation is necessary for understanding organizations' adoption behavior and identifying the determinants of innovation in them (Knight, 1967; Rowe & Boise, 1974; Downs & Mohr, 1976). Among numerous typologies of innovation advanced in the relevant literature, the pair of types of innovation, administrative and technological (or technical) innovation, is commonly used (Damanpour, 1991). Technological innovation pertains to products, services, and production process technology; it is related to basic activities and can concern either product or process (Knight, 1967; Damanpour & Evan, 1984). Administrative innovation involves organizational structure and administrative processes; it is indirectly related to the basic work activities of an organization and is more directly related to its management (Knight, 1967; Kimberly & Evanisko, 1981; Damanpour & Evan, 1984). Because the implementation of RFID technology is still in its infancy (Davis & Luehlefing, 2004), it is reasonable to assume that the adoption of RFID technology can be taken as an innovative process for a logistics company. Therefore, we will utilize the concept of technological innovation as the theoretical foundation to study the factors affecting the adoption of RFID technology.

A body of research studied the determinants or influencing factors on innovation (Kimberly & Evanisko, 1981; Amabile, 1988; Tornatzky & Fleischer, 1990; Damanpour, 1991; Wolfe, 1994; Tidd, Bessant & Pavitt, 1997). Kimberly and Evanisko (1981) suggested that the individual factor, organizational factor, and contextual factor would influence hospital adoption of technological innovation. Kwon and Zmud (1987) classified variables affecting technology adoption into individual, task-related, innovation-related, organizational, and environmental characteristics. Tornatzky and Fleischer (1990) suggested that the adoption and implementation of technological innovation would be affected by the technological context, organizational context, and the external environmental context. Patterson, Grimm and Corsi (2003) indicated that technology adoption is affected by organizational size, structure, and performance, supply chain strategy, transaction climate, supply chain member pressure, and environmental uncertainty. Scupola (2003) used technological, organizational, and environmental characteristics to explain the adoption of Internet commerce. This paper will investigate the influence of technological, organizational, and environmental factors on the adoption of RFID technology in China's logistics industry. Although the individual factor might affect adopting RFID technology for logistics companies, this paper will not investigate each individual's influence on the company's adoption of RFID technology.

2.1 Technological Factors

Technologies can be viewed as one kind of knowledge (Grant, 1996). Tsai and Ghoshal (1998) found that an organization will have higher innovative capability when knowledge can be shared more easily within the organization. The transferability of knowledge or technology will influence technological innovation; technological innovation can be advanced when the technology has higher transferability. The transferability of technology is determined by the explicitness of technology. It is more easily to transfer or share technological knowledge with higher explicitness (Grant, 1996; Teece, 1996). In addition to the explicitness of the technology, how the technology fits with the technologies that a firm already possesses will also be another important technological characteristic (Tornatzky & Fleischer, 1990; Chau & Tam, 1997). Teece (1996) found that technological innovation usually follows a technological paradigm. The cumulative nature of technologies will influence the innovation in technologies. Grant (1996) and Simonin (1999) also concluded that an organization with rich experiences in the application or adoption of related technologies will have higher ability in technological innovation. Therefore we would expect that explicitness and accumulation of technology might influence the adoption of RFID technology. The following hypotheses are consequently proposed:

Hypothesis H1a. *The more the explicitness of the RFID technology, the more likely that the logistics service providers will adopt RFID technology.*

Hypothesis H1b. *The more the accumulation of the related technology in the firm, the more likely that the logistics service providers will adopt RFID technology.*

2.2 Organizational Factors

A body of research about organizational behaviors has argued that certain features of organizations themselves, including structures, climates, and cultures of organizations, will influence the adoption of innovation (Kimberly & Evanisko, 1981; Tornatzky & Fleischer, 1990; Russell & Hoag, 2004). Amabile (1988) found that the management skills, organizational encouragement for innovation, and support of innovation resources would help the improvement of organizational innovation. Tornatzky and Fleischer (1990) suggested that informal linkages and communication among the employees, the quality of human resources, top management's leadership behavior and the amount of internal slack resources would significantly influence the adoption of technological innovation. A firm with higher quality of human resources such as better education or training will have higher ability in technological innovation. Therefore we would expect that encouragement for innovation and quality of human resources might influence the adoption of RFID technology. The following hypotheses are consequently proposed:

Hypothesis H2a. *The more the encouragement for innovation, the more likely that the logistics service providers will adopt RFID technology.*

Hypothesis H2b. *The higher the quality of human resources, the more likely that the logistics service providers will adopt RFID technology.*

2.3 Environmental Factors

In addition to technological and organizational characteristics, the external environment in which a firm conducts its business will also influence the innovative capability (King & Anderson, 1995). Miles and Snow (1978) found that organizations would pay more attention on innovation when they faced environments with higher instability and chaos. Kimberly and Evanisko (1981) concluded the environmental complexity and uncertainty would influence the organizational innovation for hospitals. Damanpour (1991) found that environments with high uncertainties would have positive influences on the relationship between organizational structures and organizational innovation. Zhu and Weyant (2003) suggested that demand uncertainty tends to increase firm's incentive to adopt new technologies. Governmental support is another important environmental characteristic for technological innovation. Government through regulation can both encourage and discourage the adoption of innovation (Tornatzky & Fleischer, 1990; Scupola, 2003). Government can provide financial incentives, pilot projects, and tax breaks to stimulate technological innovation for logistics companies. Therefore we would expect that environmental uncertainty and governmental support might influence the adoption of RFID technology. The following hypotheses are consequently proposed:

Hypothesis H3a. *The more the environmental uncertainty, the more likely that the logistics service providers will adopt RFID technology.*

Hypothesis H3b. *The more the governmental support, the more likely that the logistics service providers will adopt RFID technology.*

3. Research Methods

3.1 Data Collection and Sample Description

The data to test our hypotheses come from a questionnaire survey of logistics service providers in China. As China becomes a global manufacturing factory, China's central and local governments delivered several policies to reinforce the logistics industry (Jiang, 2002). Moreover, after China's accession into WTO, allowing foreign logistics companies to operate in China more freely boost the growth of China's logistics industry. More and more logistics companies in China begin to adopt technological innovations to increase their logistics service capabilities. However, the logistics industry in China is still in its infancy compared with its counterparts in more developed countries. Ta, Choo and Sum, (2000) found that the logistics barriers to international operations in China include the lack of cargo tracing services, the lack of delivery reliability for local carriers, the lack of carrier selection, complicated customs procedures, and geographical fragmentation of transportation networks.

Generally, logistics companies carry out logistics activities for their customers, which include warehousing, transportation, inventory management, order processing, and packaging (Sink, Langley & Gibson, 1996; Delfmann, Albers & Gehring, 2002). The sample frame was drawn from members of the logistics councils in Beijing, Shanghai and Shenzhen regions because the development of logistics industry in these three regions are more mature than other regions in China. The Beijing Municipal Government has placed the establishment of a highly effective logistics platform by 2010 in its tenth five-year development plan. The Shanghai Municipal Government has been giving priority to the development of three large-scale logistics parks during its tenth five-year plan period. The Shenzhen Municipal Government plans to develop logistics services into one of the three mainstay industries in the 21st century. Six hundred questionnaires were mailed or delivered directly to the sampled companies in each region from June to August in 2006. In order to get a higher rate of response, we also personally deliver questionnaires to some logistics companies in each area.

In total, we delivered 1800 questionnaires and 617 questionnaires were returned, 177 in Beijing, 219 in Shanghai and 221 in Shenzhen. Of these respondents, 43 uncompleted or unconfident questionnaires were excluded. The overall response rate is 31.9 percent. The basic information of these companies is shown in Table 1. In China, most logistics companies belong to small and medium size enterprises. Because RFID technology has been seen as a product data identification technology to replace bar code, we also surveyed the experience of using bar code for logistics companies. We can find that about sixty percent of logistics companies in China have the experience of using bar code in their logistics service processes. According to the survey results, it can be found that about fifty percent of logistics companies are interested in RFID technology, but only about eight percent of logistics companies have the experiences of using RFID technology.

