Factors affecting innovation in logistics technologies for logistics service providers in China

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Abstract

Purpose – 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. China's logistics service providers need to pay more attention to adopt more efficient logistics technologies to provide better services for their customers. The purpose of this paper is to study the factors affecting the innovation in logistics technologies for logistics service providers in China.

Design/methodology/approach – Questionnaire survey on logistics service providers in Beijing, Shanghai and Shenzhen is conducted to study the innovation in logistics technologies by China's logistics industry. Logistics technologies are classified into four types: data acquisition technologies, information technologies, warehousing technologies, and transportation technologies. The influencing factors include internal and external factors. Regression analysis is used to analyze the influences of these factors on technological innovation.

Findings – The innovation in logistics technologies is significantly positively influenced by organizational encouragement, quality of human resources, environmental uncertainty, and governmental support for logistics service providers in China.

Originality/value – Owing to the lack of empirical research on the adoption of logistics technologies in China, this paper provides an empirical study on the factors influencing the innovation in logistics technologies by logistics service providers in China. Our research results can help China's logistics companies develop better strategies to adopt innovative logistics technologies, and can make them become innovation-based logistics service providers.

Keywords Innovation, Distribution management, China

Paper type Research paper

Introduction

One key to effective supply chain is to make the logistics function more efficiently (Bowersox *et al.*, 2002). The globalization of supply chain has prompted many firms to develop logistics as a part of their corporate strategy (McGinnis and 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 service providers to satisfy increasing need for logistics services (Lieb and Miller, 2002). China is now the world's largest manufacturing base as well as the world's largest market. Owing to the fast growth in China's economy and China's accession into WTO, the demand for logistics services has been growing significantly in China. As China continues to develop into a global manufacturing factory, China's logistics industry will play an important role in the global supply chain (Jiang, 2002). The logistics industry in China is set to take off, and the total logistics value has grown by 29.9 percent year-on-year (China Distribution & Trading, 2005). New modern

Journal of Technology Management in China
Vol. 2 No. 1, 2007
pp. 22-37

1746-8779
DOI 10.1108/17468770710723604

facilities such as logistics parks, distribution centers and warehouses are being built at a record setting pace. However, Ta *et al.* (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. To overcome these barriers, logistics service providers should invest extensively in information and logistics technologies.

The survival of an enterprise in the age of knowledge-based economy depends on how to improve their technological innovation capability. Many studies have found that adopting technological innovations is the most important tool for enterprises to keep their competitive advantage (Kimberly and Evanisko, 1981; Damanpour and Evan, 1984). Therefore, the innovation in logistics technologies is a key variable and means of differentiation between logistics service providers (Sauvage, 2003). Some studies revealed that to fully satisfy the diversifying requirements of customers, logistics service providers should improve their service efficiency by continuous adoption of information or automation technologies (Mason-Jones and Towill, 1999; Sauvage, 2003). Nixon (2001) suggested that logistics service providers should employ 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. Chapman *et al.* (2003) suggested that the 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. Adopting innovative logistics technologies might enable logistics service providers to enhance their service abilities. However, most research about technology adoption and innovation focused on manufacturing industries though increasing attention has been paid to technological innovation in service industries recently (Gallouj, 2002; Howells and Tether, 2004; Miles, 2004).

We can conclude that it is important for China's logistics service providers to adopt technological innovations to improve their process efficiency and provide better logistics services. Most operations in China's logistics service providers 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 service providers 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. When logistics service providers draw up strategies for adopting technological innovations, they should know what factors will influence the innovation in logistics technologies. However, there is still a lack of empirical research on technological innovation for China's logistics industry. Therefore, the main purpose of this paper is to explore the factors affecting the innovation in logistics technologies by the logistics industry in China. The next section presents the theoretical foundations of the factors affecting technological innovation and the following section introduces a summary of innovation in logistics technologies. Fourth section gives a description of the research methodology, while fifth section focuses on the analysis of the results and

the discussion of the findings. The final section gives conclusions and research's implications.

