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The Determinants of RFID Adoption in the Logistics Industry - A Supply Chain Management Perspective

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Abstract:

Despite the literature exploring the factors of adopting information technology (IT) applications for the logistics industry, Radio Frequency Identification (RFID) is still considered an innovative technology, because of its unique characteristics compared with other IT applications. To avoid the negative effects derived from careless IT investments, companies in Taiwan's logistics industry must evaluate the factors that could affect the adoption of RFID prior to its introduction. This research employed encoding and utilized a questionnaire survey with the aim of assessing the factors that affect the adoption of this technology within the industry. Based on the results of discriminant analysis and verification, this investigation found that competition in the marketplace, pressure of transaction partners, suppliers' industry environment, cost, integration of supply chain strategy, complexity of RFID, and mutual standard were among the critical factors. This research anticipates these factors as crucial and beneficial for the initial introduction phase of RFID adoption.

Keywords: Information Technology Adoption, Radio Frequency Identification (RFID), Supply Chain Management

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I. INTRODUCTION

Previous information technology applications commonly used in Supply Chain Management (SCM) activities and processes included Electronic Data Interchange (EDI), Global Positioning System (GPS), and BarCode, among others [Simchi-Levi et. al. 2000; Wu et al. 2006]. Since Wal-Mart's mandate at the beginning of 2003 regarding the use of Radio Frequency Identification (RFID) on the packaging of its top 100 suppliers' products from 2005 onward, as well as a tool to identify all of Wal-Mart's suppliers' products from December 2006, this technology has topped the priority list of potential applications employed by supply chain managers. Certainly, RFID has become one of the most important "innovative technologies" in the area of supply chain management. In fact, its applications had drawn much attention from business experts in recent years.

As an identification technique, RFID employs chips inserted in products, labels, receivers, and intermediary software of back-end systems with an electronic product code (EPC) on the label of each item. Due to the fact that an EPC's data length has expanded from the earlier 64 bits to the current 96 bits, RFID can be used not only to identify various products, including its different manufacturers, but also to keep track of the production process and sequence of activities from the material production of upstream companies to the ultimate delivery activity of their downstream counterparts. It is no wonder that in recent years, America, Japan, and developed countries in Europe have actively introduced RFID technology into their daily logistics operations and product distributions. These companies have employed RFID's unique characteristics to enhance the tracking of global products and perform immediate inventory control as a means to streamline their enterprises and increase managerial efficiency. Other realized benefits include cost reduction, as well as value and quality enhancement of the manufactured products. The logistics and manufacturing industries in Taiwan, not to mention its libraries and medical treatment facilities have likewise recognized the benefits of adopting and applying RFID.

Nonetheless, even with all the documented benefits of using RFID technology, the technique still remains in the "innovative application" phase, and its specific application to SCM activities remains unclear. In addition, the adoption of a flexible IT affects important factors, such as the organizational structure and managerial strategies of corporations, protocols related to the exchange and sharing of communication, procedures and relevant operation policies, the relationship between consumers and suppliers, and the capacity of bargaining [Bowersox and Daugherty 1995; Lewis and Talalayevsky 1997; Clemons and Row 1991; Gunasekaran et al. 2006; Ngai et al. 2007]. If logistics companies abruptly introduce RFID, they may encounter a number of managerial difficulties, such as conflicting business procedures and insufficient user experience.

At present, business enterprises and industries still lack the best model of introduction. As a result, the risk of applying RFID technologies within SCM activities is still high. Furthermore, even if RFID lives up to the hype, pressing questions remain: Will companies within Taiwan's logistics industry be more willing to invest in the adoption of this technology? What are the factors that will influence its adoption in logistics industry companies? Indeed, these are the challenges that Taiwanese companies must investigate to avoid any rash investments. Unfortunately, very little literature related to the management of RFID can be found. With this in mind, this study chose Taiwan's logistics industry as the main target, as we attempted to assess the current situation of RFID adoption within the industry, evaluate the factors affecting its adoption, and provide research findings as reference for practitioners in the industry and researchers in the academic field.

The objectives of this research include the following: (1) to identify the critical success factors could affect the adoption of RFID in the logistics industry, using the SCM perspective; and (2) to recognize the development of current RFID application in the logistics industry based on survey data on the current progress of its adoption in Taiwan.