Insert Table 1 about here

3.2 Measures

To test above hypotheses, data were collected by means of delivering questionnaires to logistics service providers in China. The questionnaire contains company's basic information, technological factors, organizational factors, environmental factors, and the adoption of RFID technology. Besides the company's basic information, the other items were measure using the 5-point Likert scales anchored by 'strongly disagree' and 'strongly agree'. The willingness to adopt RFID technology is measured. In addition, the adopting behaviors in RFID technology were also asked in the questionnaire to investigate the current application of RFID technology by the logistics industry in China.

Explicitness of technology was measured according to the degrees that the technology can be transferred and codified (Grant, 1996; Teece, 1996; Tsai & Ghoshal, 1998). Accumulation of technology was measured according to the degrees of fitness of related technologies a firm that possessed (Grant, 1996; Chau & Tam, 1997; Simonin, 1999). Organizational encouragement for innovation was measured according to the degrees that companies' resource supports and leaders' attitudes (Amabile, 1988; Tornatzky & Fleischer, 1990). Quality of human resources was measured according to employees' information skills and innovation capabilities (Tornatzky & Fleischer, 1990). Customers' requirements, competitors' innovative abilities, and development of logistics technologies were used to measure the environmental uncertainty (Kimberly & Evanisko, 1981; Zhu & Weyant, 2003). Governmental support was measured from the perspective of finance, technology, law and human resources (Tornatzky & Fleischer, 1990; Scupola, 2003).

In this paper, the measured scales were submitted to factor analysis. Varimax rotation was used because it is the most commonly used and can minimize the number of variables that have high loadings on each factor and simplify the interpretations of the factors. Factors with eigenvalues greater than 1.0 are summarized in Table 2, Table 3, and Table 4. The technological factors consist of "explicitness of technology" and "accumulation of technology"; organizational factors consist of "encouragement for innovation" and "quality of human resources"; environmental factors consist of "environmental uncertainty" and "governmental support." From the results of factor analysis, we can confirm the construct validity of this study. Results of the reliability analysis are also illustrated in these tables. The overall reliability is 0.8416. As the smallest value of Cronbach's alpha for this study is 0.7821, the sampling results are reliable (Nunnally, 1978).

Insert Table 2 about here

Insert Table 3 about here

Insert Table 4 about here

Table 5 shows the correlations among these factors and the willingness to adopt RFID technology. The correlation matrix gives us initial evidences of our hypotheses: technological, organizational and environmental factors are associated positively with the adoption of RFID technology. Moreover, the technological, organizational and environmental factors are not highly correlated.

Insert Table 5 about here

4. Results and Discussions

To find the influences of technological, organizational, and environmental factors on the adoption of RFID technology, the method of multiple regression analysis was used in this study. Based on the above results obtained by the method of factor analysis, the technological factor is classified into explicitness of technology and accumulation of technology; the organizational factor is classified into organizational encouragement and quality of human resource; the environmental factor is classified into environmental uncertainty and governmental support. This paper took these six factors as independent variables and the willingness to adopt RFID technology as the dependent variable, and consequently, employed the method of regression analysis to determine their relationship. Moreover, as firm size and history (Spencer, 2003) and past experiences or related technologies (Grant, 1996; Simonin, 1999) might influence the adoption of technological innovation, company history, number of employee, capital size, and bar code experience are taken as the control variables in the regression analysis.

Before applying the regression model, we examined whether the regression assumptions of homoescedasticity, linearity, normality, independence of residuals, and the absence of multicollinearity are satisfied. Based on a plot of residuals versus predicted values, we found that the assumptions of homoescedasticity and independence of residuals are met. To examine the assumption of linearity, scatterplots for all independent variables against the dependent variable in a pairwise manner were inspected. The assumption of linearity seems to be satisfied. The Anderson-Darling test was used to examine the normality of residuals. Because the obtained test statistic A^2 is 0.3604 (p-*value* > 0.1), the assumption of normality holds (Stephens, 1974). Multicollinearity was examined by checking the values of variance inflation factor (VIF) in this study and it was found that the VIF values are all less than 10 and therefore we can confirm that there is no extreme multicollinearity in the regression model (Hair, et al., 1998). Moreover, we could also confirm that autocorrelation does not present in the residuals of the regression equation because the Durbin-Watson value is 1.698 which lies within the range of critical values (Hair, et al., 1998). The results of regression analysis are shown in Table 6.