Theoretical foundations

Companies can achieve competitive advantage through acts of innovation, and they can approach innovation in its broadest sense, including both new technologies and new ways of doing things (Porter, 1990). What is innovation? A variety of definitions has been addressed. Drucker (1985) defined innovation as the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or service. It is capable of being presented as a discipline, capable of being learned, and capable of being practiced. Betz (1997) assumed that innovation is to introduce a new or improved product, process, or service into the marketplace. Tidd *et al.* (1997) defined innovation as a process of turning opportunity into new ideas and putting these into widely used practice. Afuah (1998) proposed that innovation is the use of new technical and administrative knowledge to offer a new product or service to customers. Therefore, we can conclude that innovation is any practices that are new to organizations, including equipments, products, services, processes, policies and projects (Kimberly and 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 and Boise, 1974; Downs and Mohr, 1976). Among numerous typologies of innovation advanced in the relevant literature, the pair of types of innovation, administrative and technological (or technical) innovations, 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 and 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 and Evanisko, 1981; Damanpour and Evan, 1984). This paper will focus on technological innovations in the logistics industry.

There are many researchers studying the determinants or influencing factors on innovation (Kimberly and Evanisko, 1981; Amabile, 1988; Tornatzky and Fleischer, 1990; Damanpour, 1991; Wolfe, 1994; Tidd *et al.*, 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 *et al.* (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.

Based on the related literature, a number of factors influencing the innovation in technologies can be found, including individual (Kimberly and Evanisko, 1981;

Amabile, 1988), technological (Teece, 1996; Chau and Tam, 1997), organizational (Kimberly and Evanisko, 1981; Amabile, 1988; Tornatzky and Fleischer, 1990), and environmental (Tornatzky and Fleischer, 1990; Damanpour, 1991) factors. Although the individual and technological factors might affect the technological innovation for logistics service providers, this paper will not investigate individual and technological influences on the company's innovation in logistics technologies. In this paper, we will only study the technological innovation from the "macro" perspective. The factors will be classified into internal factors and external factors respect to a firm. The research framework of this paper is shown in Figure 1.

Internal factors

Many researchers have argued that certain features of organizations themselves, including structures, climates, and cultures of organizations, will influence the adoption of innovation (Kimberly and Evanisko, 1981; Kanter, 1988; Fink, 1998; Thong, 1999; Dholakia and Kshetri, 2004; Russell and Hoag, 2004). Amabile (1988) found that the management skills, organizational encouragement for innovation, and support of innovation resources would help the improvement of 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 abilities in technological innovation. This paper, therefore, suggests that the innovation in logistics technologies for logistics service providers will be influenced by the internal factors including organizational encouragement and quality of human resources. The following hypotheses are consequently proposed:

- H_1. The more the organizational encouragement, the more likely that China's logistics service providers will adopt innovation in logistics technologies.
- H_2. The higher the quality of human resources, the more likely that China's logistics service providers will adopt innovation in logistics technologies.

External factors

The external environment in which a firm conducts its business will also influence the innovative capability (King and Anderson, 1995). Scupola (2003) suggested that external environment including pressure from competitors and role of government would affect the adoption of internet commerce by small and medium size enterprises. Miles and Snow (1978) found that organizations would pay more attention on

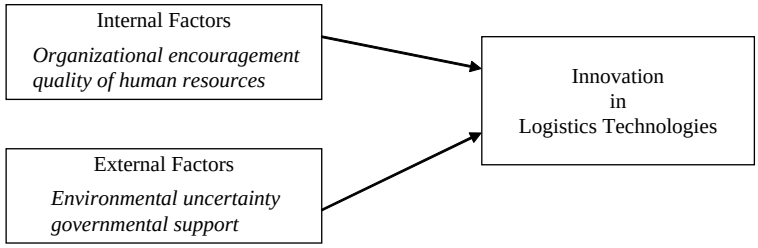

Figure 1.
Research framework

innovation when they faced environments with higher instability and chaos. Kimberly and Evanisko (1981) concluded that 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 tended 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 and Fleischer, 1990; Lai *et al.*, 2005). This paper, therefore, suggests that the innovation in logistics technologies for logistics service providers will be influenced by the external factors including environmental uncertainty and governmental support. The following hypotheses are consequently proposed:

H_3. The more the environmental uncertainty, the more likely that China's logistics service providers will adopt innovation in logistics technologies.

H_4. The more the governmental support, the more likely that China's logistics service providers will adopt innovation in logistics technologies.