There are five sections to this article. After an introductory section, the second section (theoretical background) elaborates on the inferences which comprise the theoretical foundation of this research. The third section consists of the research method and design. The fourth section introduces the data analysis and related discussion. Finally, the fifth section includes the conclusion and recommendations.

II. THEORETICAL BACKGROUND

This section covers the definition and unique dynamics specific to the industry of supply chain management, as well as the current situation of RFID's application in Taiwan. It is the authors' intention to use the encoding method to develop the research framework's prototype model.

Definition and Unique Characteristics of Supply Chain Management

The varying definitions of SCM in previous literature depend on the particular research topic in which it is discussed. For example, New and Payne [1995] mainly used the value chain to enhance the procedure of supply; thus, they defined SCM as "delivering the products to the hands of ultimate consumers through the connection of manufacture and supply processes." Others, like Christopher et al. [1998], used characteristics of transportation and logistics as the basis, thereby defining SCM as "the efficient delivery process of physical products from manufacturers to ultimate consumers." This study utilized a combination of these scholars' opinions, so that SCM now refers to "the integration of business procedures from ultimate consumers to the suppliers of upstream companies that offer products, service, and information."

As the supply chain is an integration of business procedures, it is generally comprised of two components: material management and physical distribution [Hokey and Gengui 2002; Wu et al. 2006). Material management is also called "inbound logistics" as it takes into consideration the materials' sources and added values. Thus, it supports the complete cycle of the logistics process, which includes purchasing, storing series such as inbound transportation, and distribution from product manufacture to the finished product [Johnson and Malucci 1999]. On the other hand, physical distribution, also called "outbound logistics," helps determine product collection from storing to points of sale and the actual process of distribution. The products might be directly distributed to retailers and the logistics centers (third party logistics providers), which subsequently transfer the products to yet another group of retailers. The procedure includes processes such as inventory and supplement, delivery, and the manner of distributing the products to the customers [Browerson and Closs 1996; Gunasekaran et al. 2006; Ngai et al. 2007].

Successful enterprises must be responsive to the integration of supply chain activities; they must also foster cooperation among its fellow members [Drucker 1998; Lamber and Cooper 2000]. Therefore, an effective SCM should aim to achieve the following characteristics [Hokey and Gengui 2002]: (1) the connection of the supply chain activities should not be a linear one-to-one relationship; instead, it should be a network of multi-enterprises; (2) the members of the supply chain should have a cooperative relationship in order to enhance additional value and trust among fellow enterprises; and (3) a reliance on the information shared among its members. From these, one could say that IT indeed plays an important role in fostering communication and trust among enterprises. The integration of supply chain activities and the cooperation of its members likewise reduce the bullwhip effect, inventory, and time of cycle, therefore improving the overall quality of the process [Levary 2000; Gunasekaran et al. 2006]. Arun et al. [2006] also found that integrated IT infrastructures enable firms to develop the higher-order capability of supply chain process integration. This capability allows firms to unbundle information flows from physical flows and share information with their supply chain partners which, in turn, create information-based approaches for superior demand planning, for the staging and movement of physical products, and for streamlining voluminous and complex financial work processes. More importantly, IT-enabled supply chain integration capability results in significant and sustained firm performance gains, particularly in the areas of operational excellence and revenue growth. With IT utilization possibly resulting in an upgrade of SCM efficiency, and with RFID being an IT application, business enterprises and industries would then expect RFID to reinforce SCM activities and processes.

Current Situation of RFID Applications in Taiwan

RFID is a technique that emerged following World War II. It garnered attention when in 2003, Wal-Mart announced that from the year 2005 onward, all packages for Wal-Mart products should be equipped with RFID capability. Since then, the technique has been the focus of many studies. It has three main components: label, aerial, and reader. Each RFID label is affixed with a reusable EPC for the products' recording-related data. Accordingly, RFID is superior to the BarCode in terms of its unique characteristics such as non-contact, large data memory, and reuse capability. For these distinctive benefits, RFID applications are significantly broad. At present, some industries in Taiwan implement this technique to improve production processes. One example is the automobile industry. Given that the assembly of an automobile includes various parts and requires complicated steps, auto companies use RFID chip labels to confirm assembly of each part and completion of each step. In the past, an RFID chip used to be costly; companies in the automobile industry would only assume this technique by taking advantage of its reusable application to save costs. However, reduced RFID costs obviously enabled low-cost units or disposable products to utilize this technology. Apart from the automobile industry, Taiwan's Yuen Foong Yu Paper Mfg. Co., Ltd. (YFY), one of Wal-Mart's packaging materials, suppliers also plans on developing RFID packages. Some of Taiwan's high tech manufacturers, such as chip plants and package factories, also apply RFID technology to track chips and other

items which are easily misplaced and/or stolen. Similarly, the medical industry and some libraries are also discussing the possibilities of RFID application in their line of work.