Insert Table 6 about here

From Table 6, we can find that the technological, organizational and environmental factors have positive influences on the adoption of RFID technology. Explicitness of technology, accumulation of technology, encouragement for innovation, quality of human resources, and governmental support all exhibit significantly positive influences on the willingness to adopt RFID technology for China's logistics companies. This means that the hypotheses, *H1a*, *H1b*, *H2a*, *H2b*, and *H3b* are accepted, but the hypothesis *H3a* is not accepted. We can conclude that higher explicitness of technology can help the transfer of technological knowledge within the organization and, therefore, raise the capability and willingness to adopt RFID technology. More accumulation of related technologies can make logistics companies have more related knowledge to adopt RFID technology. Actually, the positive relationship between the experience of using bar code and the willingness to adopt RFID technology also reveals the positive influences of accumulation of technology. Organizational encouragement for innovation can give employees motivation and support to adopt new logistics technologies, such as RFID technology. High quality of human resources means that employees are capable of learning and using innovative logistics technology like RFID technology. Governmental support can encourage and guide logistics service providers to adopt RFID technology.

The reason that environmental uncertainty did not have significant influences on the adoption of RFID technology may be due to the fact that most logistics companies in China are small and medium size. Providing flexible logistics service to satisfy customers' varying requirements is their major competence. Environmental uncertainty is common to these logistics companies. Therefore, environmental uncertainty did not have significant influences on the adoption of innovative logistics technology such as RFID technology for logistics service providers in China.

5. Conclusions

Since the China's government has been actively formulating policies to encourage a stronger linkage between the national economy and the global economy, China has become an important investment destination for multinational corporations. More and more foreign companies invest in China to take advantage of low labor costs and the potentially huge market. However, many foreign investors have faced several logistics problems such as the transportation of materials or products and the flow of information. The logistics cost in China is still high compared to many developed countries. To solve the logistics problems, accelerating the development of the logistics industry is one of the major economic policies of the China's government.

To improve their logistics services, many logistics service providers in China begin to adopt innovative logistics technologies. Advanced technologies and innovations play a critical role in expediting further growth of the logistics industry in China. However, there is a lack of empirical research on the adoption of innovative logistics technologies in China. As RFID technology is one of the innovative logistics technologies, this paper investigated the factors influencing the adoption of RFID technology in China's logistics industry. From the research results, we can find that only a few of logistics companies in China had the experiences of using RFID technology though about half of logistics companies were interested in RFID technology. This implies that the application of RFID technology in China's logistics industry is still in its infancy. There is a vast area of RFID market in China for RFID technology providers.

Logistics companies play an important role in the supply chain systems. As logistics companies must pay more and more attention to innovation in logistics technologies to provide better services for their customers, most of them begin to utilize many innovative logistics technologies to improve their performance and reinforce their competitive advantages. Based on the research results, we can conclude that higher explicitness of technology can help the transfer of technological knowledge within the organization and, consequently, can raise the willingness of adopting RFID technology. Therefore, to increase the logistics company's willingness to adopt RFID technology, RFID technology providers can improve the explicitness of RFID technology. Logistics companies can also increase their ability to adopt RFID technology by accumulating more related technologies, by encouraging or supporting their employees to learn new technology and by training and educating their employees to become knowledge workers. Therefore, based on our

research about the adoption of RFID technology in China's logistics industry, both logistics companies and RFID technology providers can plan better strategies to improve the development and application of RFID technology in China's logistics industry.

In addition, the government also plays an important role in the adoption of RFID technology in China's logistics industry. Under normal condition, the viability of technologies that are on the cutting edge as well as the economic consequences of using these technologies could be largely unknown. An investment in replacing and redesigning existing technologies and processes in a competitive environment is financially significant and involves substantial risk. Without governmental action, it would be even more risky to make the decision to adopt new technologies and processes (Kemp, 1993). As the application of RFID technology in China's logistics industry is still in its initial stage, the China's government should provide financial incentives, pilot projects, and tax breaks to stimulate technological innovation for logistics industry. The willingness to adopt RFID technology will be reinforced for logistics companies if the government can provide various supports of resources and continuous encouragement policies.