Innovation in logistics technologies

The so-called "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. The council of logistics management (currently, council of supply chain management) in USA defines "logistics management" as "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 and Closs, 1996). Logistics has become an important source of competitive advantage (Day, 1994; Olavarrieta and Ellinger, 1997). Owing to the emergence of the concept of supply chain management, logistics management has attracted more and more attention. Logistics management has become a strategic factor that provides a unique competitive advantage (Christopher, 1993). A supply chain includes all the interactions between suppliers, manufactures, distributors, and customers. The chain includes transportation, scheduling information, cash and credit transfers, as well as ideas, designs, and material transfers. Logistics service providers play an important role in the supply chain. One of the keys to effective supply chain management is to make the logistics function more efficiently in the supply chain (Bowersox *et al.*, 2002).

A logistics service provider is a provider of logistics services that performs all or part of a client company's logistics function (Coyle *et al.*, 1996; Delfmann *et al.*, 2003). To fully satisfy the increasing requirements of customers for one-stop services, many logistics service providers have taken initiatives to broaden the scope of their services (Murphy and Daley, 2001). In addition to transportation and warehousing functions, logistics service providers can also provide other services such as materials management services, information-related services, and value-added services (Berglund *et al.*, 1999). Recently, many logistics service providers try to improve their operation efficiency by continuous implementation of information or automation

technologies according to their business characteristics (Mason-Jones and Towill, 1999; Sauvage, 2003). The operation processes in logistics service providers, such as distribution centers, have their own features and know-how knowledge. It is important for logistics service providers, in this age of knowledge-based economy, to accumulate and use their skills and knowledge efficiently and consistently. In order to keep the competitive advantage, logistics companies must make use of knowledge more efficiently to make them become innovation-based logistics service providers (Chapman *et al.*, 2003).

Technology has traditionally been viewed as the key to productivity in manufacturing; however, technology has assumed greater significance in services recently (Bitner *et al.*, 2000; Howells and Tether, 2004). Technology enables service firms to improve service efficiency and effectiveness. Based on the above discussion about innovation, we think that innovation is a process of turning opportunity into new ideas and of putting these into widely used practice. According to the logistics activities, innovation in logistics technologies can be classified into four categories: data acquisition technologies, information technologies, warehousing technologies, and transportation technologies.

Data acquisition technologies

Logistics service providers usually deal with a large amount of goods and data. Data collection and exchange are critical for logistics information management and control. Good quality in data acquisition can help logistics service providers deliver customers' goods more accurately and efficiently. The bar code system and radio frequency identification system (RFID) are data acquisition technologies that can facilitate logistics data collection and exchange.

Information technologies

Information technologies are the devices or infrastructures to make communications of business information among several organizations more efficiently. Many logistics managers see the information technology as a major source of improved productivity and competitiveness. Information technologies may increase organizational productivity, flexibility and competitiveness as well as stimulate the development of inter-organizational networks (Prasad and Sounderpandian, 2003). The information technologies that are commonly used in the logistics industry include electronic data interchange (EDI), the Internet, value added network (VAN), point of sales (POS), electronic ordering system (EOS), logistics information system, computer telephony integration, and enterprise information portals. EDI is identified as inter-company computer-to-computer exchange of business documents in standard formats. Recently, extensible markup language (XML) provides a more efficient way for data exchange.

Warehousing technologies

A warehouse is typically viewed as a place to store inventory. However, in many logistical systems, the role of the warehouse is more properly viewed as a switching facility as contrasted to a storage facility. Warehousing plays an important role in a logistical system. The design of a warehousing management system should address physical facility characteristics and product movement. The warehousing technologies that are commonly used in the logistics industry include automated storage and

retrieval system (AS/RS), automatic sorting system, computer-aided picking system, and thermostat warehouse. The automated storage and retrieval system is a mean to high density, hands free buffering of materials in distribution and manufacturing environments and can offer a quick and efficient way to search and move storages from a warehouse.

Transportation technologies

Transportation is one of the most visible elements of logistics operations. Transportation provides the major function of product movement. The major objective of a transportation management system is to move product from an origin location to a prescribed destination while minimizing costs and damage expenses. The movement, at the same time, must take place in a manner that meets customer demands regarding delivery performance and shipment information availability. The transportation technologies that are commonly used in the logistics industry include transportation information system, global positioning system (GPS), geographical information system (GIS), radio-frequency communication system, and transportation data recorder. The transportation information system and geographical information system can help logistics managers planning, managing and controlling transportation issues. The global positioning system, and radio-frequency communication system can track and guide drivers during the transportation of products.