Aside from enterprises, some government units in Taiwan also plan on using RFID technology to improve their operational efficiency. For example, as it is the harbor and sea port authorities' responsibility to examine containers that enter their ports, Taiwan's sea port officials plan on employing an "e-seal" type of authentication using RFID, in order to improve container inspection efficiency. This answers the problem of misappropriation of the labor force necessary to move the products in and out of the container. Moreover, it serves as an efficient tool in examining numerous containers within limited working hours since the e-seal, which combines the steel cable and RFID chip, ensures that the containers will neither be opened nor its contents exchanged. At present, Singapore and China's Ta Lien harbor have applied the RFID technique.

So significant is this technology that international software giants such as Microsoft and HP have recognized the business potential of the "RFID back-end system" and even planned to implement this application In fact, an investment is being planned to house one of Microsoft's three RFID centers in Taiwan. According to Microsoft, such a venture is made mainly because Taiwan possesses the world's largest number of domestic PC manufacturers. Accordingly, the supply chain issues these companies face are complicated. The Taiwanese government is taking into account the acceleration of RFID technology development, since it is apparent that many prominent researchers and manufacturers, which regard Taiwan's status as an export-oriented country, readily advocate the RFID technique. However, its application requires a great deal of specialized knowledge which Taiwan, at this stage, may not yet possess. Compliance with RFID standards necessitate the introduction of additional product development resources from America. These, together with the integrated capacity of Indian software systems, are expected to assist Taiwanese manufacturers in actual implementation. In the same manner, HP recognized the demand for the RFID technique in the global marketplace, as typified by Taiwan. Thus, in April 2004, HP established the first RFID Center of Excellence in the Asia Pacific Zone in Taiwan and offered simulations and solutions for RFID system customization of the manufacturing and retailing industries. This practice further legitimized the efficiency of Supply Chain Management and reinforced the critical position of the Taiwanese industry in the global supply chain.

The logistics yearbook in Taiwan [2003] presented an environment analysis report on the promotion of RFID application in Taiwan, including a managed survey about RFID application scale in the area of logistics The yearbook demonstrated that RFID not only provided various beneficial results in the center of logistics, but also offered positive results with respect to the different targets and application fields in the supply chain. However, inclusion of several factors, such as degree of accuracy in tracking, costs, and product application, has led to the reasonable conclusion that RFID application in the logistics industry should be divided into four phases—container level, pallet level, case level, and item level—with the sequence of execution supposedly from containers to products. It is also worth mentioning that, among these four phases, the Auto-ID center [2002] identified RFID application onto the product item as the most critical influence to the retail industry. Yet the same source also revealed the less significant effect of RFID application within the logistics industry.

Taiwan is currently witnessing RFID application in its infancy. Regardless of the fact that the automobile industry has, for years, adopted RFID in their high-cost units, the technique's adoption in many other companies in the logistics industry is still in the nascent stage. With respect to the speed of RFID adoption, one must consider the myriad aspects of its application in the production area, as well as the results of empirical studies concluding that those companies looking to adopt this technology are cognizant of the fact that is still in its juvenile development phase. Moreover, some technical and cultural problems might also prolong or encumber RFID's evolution. Nevertheless, based on initial experimentation within the business industry, one can expect RFID's promotion of the SCM's information flow and error reduction of the upstream companies' estimation of demands [Lapide 2004]. In addition, the highly concentrated structure of the manufacturing industry and the promotion of the government's industry policy paves the way for RFID's infinite growth potential.

Developing the Research Framework

Due to the fact that there were various literature exploring the factors of adoption with regard to the application of innovative technology, this research initially employed "open coding" and "axial coding" to conduct the study. Furthermore, by means of a questionnaire, this research discerned the opinions of industry experts and official organizations, gradually developing the model of the research framework. The detailed content is presented in the sections discussed below.