This paper only studies the influences of technological, organizational and environmental factors on the adoption of RFID technology in China's logistics industry. While there are differences between China and other countries in political structures, cultural background, historical perspective, social value, and so on (Li-Hua and Khalil, 2006), logistics service providers in different countries may have different views on the influences of these influential factors on the adoption of RFID technology. It will be worthwhile to advance a cross-national comparative study on the adoption of RFID technology among logistics industries in China and in other countries. In addition, there are some limitations to our research. Because we used the questionnaire survey, it is possible that the results of this study might suffer from the respondent bias. As we know, logistics companies cover a wide range of service types. In this study, we did not take the influences of service types of logistics companies on the adoption of RFID technology. There might be different effects of technological, organizational and environmental factors on the adoption of RFID technology for different logistics service types. It is worthwhile to carry out further studies on the moderating effect of logistics service types on the adoption of RFID technology. Moreover, other possible influential factors on the adoption of RFID technology will also be taken into consideration in further studies

References

Abernathy, W. J. & Utterback, J. M. (1978). Patterns of innovation in technology. *Technology Review*, 80(7): 40-47.

Afuah, A. (1998). *Innovation management: Strategies, implementation, and profits.* New York: Oxford University Press.

Amabile, T. M. (1988). A model of creativity and innovation in organization. In B. M. Staw & L. L. Cummings (Eds.), *Research in Organizational Behavior*, vol. 10: 123-167. Chicago: Aldine Publishing Company.

Angeles, R. (2005). RFID technologies: Supply-chain applications and implementation issues. *Information System Management*, 22(1): 51-65.

Betz, F. (1997). *Managing technological innovation: Competitive advantage from change.* New York: John Wiley & Sons, Inc.

Bowersox, D. J. & Closs, D. J. (1996). *Logistical management: The integrated supply chain process.* New York: McGraw-Hill.

Bowersox, D. J., Closs, D. J. & Cooper, M. B. (2002). *Supply chain logistical management.* New York: McGraw-Hill.

Boyle, M. (2003). Wal-Mart keeps the change. *Fortune*, November 10: 46.

Capon, N., Farley, J. U. & Hoenig, S. (1990). Determinants of financial performance: A meta-analysis. *Management Science*, 36(10): 1143-1159.

Chapman, R. L., Soosay, C. & Kandampully, J. (2003). Innovation in logistic services and the new business model: A conceptual framework, *International Journal of Physical Distribution & Logistics Management*, 33(7): 630-650.

Chau, P. Y. K. & Tam, K. Y. (1997). Factors affecting the adoption of open systems: An exploratory study. *MIS Quarterly*, 21(1): 1-24.

Li & Fung Research Centre. (2005). Recent Development of the Logistics Industry in China (2004-2005). *China Distribution & Trading,* June (27). (http://www.lifunggroup. com/research/china_dis02.htm)

Christopher, M. (1993). Logistics and competitive strategy. *European Management Journal*, 11(2): 258-261.

Cohen, S. L. (2000). The supermarket in 2010. *IIE Solutions*, 32(4): 38-41.

Damanpour, F. (1991). Organizational innovation: A meta-analysis of effects of determinants and moderators. *Academy of Management Journal*, 34(3): 555-590.

Damanpour, F. & Evan, W. M. (1984). Organizational innovation and performance: The problem of organizational lag. *Administrative Science Quarterly,* 29(3): 392-409.

Davis, H. E. & Luehlfing, M. S. (2004). Radio frequency identification: The wave of the future. *Journal of Accountancy*, 198(5): 43-49.

Delfmann, W., Albers, S. & Gehring, M. (2002). The impact of electronic commerce on logistics service providers. *International Journal of Physical Distribution & Logistics Management,* 32(3): 203-222.

Donovan, J. (2003). RF identification tags: Show me the money. *Electronic Engineering Times,* May 12: 41.

Downs, G. W. & Mohr, L. B. (1976). Conceptual issues in the study of innovation. *Administrative Science Quarterly,* 21(4): 700-714.