Methodology

Measures

The present research framework will be tested from the questionnaire survey in China's logistics industry. The questionnaire contains questions about internal factors, external factors, the adoption of innovation in logistics technologies, and company's basic information. Except the company's basic information, the other items were measured using the five-point Likert scales anchored by "strongly disagree" and "strongly agree".

The willingness to innovate or acquire new logistics technologies was used as measurements of adoption of technological innovation. Based on the theory of planned behavior (Ajzen, 1985) or the technology acceptance model (Davis, 1989), the intention of acquiring innovative logistics technologies may have positive influences on the actual behavior in acquiring the technologies. This paper assumes that logistics service providers will tend to innovate or acquire new logistics technologies when they have strong willingness. In addition, the utilization of new logistics technologies was also asked in the questionnaire to investigate the application of logistics technologies for the logistics industry in China.

Organizational encouragement was measured according to the degrees that companies' resource supports and leaders' attitudes. Quality of human resources was measured according to employees' information skills and innovation capabilities. Customers' requirements, competitors' innovative abilities, and development of logistics technologies were used to measure the environmental uncertainty. Governmental support was measured from the perspective of finance, technology, law and human resources.

Data collection and sample

As China has become 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. New modern facilities such as logistics parks, distribution centers and warehouses are being built at a record setting pace. More and more logistics companies in China begin to adopt new logistics technologies 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.

The data to test our hypotheses came from a questionnaire survey of logistics service providers in China. The sample frame was drawn from members of the logistics councils in Beijing, Shanghai and Shenzhen regions because the development of logistics service providers 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 twenty-first century.

Totally 500 questionnaires were mailed and/or delivered directly to the sampled companies in each region from June to August in 2005. In order to get a higher response rate, we also personally delivered questionnaires to several logistics companies in each area. In total, we delivered 1,500 questionnaires and 583 completed questionnaires were returned, 163 in Beijing, 201 in Shanghai and 219 in Shenzhen. Of these respondents, 26 uncompleted or unconfident questionnaires were excluded. The overall response rate is 37.1 percents. The basic information of these companies is shown in Table I. It can be found that most of logistics service providers in China do not establish the R&D department. Only about 4 percent of the sampling companies have R&D

	Category	Total (557)	Beijing (153)	Shanghai (192)	Shenzhen (212)
Company history (years)					
	0 ~ 5	389 (69.8)	106	129	154
	6 ~ 10	123 (22.1)	35	48	40
	11 ~ 20	35 (6.3)	19	12	14
	Above 20	10 (1.8)	3	3	4
Number of employee	Below 50	204 (36.6)	53	70	81
	51 ~ 100	186 (33.4)	54	62	70
	101 ~ 300	103 (18.5)	29	31	43
	301 ~ 500	43 (7.7)	11	20	12
	Above 501	21 (3.8)	6	9	6
Capital (million, RMB Yuan)					
	Below 1	133 (23.9)	36	48	49
	1 ~ 5	184 (33.0)	51	69	64
	5 ~ 10	117 (21.0)	33	47	37
	10 ~ 50	76 (13.7)	17	13	46
	Above 50	47 (8.4)	16	15	16
R&D department	Yes	23 (4.1)	8	9	6
	None	534 (95.9)	145	183	206

Note: Figures in parenthesis are percentages

Table I.
Basic information of the sample

department. In China, most logistics companies belong to small and medium size enterprises.

Based on the above illustrations about the innovation in logistics technologies, logistics technologies are divided into four categories: data acquisition technologies, information technologies, warehousing technologies, and transportation technologies. This paper asked the logistics service providers what kinds of innovative logistics technologies they acquired during the past three years. A summary of the adoption of technological innovations by logistics service providers in China is shown in Table II. It can be found that almost all respondents acquired innovative information technologies during the past three years. This might be caused by the rapid growth in information and communication technologies over the past decade and by the urgent needs for logistics companies to deal with a great amount data. However, only about one half of the respondents acquired innovative data acquisition technologies such as bar code or RFID technologies.

