Influences of Individual, Organizational and Environmental Factors on Technological Innovation in Taiwan’s Logistics Industry

Dr. Chieh-Yu Lin, Department of International Business, Chang Jung Christian University

ABSTRACT

This paper studies the factors influencing technological innovation in Taiwan’s logistics industry. Based on the results of reviews of related literatures and interviews to some experts, a questionnaire is developed to survey the technological innovation for logistics industry in Taiwan. In this study, 114 logistics service providers in Taiwan are investigated. Individual, organizational, and environmental are taken as the determinants of technological innovation. The method of factor analysis is used to find some major configurations of influencing factors. The innovation in logistics technologies can be classified into four types: data acquisition technologies, information technologies, warehousing technologies, and transportation technologies. It can be found that individual, organizational and environmental factors have significant influences on technological innovation for the logistics industry. Based on this study about technological innovation for logistics service providers, logistics companies can develop better strategies to construct their technological innovation systems and to make them become innovation-based logistics service providers.

Keywords: Technological innovation, Logistics technologies, Logistics service providers, Determinants of innovation.

INTRODUCTION

The rapidly changing and uncertain environment makes enterprises face the biggest challenge that how to capture their competitive advantage in this age of knowledge-based economy. Innovation is one of the important tools for enterprises to keep their competitive advantage (Kimberly & Evanisko, 1981; Damanpour & Evan, 1984). The survival of an enterprise depends on how to improve their technological innovation capability.

Logistics industry plays an important intermediate role in the supply chain systems, which can integrate functions of business flow, physical flow, money flow, and information flow in a supply chain. Most operations in the logistics service processes require a large number of service workers, and thus logistics industry belongs to a labor-intensive industry. Nowadays, how the logistics service providers can be transformed from labor-intensive 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 in order to promote the competence of organizations, are the topics worth taking into deep consideration in the age of knowledge-based economy.

However, only a little research about technological innovation for the logistics industry has been illustrated (Chapman, Soosay & Kandampully, 2003). This paper therefore will study the topic about technological innovation for the logistics industry. The main purpose of this paper is to explore the factors influencing technological innovation for the logistics service providers. The study is conducted in Taiwan. This region is interesting because Taiwan is one of the important sources of electronic hardware products in the world and logistics is one of the key success factors of Taiwan (Shan & Marlow, 2005). Moreover, due
to the trend of globalization, Taiwan’s government delivered several policies to make Taiwan become a global logistics center. Many logistics companies in Taiwan begin to adopt new technologies because of global logistics policies.

TECHNOLOGICAL INNOVATION

What is “innovation”? 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, capable of being practiced. Porter (1990) said “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.”

Innovation is the use of new technical and administrative knowledge to offer a new product or service to customers. The knowledge is new because the firm has never used it before or because it used it but only for applications unrelated to the one for which the new product is earmarked. 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. Often the new product or service itself is called an innovation, reflecting the fact that it is the creation of new technical or administrative knowledge, or it is new 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 & Evanisko, 1981; Damanpour, 1991).

Past research has argued that distinguishing types of innovation is necessary to understand 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) innovations (Damanpour, 1991). Technological innovations pertain to products, services, and production process technology; they are related to basic activities and can concern either product or process (Knight, 1967; Damanpour & Evan, 1984). Administrative innovations involve organizational structure and administrative processes; they are indirectly related to the basic work activities of an organization and are more directly related to its management (Knight, 1967; Kimberly & Evanisko, 1981; Damanpour & Evan, 1984). This paper will focus on the technological innovation for logistics service providers.

INNOVATION IN LOGISTICS TECHNOLOGIES

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. The Council of Logistics 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 & Closs, 1996).

Due 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, 1983). A supply chain includes all the interactions between suppliers, manufactures, distributors, and customers. Supply chain management is the integration of the activities that procure materials, transform them into intermediate goods and final products, and deliver them to customers. These activities include the traditional purchasing function, plus many other activities that are important to
the relationship with suppliers and distributors. The term supply chain management as currently used typically includes the construction of information system and the preservation of partner relationships to reinforce the supply, storage, and movement of materials, information, personnel, equipment, and finished goods within the organization and between it and its environment. One of the keys to effective supply chain management is to make the logistics function more efficiently in the supply chain and consequently logistics service providers play an important role in the supply chain (Bowersox, Closs, & Cooper, 2002).

Many logistics service providers 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). 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).