Grant, R. M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science*, 7(4): 375-387.

Groenwegen, P. & Vergragt, P. (1991). Environmental issues as threats and opportunities for technological innovation. *Technology Analysis and Strategic Management*, 3(1): 43-55.

Hair, J. F., Anderson, R. E., Tatham, R. L. & Black, W. C. (1998). *Multivariate data analysis.* London: Prentice-Hall International.

Hart, S. L. (1995). A natural resource-based view of the firm. *Academy of Management Review*, 20(4): 986-1014.

Jiang, B. (2002). How international firms are coping with supply chain issues in China. *Supply Chain Management: An International Journal*, 7(4): 184-188.

Kärkkäinen, M. (2003). Increasing efficiency in the supply chain for short shelf life goods using RFID tagging. *International Journal of Retail & Distribution Management*, 31(10): 529-536.

Kemp, R. (1993). An economic analysis of cleaner technology: Theory and evidence. In K. Fischer & J. Schot (Eds.), *Environmental strategies for industry*: 79-113. Washington, DC: Island Press.

Kimberly, J. R. & Evanisko, M. J. (1981). Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. *Academy of Management Journal*, 24(4): 689-713.

King, N. & Anderson, N. R. (1995). *Innovation and change in organizations.* London: Routledge.

Knight, K. E. (1967). A descriptive model of the intra-firm innovation process. *Journal of Business,* 40(4): 478-496.

Kunii, I. M. (2003). Radio ID tags so cheap they'll be everywhere. *Business Week*, October 20: 147.

Kwon, T. H. & Zmud, R. W. (1987). Unifying the fragmented models of information systems implementation. In J. R. Boland & R. Hirshheim (Eds.), *Critical Issues in Information Systems Research.* New York: John Wiley and Sons Ltd, pp. 227-251.

Lieb, R. & Miller, J. (2002). The use of third-party logistics services by large US manufacturers: The 2000 survey. *International Journal of Logistics: Research and Applications,* 5(1): 1-12.

Li-Hua, R. & Khalil, T. M. (2006). Technology management in China: A global perspective and challenging issues. *Technology Management in China*, 1(1): 9-26.

Mason-Jones, R. & Towill, D. R. (1999). Using the information decoupling point to improve supply chain performance. *The International Journal of Logistics Management*, 10(2): 13-26.

McGinnis, M. A. & Kohn, J. W. (2002). Logistics strategy-revised. *Journal of Business Logistics*, 23(2): 1-17.

Miles, R. E. & Snow, C. C. (1978). *Organizational strategy, structure, and process.* New York: McGraw-Hill.

Niemeyer, A. & Pak, M. H. (2003). Smart tags for your supply chain. *The McKinsey Quarterly*, (4). (http://www.mckinseyquarterly.com/article_abstract.aspx?ar=1347&L2=1&L3=26).

Nixon, M. (2001). Innovations in logistics technology: Generating top-line value and bottom-line ROI. *World Trade*, 14: 62-64.

Nunnally, J. C. (1978). *Psychometric theory*. New York: McGraw-Hill.

Patterson, K. A., Grimm, C. M. & Corsi, T. M. (2003). Adopting new technologies for supply chain management, *Transportation Research Part E: Logistics and Transportation Review*, 39(2), 95-121.

Porter, M. (1990). *The competitive advantage of nations.* London: Macmillan.

Prater, E., Frazier, G. V. & Reyes, P. M. (2005). Future impacts of RFID on e-supply chains in grocery retailing. *Supply Chain Management: An International Journal*, 10(2): 134-142.

RFID Journal. (2004_. Mandate for change. *RFID Journal*, January.

Rowe, L. & Boise, W. B. (1974). Organizational innovation: current research and evolving concepts. *Public Administration Review*, 34(3): 284-293.

Russell, D. M. & Hoag, A. M. (2004). People and information technology in the supply chain: Social and organizational influences on adoption. International Journal of Physical Distribution & Logistics *Management,* 34(1/2): 102-122.

Russo, M. V. & Fouts, P. A. (1997). A resource-based perspective on corporate environmental performance and profitability. *Academy of Management Journal*, 40(3): 534-559.