Results and discussions

In this study, the measured scales were submitted to factor analysis. Factors with eigenvalues greater than 1.0 for each context are summarized in Tables III and IV.

Table II.
Adoption of technological innovations by China's logistics service providers

Logistics technologies	Total ($N = 557$)	Beijing (153)	Shanghai (192)	Shenzhen (212)
Data acquisition technologies	312 (56.0)	83	115	114
Information technologies	529 (94.9)	141	182	206
Warehousing technologies	411 (73.8)	115	146	150
Transportation technologies	493 (88.5)	137	172	184

Note: Figures in parenthesis are percentages

Table III.
Results of factor analysis for internal factors

Items	Factor loading (standardized) Factor 1	Factor 2
Organizational encouragement (Factor 1)		
Companies provide supports for employees to learn new information	0.858	0.104
Companies' leaders encourage employees to learn new information	0.837	0.123
Companies provide rewards for innovative employees	0.801	0.089
Companies' leaders can help employees when they face new problems	0.754	0.101
Companies have precise innovation strategies	0.710	0.098
Quality of human resources (Factor 2)		
Employees can learn new technologies easily	0.099	0.820
Employees possess abilities to use technologies to solve problems	0.108	0.781
Employees can share knowledge with each others	0.126	0.743
Employees usually provide new ideas for companies	0.154	0.706
Eigenvalue	4.603	2.421
Variance explained (percent)	36.211	31.098
Accumulated variance explained (percent)	36.211	67.309
Cronbach's α for each dimension	0.8974	0.7843
Cronbach's α	0.8416	

Items	Factor loading (standardized)	
	Factor 1	Factor 2
Governmental support (Factor 1)		
Government provides financial support for the development of logistics technologies	0.863	0.094
Government relieves the regulation for the logistics industry	0.837	0.102
Government help training manpower with logistics skills	0.801	0.086
Government encourages companies to propose projects of logistics technologies	0.784	0.073
Environmental uncertainty (Factor 2)		
Customers' requirements vary quickly	0.094	0.831
Customers' requirements are diversified	0.103	0.809
The advance in new logistics technologies is quickly	0.098	0.742
Competitors usually provide new logistics services	0.112	0.693
Eigenvalue	4.221	2.065
Variance explained (percent)	38.709	33.906
Accumulated variance explained (percent)	38.709	72.615
Cronbach's α for each dimension	0.8878	0.8027
Cronbach's α	0.8395	

Table IV.
Results of factor analysis for external factors

The reliability analysis was also conducted. According to the reliability coefficients, the smallest value of Cronbach's α for this study is 0.7843. The overall reliability is 0.8407. This implies that the sampling results are reliable (Nunnally, 1978). Based on the results of factor analysis, we can confirm the construct validity of this study. The internal factor can be classified into organizational encouragement and quality of human resources, and the external factor can be classified into environmental uncertainty and governmental support. Table V shows the correlations among these factors and the innovation in logistics technologies. The correlation result gives us initial evidences of our hypotheses: organizational encouragement, quality of human resources, environmental uncertainty, and governmental support are positively associated with the adoption of technological innovations. Moreover, these influencing factors are not highly correlated.

In order to find the influence of internal and external factors on the innovation in logistics technologies, the method of multiple regression analysis was used in this study. Based on the above results obtained by the method of factor analysis, the internal factors contain organizational encouragement and quality of human resource, and the external factors contain environmental uncertainty and governmental support. This paper took these four factors as independent variables and the adoption of

Variable	1	2	3	4	5
1. Organizational encouragement	1.00				
2. Quality of human resources	0.13	1.00			
3. Environmental uncertainty	0.04	0.01	1.00		
4. Governmental support	0.10	0.11	0.05	1.00	
5. Innovation	0.60**	0.63**	0.53*	0.66**	1.00

Notes: *$p < 0.05$; **$p < 0.01$

Table V.
Results of correlation analysis

innovative logistics technologies as the dependent variable, and consequently, employed the method of multiple regression analysis to determine their relationship. Moreover, company history, number of employee, capital size, and establishment of R&D department are taken as the control variables in the multiple regression analysis.

Based on the standardized results of the multiple regression analysis shown in Table VI, it can be found that both internal and external factors have positive influences on the innovation in logistics information systems. Except the establishment of R&D department, other control variables do not have significant influences on the adoption of new logistics information systems. The establishment of R&D department has significant influences on the innovation in logistics technologies (p-value < 0.1). This means that logistics service providers who establish R&D departments should have stronger willingness to adopt new logistics technologies.