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. Technological innovation pertains to products, services, and production process technologies; they are related to basic activities and can concern either product or process (Knight, 1967; Damanpour & Evan, 1984). According to the logistics activities, the 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 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. The information technologies that are commonly used in 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. Electronic data interchange 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 warehouse management system should address physical facility characteristics and product movement. The warehousing technologies that are commonly used in 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. There are several classes of AS/RS that are characterized by weight and size.
handling characteristics. Automated storage and retrieval system can offer a quick and efficient way to search and move storages from a warehouse. Computer-aided picking system increases the accuracy and efficiency of picking orders in a warehouse environment. This system virtually eliminates both shipment errors due to incorrect picking and billing errors due to incorrect invoicing. Additionally for companies having to track serial numbers, it eliminates the need to ever have to manually record a serial number.

**Transportation technologies**

Transportation is one of the most visible elements of logistics operations. Transportation functionality 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 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.

**DETERMINANTS OF INNOVATION**

There are many researches studying the determinants or influencing factors on innovation (Kimberly & Evanisko, 1981; Amabile, 1988; Damanpour, 1991; Wolfe, 1994; Tidd et.al, 1997) Three kinds of influencing factors on technological innovation will be used in this paper. They are individual, organizational, and environmental factors.

**Individual factors**

Kimberly and Evanisko (1981) found that the technological innovation would be influenced by the individual factor for manufacturing industries. The individual factor in this paper includes the variable about the individual adaptability to changes or challenges in jobs and the variable about the individual attitude to assigned jobs (Amabile, 1988; Kanter, 1988). An employee with higher adaptability or positive attitude will have stronger innovation ability. Consequently, we predict the following:

\[ H_1: \text{Individual factors will influence the technological innovation for logistics service providers.} \]

\[ H_{1a}: \text{The higher the individual adaptability, the more likely that the logistics service provider will adopt technological innovation.} \]

\[ H_{1b}: \text{The more positive the individual attitude, the more likely that the logistics service provider will adopt technological innovation.} \]

**Organizational factors**

Many researches have argued that certain features of organizations themselves, including structures, climates, and cultures of organizations, will influence the adoption of innovation (Kimberly & Evanisko, 1981). Ambile (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 ability in technological innovation. This study will investigate
the influence of organizational encouragement and quality of human resources on the technological innovation for logistics service providers, and therefore, the following hypothesis is proposed:

\( H_2: \) Organizational factor will influence the organizational innovation for logistics service providers.

\( H_{2a}: \) The more the organizational encouragement, the more likely that the logistics service provider will adopt technological innovation.

\( H_{2b}: \) The higher the quality of human resources, the more likely that the logistics service provider will adopt technological innovation.

Environmental factor

Damanpour (1996) found that environments with high uncertainties would have positive influence on the relationship between organizational structures and organizational innovation. 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). This paper, therefore, suggests that the technological innovation for logistics service providers will be influenced by the environmental factor including environmental uncertainty and governmental support. The following hypothesis is consequently proposed:

\( H_3: \) Environmental factors will influence the technological innovation for logistics service providers.

\( H_{3a}: \) The more the environmental uncertainty, the more likely that the logistics service provider will adopt technological innovation.

\( H_{3b}: \) The more the governmental support, the more likely that the logistics service provider will adopt technological innovation.

RESEARCH METHODS

Research framework

Based on the above discussions, the research framework is organized around the three main hypotheses, as shown in Figure 1.

Data Collection and Sample

Data were collected in Taiwan by means of a questionnaire mailed to logistics service providers. The questionnaire contains four parts: questions about individual factor, organizational factor, environmental factor, and organizational innovation. There are 47 questions in that questionnaire. Besides the company’s information, the other items were measure using the 5-point Likert scales anchored by 'strongly disagree'
and ‘strongly agree’. The willingness to innovate or acquire new technologies and the utilization of innovative technologies were used as measurements of adoption of technological innovation.

The sample frame was drawn from members of the Logistics Council in Taiwan and the Internet which was used to search companies whose business models conforming to the logistics services. 400 questionnaires were mailed to the selected sampling companies. In total, 122 completed questionnaires were returned. Of these respondents, 8 uncompleted or unconfident questionnaires were excluded. The overall response rate is 28.5%. The basic information of the sample companies is shown in Table 1.