Sauvage, T. (2003). The relationship between technology and logistics third-party providers. *International Journal of Physical Distribution & Logistics Management*, 33(3): 236-253.

Scupola, A. (2003). The adoption of Internet commerce by SMEs in the South of Italy: An environmental, technological and organizational perspective. *Journal of Global Information Technology Management*, 6(1): 52-71.

Shrivastava, P. (1995). Ecocentric management for a risk society. *Academy of Management Review*, 20(1): 118-137.

Simonin, B. L. (1999). Transfer of marketing know-how in international strategic alliances: An empirical investigation of the role and antecedents of knowledge ambiguity. *Journal of International Business Studies*, 30(3): 463-490.

Sink, H. L., Langley, C. J. Jr. & Gibson, B. J. (1996). Buyer observations of the US third-party logistics market. *International Journal of Physical Distribution & Logistics Management,* 26(3): 36-46.

Smith, A. D. (2005). Exploring radio frequency identification technology and its impact on business systems. *Information Management & Computer Security*, 13(1): 16-28.

Speakman J. P. (2002). Innovation leads to new efficiencies. *Logistics Management*, 41: 71.

Spencer, J. W. (2003). Firms' knowledge-sharing strategies in the global innovation system: Empirical evidence from the flat panel display industry. *Strategic Management Journal*, 24(3): 217-233.

Srivastava, B. (2004). Radio frequency ID technology: The next revolution in SCM. *Business Horizons*, 47(6): 60-68.

Stephens, M. A. (1974). EDF statistics for goodness of fit and some comparisons. *Journal of the American Statistical Association,* 69(347): 730-737.

Ta, H. P., Choo, H. L. & Sum, C. C. (2000). Transportation concerns of foreign firms in China. *International Journal of Physical Distribution & Logistics Management*, 30(1): 35-53.

Teece, D. J. (1996). Firm organization, industrial structure, and technological innovation. *Journal of Economic Behavior and Organization*, 31(2): 193-224.

Tidd, J. Bessant, J. & Pavitt, K. (1997). *Managing innovation: Integrating technological, market, and organizational change*. New York: John Wiley & Sons, Inc.

Tornatzky, L. G. & Fleischer, M. (1990). *The process of technological innovation.* Lexington, MA: Lexington Books.

Tsai, W. & Ghoshal, S. (1998). Social capital and value creation: the role of intra-firm networks. *Academy of Management Journal*, 41(4): 464-476.

Wolfe, R. A. (1994). Organizational innovation: review, critique and suggested research directions. *Journal of Management Studies*, 31(3): 405-431.

Yao, A. C. & Carlson, J. G. (1999). The impact of real-time data communication on inventory management. *International Journal of Production Economics*, 59(1): 213-219.

Zhu, K. & Weyant, J. P. (2003). Strategic decisions of new technology adoption under asymmetric information: A game-theoretic model. *Decision Sciences*, 34(4): 643-675.

Table 1. Basic Information of the Sample

	Category	**Number**	**Percentage (%)**
Company history (Years)	0~5	394	68.6
	6~10	133	23.2
	11~20	37	6.4
	Above 20	10	1.7
Number of employee	Below 50	209	36.4
	51~100	197	34.3
	101~300	104	18.1
	301~500	44	7.7
	Above 501	20	3.5
Capital (Million, RMB Yuan)	Below 1	137	23.9
	1~5	188	32.8
	5~10	121	21.1
	10~50	79	13.8
	Above 50	49	8.5
Bar Code experience	Yes	351	61.1
	No	223	38.9
Adoption of RFID	Yes	44	7.6
	No but Interested	251	43.7
	No and Uninterested	279	48.6

Table 2. Result of Factor Analysis for Technological Factors

Items	Factor loading (Standardized)	
	Factor 1	**Factor 2**
Explicitness of technology (Factor 1)		
It is easy to find books or other resources about the technology.	0.821	0.134
It is easy to learn the application of the technology from the books.	0.803	0.121
It does not need too many experiences to learn the technology.	0.786	0.193
It is easy to understand that technology	0.751	0.207
Accumulation of technology (Factor 2)		
It is necessary to have experiences in using related technologies.	0.112	0.809
Our company has implemented many related technologies.	0.204	0.783
It is easy to integrate that technology with company's current logistics system.	0.143	0.742
Eigenvalue	4.201	2.983
Variance explained	36.241 %	31.087 %
Accumulated variance explained	36.241 %	67.328 %
Cronbach's α for each dimension	0.8311	0.8287
Cronbach's α	0.8301	