The overall regression equation for model 2 is significant. Organizational encouragement, quality of human resources, environmental uncertainty, and governmental support all have significant influences on the innovation in logistics technologies for China's logistics service providers. This means that the hypotheses, *H1*, *H2*, *H3*, and *H4* are not rejected. It can be concluded that the innovation in logistics technologies will be reinforced for logistics companies if they have higher quality of human resources and can provide better support to encourage organizational innovation. Organizational encouragement can give employees motivation and support to adopt technological innovation. High quality of human resources means that employees are capable of innovation in technologies. The governmental support will also improve innovation in information technologies for logistics service providers. Governmental support can encourage and guide logistics service providers to innovate in logistics technologies. The positive effect of environmental uncertainty on technological innovation reveals that China's logistics service providers want to adopt innovative logistics technologies to overcome the challenges of environmental

	Dependent variables: innovation in logistics technologies			
	Model 1	Model 2		
Predictors	Coefficient β	t	Coefficient β	T
Control variables				
Company history	0.012	0.601	0.009	0.571
Number of employee	0.040	1.142	0.031	0.992
Capital	0.041	1.439	0.032	1.335
R&D department	0.056	1.851*	0.051	1.693*
Internal factors				
Organizational encouragement			0.210	3.727***
Quality of human resources			0.203	3.618***
External factors				
Environmental uncertainty			0.192	2.109**
Governmental support			0.219	3.954***
R^2	0.100	0.601		
Adj R^2	0.074	0.493		
F	1.002	7.184**		
Durbin-Watson value	1.674	1.711		

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table VI.
Standardized regression results

uncertainties. Innovative logistics technologies will be helpful for them to provide flexible logistics service to satisfy customers' varying requirements.

Conclusions

This paper analyzes the influences of internal and external factors on the innovation in logistics technologies for logistics service providers in China. Since, 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 policies of the China's government. To improve their logistics services, many logistics companies 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 logistics technologies in China. This paper provides an empirical study on the factors affecting of the adoption of technological innovations by the logistics industry in China.

From the research results, it can be found that most logistics service providers in China begin to place emphases on the innovation in logistics technologies, especially information technologies. There is a trend that logistics companies in China will rely more on information technologies to enhance their logistics service performance. This paper categorizes the factors influencing innovation in logistics technologies into internal and external; the internal factor includes organizational encouragement and quality of human resources, and the external factor includes the environmental uncertainty and governmental support. The statistical analysis results reveal that these factors all have significant positive influences on the innovation in logistics technologies for logistics service providers in China.

Based on our research about innovation in logistics technologies for the logistics industry in China, China's logistics service providers can draw up better strategies to construct their technological innovation systems and to make them become innovation-based logistics service providers. Logistics service providers in China can improve their innovative abilities in logistics technologies by training and educating their employee to become high quality of human resources. These logistics companies and their leaders should also provide better support and resources to encourage technological innovation. Moreover, the government should give strong support for logistics industry in adopting innovative logistics technologies. The government can draw up public policies to encourage private sector performance improvements through trade and inter-modal policies, infrastructure investment and development, creative financing arrangements, tax incentives, safety regulation, public/private partnerships, and special programs and projects (Morash and Lynch, 2002). The innovation will be reinforced for logistics companies if the government can provide various supports of innovation resources and continuous encouragement policies. The government can provide financial incentives, pilot projects, and tax breaks to stimulate innovation in logistics technologies for the logistics industry.

This paper conducted a survey on China's logistics service providers and showed that organizational encouragement, quality of human resources, environmental uncertainty, and governmental support all have significant positive influences on the adoption of innovative logistics technologies for logistics service providers in China. 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 internal and external factors on technological innovation. It will be worthwhile to advance a cross-national comparative study on innovation in logistics technologies among logistics service providers in China and those in other countries. In addition, there are some limitations to our research. Because we used a mail survey, it is possible that the results of this study might suffer from respondent bias. This study focused on the influences of internal and external factors on the innovation in logistics technologies. Other factors such as individual, cultural and technological context might have influences on the innovation in logistics technologies. Future research can take these factors into account.

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