Table 1. Basic Information of the Sample

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company history (Years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5</td>
<td>31</td>
<td>27.2%</td>
</tr>
<tr>
<td>6–10</td>
<td>26</td>
<td>22.8%</td>
</tr>
<tr>
<td>11–20</td>
<td>35</td>
<td>30.7%</td>
</tr>
<tr>
<td>Above 20</td>
<td>22</td>
<td>19.3%</td>
</tr>
<tr>
<td>Number of employee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 50</td>
<td>21</td>
<td>18.4%</td>
</tr>
<tr>
<td>51–100</td>
<td>22</td>
<td>18.4%</td>
</tr>
<tr>
<td>101–300</td>
<td>24</td>
<td>21.0%</td>
</tr>
<tr>
<td>301–500</td>
<td>26</td>
<td>22.8%</td>
</tr>
<tr>
<td>Above 501</td>
<td>21</td>
<td>18.4%</td>
</tr>
<tr>
<td>Capital (Million, NT Dollars)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 5</td>
<td>21</td>
<td>18.4%</td>
</tr>
<tr>
<td>5–10</td>
<td>24</td>
<td>21.0%</td>
</tr>
<tr>
<td>10–50</td>
<td>30</td>
<td>26.3%</td>
</tr>
<tr>
<td>50–500</td>
<td>22</td>
<td>18.4%</td>
</tr>
<tr>
<td>Above 500</td>
<td>17</td>
<td>14.9%</td>
</tr>
<tr>
<td>R&amp;D department</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>40</td>
<td>35.1%</td>
</tr>
<tr>
<td>None</td>
<td>74</td>
<td>64.9%</td>
</tr>
</tbody>
</table>

It can be found that most of logistics service providers do not establish the R&D department. Only about 35 percent of the sampling companies have R&D department. Although there are only 35% of companies establish R&D department, most logistics service providers take innovation activities. This implies that organizational innovation is an important topic for logistics industries. According to the reliability analysis, the smallest value of Cronbach’s alpha for this study is 0.6742. This implies that the present sampling results are reliable.

RESULTS AND DISCUSSIONS

In order to find the influence of individual, organizational, and environmental factors on the technological innovation, the methods of factor analysis and regression analysis were used in this study. By using the method of factor analysis, the individual factor can be classified into individual adaptability and individual attitude; the organizational factor can be classified into organizational encouragement and quality of human resource; the environmental factor can be classified into environmental uncertainty and governmental support. We took these six factors as independent variables and the adoption of innovative logistics technologies as the dependent variable. Table 2 shows the results of regression analysis. It can be found that both overall regression equations for technological innovations are significant, but the three factors have different influencing effects. Individual attitude, organizational encouragement, quality of human resource and governmental support exhibit significant influences on the innovation in logistics technologies. This means that the hypotheses, $H_{1b}$, $H_{2a}$, $H_{2b}$, and $H_{3b}$ are not rejected, but the hypothesis $H_{1a}$ and $H_{3a}$ are rejected. This means that the hypotheses proposed by this paper are partly supported.
Table 2. Regression Results for the Determinants of Technological Innovation

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Coefficient $\beta$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.384</td>
<td>1.039</td>
</tr>
<tr>
<td>Individual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adaptability</td>
<td>0.126</td>
<td>1.123</td>
</tr>
<tr>
<td>Attitude</td>
<td>0.195</td>
<td>2.064*</td>
</tr>
<tr>
<td>Organizational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encouragement</td>
<td>0.172</td>
<td>4.328**</td>
</tr>
<tr>
<td>Human resource</td>
<td>0.141</td>
<td>4.617**</td>
</tr>
<tr>
<td>Environmental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainty</td>
<td>0.121</td>
<td>1.112</td>
</tr>
<tr>
<td>Government</td>
<td>0.183</td>
<td>2.651*</td>
</tr>
</tbody>
</table>

$R^2$ 0.489
$adj\ R^2$ 0.4328
$F$ 6.011**

* $p<0.05$  ** $p<0.01$

It can be concluded that individuals exhibit more positive attitude to assigned jobs can improve the innovation in logistics technologies for logistics service providers. 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. The governmental support will also improve innovation in logistics technologies for logistics service providers. The reasons that the hypothesis $H_{1a}$ and $H_{3a}$ are rejected may be due to the fact that most logistics service providers in Taiwan are small and medium size. Providing flexible logistics service to satisfy customers’ varying requirements is their major competence. Logistics companies with or without administrative and technical innovations should possess higher adaptability to changes or challenges, and environmental uncertainty is common to these logistics service providers. Therefore individual adaptability and environmental uncertainty do not have significant influences on the technological innovation for logistics service providers in Taiwan.

SUMMARY

Based on the research results, it can be found that most logistics service providers think that innovation is very important and try to reinforce their ability of innovation. The technological innovation for the logistics industry can be divided into four types: data acquisition technologies, information technologies, warehousing technologies, and transportation technologies. This paper divides the influencing factors on technological innovation into individual, organizational, and environmental categories. For logistics service providers, these factors have significantly positive influence on the technological innovation. Therefore, a logistics service provider can improve its innovation ability by improving employees’ attitudes and providing organizational encouragement and high quality of human resources. The government should also give strong support for logistics industry in technological innovation. This paper only studies the factors influencing technological innovation for Taiwan’s logistics industry. A study on the relationship between technological innovation and global supply chain performance will be conducted in the future.

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