Table 3. Result of Factor Analysis for Organizational Factors

Items	Factor loading (Standardized)	
	Factor 1	**Factor 2**
Encouragement for innovation (Factor 1)		
Company's leaders encourage employees to learn new information.	0.849	0.147
Our Company provides rewards for innovative employees.	0.821	0.131
Our company provides supports for employees to learn new information.	0.794	0.109
Company's leaders can help employees when they face new problems.	0.753	0.113
Quality of human resources (Factor 2)		
Employees can learn new technologies easily.	0.100	0.839
Employees usually provide new ideas for companies.	0.136	0.807
Employees possess abilities to use computer to solve problems.	0.171	0.751
Employees can share knowledge with each others.	0.261	0.725
Eigenvalue	4.622	2.831
Variance explained	35.982 %	31.793 %
Accumulated variance explained	35.982 %	67.775 %
Cronbach's α for each dimension	0.8832	0.8481
Cronbach's α	0.8694	

Table 4. Result of Factor Analysis for Environmental Factors

Items	Factor loading (Standardized)	
	Factor 1	**Factor 2**
Governmental support (Factor 1)		
Government provides financial support for the development of logistics technologies	0.869	0.063
Government encourages companies to propose projects of logistics technologies	0.831	0.089
Government help training manpower with logistics skills	0.795	0.112
Government relieves the regulation for the logistics industry	0.766	0.037
Environmental uncertainty (Factor 2)		
The advance in new logistics technologies is quickly	0.083	0.836
Competitors usually provide new logistics services	0.094	0.808
Customers' requirements are diversified	0.116	0.780
Customers' requirements vary quickly	0.143	0.731
Eigenvalue	4.231	2.483
Variance explained	37.533 %	31.986 %
Accumulated variance explained	37.533 %	69.519 %
Cronbach's α for each dimension	0.8308	0.7821
Cronbach's α	0.8085	

Table 5. Result of Correlation Analysis

Variables	**Means**	**Std**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Explicitness of technology	3.79	0.89	1.0						
2. Accumulation of technology	3.26	0.93	0.26	1.0					
3. Encouragement for innovation	4.01	0.81	0.18	0.25	1.0				
4. Quality of human resources	3.86	0.96	0.25	0.31	0.38	1.0			
5. Environmental uncertainty	3.01	1.05	-0.03	0.06	0.08	0.11	1.0		
6. Governmental support	4.15	0.68	0.09	0.15	0.12	0.08	-0.06	1.0	
7. Adoption of RFID technology	3.58	1.02	0.41^{+}	0.58^{**}	0.61^{**}	0.66^{**}	0.33	0.71^{**}	1.0

$+ p<0.1$ $* p<0.05$ $** p<0.01$

Table 6. Standardized Regression Results for the Determinants of RFID Technology Adoption

Dependent variables: Adoption of RFID technology				
Predictors	Model 1		Model 2	
	Coefficient β	*t*	Coefficient β	*t*
Control variables				
Company history	0.010	0.593	0.005	0.610
Number of employee	0.031	0.861	0.022	0.774
Capital size	0.038	1.502^{+}	0.028	1.024
Bar code experience	0.063	1.721^{+}	0.052	1.654^{+}
Technological factors				
Explicitness			0.161	2.831*
Accumulation			0.193	4.438**
Organizational factors				
Encouragement			0.152	4.114**
Human resource			0.188	3.986**
Environmental factors				
Uncertainty			0.098	1.154
Government			0.199	4.587**
R^2	0.093		0.541	
adj R^2	0.072		0.493	
F	1.010		6.863**	
Durbin-Watson value	1.689		1.798	

$^{+}$ $p<0.1$ * $p<0.05$ ** $p<0.01$