Sources and Content of Data

In order to organize and code the factors of RFID adoption, gathering and reading related literature is essential. Below are the criteria used in the collection of literature. First, we sought to understand the terms *supply chain management, logistics, radio frequency identification (RFID)*, and *information technology* as used in article titles and

summaries. This was done through two approaches: English journal papers were searched in the ProQuest and SDOS database, while Chinese academic studies were acquired from exploration of the National Dissertation Web and National Library. Given that RFID is a kind of innovative technology and one of the supply chain technologies, this research used keywords related to the IT of SCM, EDI, interorganizational data system, saving of online data, e-commerce, methods of adoption, CASE technique, and data storage, before we further organized 27 technical literature as the sources of data. The factors of adoption we present here are the results of verification via quantitative research. The data content revealed different results according to specific research topics (see Table 1).

Table 1. Sources and Content of Technical Literature

Items	Topics	Literature	Numbers
1	Innovative technology	Rogers [1983], Kwon and Zmud [1987], Gatignon and Roberson [1989], Rogers [1995]	4
2	Information technology	Cooper and Zmud [1990], Thong [1999]	2
3	Supply chain technology	Patterson et al. [2003]	1
4	EDI	Premkumar et al.[1992], Saunders and Clark [1992], Bouchard [1993], Premkumar et al. [1994], Iayover et al. [1995], Premkumar et al. [1997], Chwelos et al. [2001], Kuan and Chau [2001]	8
5	Interorganizational data system	Grover [1993], Premkumar and Ramamurthy [1995], Bensaou and Venkatraman [1996]	3
6	Open system	Chau and Tam [1997]	1
7	Data saving online	Grover and Goslar [1993], Premkumar and Roberts [1999]	2
8	E-commerce	Mirchandani and Motwani [2001], Grandon and Pearson [2004]	2
9	Methods of adoption	Sauer and Lau [1997], Lyytinen [2003]	2
10	CASE technique	Premkumar and Potter [1995]	1
11	Data storage	Hwang H.G et al. [2004]	1
Total number of articles			27

Open Coding

Open coding is a method of analysis that names or classifies a phenomenon after careful examination. This research encoded the factors of adoption in the 27 previous studies and found 171 conceptualized results. Based on the definitions of adoption factors and after conducting decomposition, examination, comparison, conceptualization, and categorization, this research organized the 171 conceptualized results into 18 categories. For instance, the degree of competition in the marketplace (Table 2) was obtained through the keywords "competition, concentration, and pressure" among the 171 conceptualized results. The names of these 18 categories preexisted in the academic literature because most of them were, in fact, already completely developed concepts. According to Strauss and Corbin's [1991] statement, the advantage of citing preexisting names is that "when one uses these concepts, one not only has the useful concept for the research, but also possibly contributes to the extremely important concept." Furthermore, during execution of the "open coding" method, the researchers might be excessively subjective during the categorization process. Consequently, we obtained the adoption factors for different categories by encoding inconsistent time, a conjoint analysis, and a comparison of different personnel (three people).

Axial Coding

Axial coding is a complex process based on deduction, induction, constant questioning, and comparison as in open coding in order to connect sub-categories and categories. The purpose of having a connection of sub-categories and categories is actually to entail the existence of a certain relationship. For example, one can ask the following question: Under the condition of being "in pain," what is their strategy of "controlling the pain"? Hence, the two categories of "pain" and "controlling the pain" could be connected [Strauss and Corbin 1991].

In order to achieve the research objective, this investigation required the establishment of links among sub-categories and categories. This was accomplished by citing five dimensions (environment, organization, mission, individual, and innovative technology) of Roger's [1995] innovative expansion theory as the means of connection. However, the research also considered the overlap of individual dimension factors with the organizational dimension factors in some literature. For instance, the support of top executives was sometimes considered as an individual dimension and sometimes as an organizational dimension factor [Premkumar et al. 1997]. Therefore, based on these properties, this study divided a mere 18 adoption factors into three categories ("industry environment," "organization," and "characteristics of IT") and further developed the research model of this study.

Table 2. Encoding Principles of the Research Model		
Dimension	Factors of adoption (sub-scale)	Conceptualized principles
Environment of industry	1. Uncertainty of environment	Uncertainty
	2. Degree of competition in the market	Competition, centralization of industry, pressure
	3. Pressure of transaction partners	Business partnership, social pressure
	4. Interorganizational dependency	Degree of interaction and communication
	5. Industry environment of supplier	Marketing of suppliers and customers
Organization	6. Organizational scale	Scale
	7. Fundamental establishment of IT	System of data, support of technique
	8. Burden of cost	Financial support, performance of cost
	9. Integration of supply chain strategy	Strategy
	10. Degree of centralization of organization	Organizational structure
	11. Degree of formalization	Support of mission
	12. Cognition of users' demand	Autonomy of mission, pressure at work
	13. Support and participation of top executives	Top executives, policy deciders
Innovation of technology (Characteristics of RFID)	14. Complexity	Try out, learning, self-examination
	15. Compatibility	Compatibility
	16. Visible profits	Beneficial result, relative profit, useful perception
	17. Visible obstacles	Obstacle
	18. Mutual standard	Mutuality, connection, standard

The result of axial coding is provided in Table 3. Given that each variable was obtained through the scholars' comparison of IT adoption factors under a constant perspective, this research defined each variable as follows, in order to avoid different definitions of variables.

- *Uncertainty of environment*—the degree of uncertainty of change in the organizational environment.
- *Degree of competition in the marketplace*—the degree of competition in order to obtain the advantage of market competition.
- *Pressure of transaction partners*—the degree of pressure experienced by supply chain members within an organization; for example, a transaction partners' adoption of novel technology would generate pressures for the organization to receive orders which further reinforces IT adoption.
- *Interorganizational dependency*—refers to the degree of inter-organizational interaction.
- Suppliers' industry environment—is inclusive of the suppliers' incentive, the suppliers' reputation in the industry, and vertical coordination with the customers.
- *Organizational scale*—signifies the scale of the organization.
- *Fundamental establishment of IT*—indicates the technology's degree of maturity in terms of its fundamental establishment.
- *Burden of cost*—the load of cost resources related to the implementation of new technology.
- *Integration of supply chain strategy*- defined as the consistency of objective strategic integration in the organization.
- *Support and participation of top executives*—the degree of the deciders' participation and support. *Complexity*—the innovative product's degree of difficulty in terms of its comprehension or utility. *Compatibility*—refers to the attunement among the users, system, and working procedure between innovative technology and the organization.
- *Visible profit*—the degree of the organization's understanding of profit-savings potential when introducing IT.
- *Visible obstacle*—refers to the degree of the organization's understanding of any impediment when introducing IT.
- *Mutual standard*—defined as the degree of IT adoption with regard to the benchmark of the business circle.

As was also identified by the scholars, one should recognize, the importance of the "degree of competition in the marketplace" as compared with other factors (Table 3). On the other hand, the "support and participation of top executives" and "users' cognition of demand" factors were more important than the other factors of the organization category, while "visible profit" and "complexity" were more important than the other factors in the innovative technology category.

III. RESEARCH METHOD AND DESIGN

This section includes the research procedure, framework, and hypotheses of the research variables.

Research Procedure

To fulfill the objective of this research, the researcher devised the following procedure: first, with the abundance of literature related to the factors affecting IT adoption, this study organized these to comprise the basis of this study's

theory. Furthermore, in as much as this research mainly focused on the factors which can affect RFID adoption in Taiwan's logistics industry, the researcher also assessed the current development of the logistics industry and the RFID technique in Taiwan. In consequence, this research combined the characteristics of the logistics industry and RFID technology aside from employing open and axial coding to establish the prototype model of the research framework. Additionally, in case the prototype model prove to be incomplete, this research likewise ensured the reliability of the framework via the answered questionnaire from experts.

Table 3. Comparison of Scholars' Opinions toward IT Adoption Factors under Consistent Perspective after Encoding

	Environment of industry						Organization						Innovation of technology					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1.Rogers [1983]														×	×	×		
2.Kwon and Zmud [1987]	×	×		×						×	×	×	×	×		×		
3.Gatignon and Roberson [1989]		×		×	×					×								
4.Cooper and Zmud [1990]															×			
5.Premkumar et al. [1992]				×				×						×	×	×		
6. Saunders and Clark [1992]								×										
7. Bouchard [1993]			×															
8. Grover [1993]	×	×						×		×		×					×	
9. Grover and Goslar [1993]						×	×				×							
10. Premkumar et al. [1994]															×	×		
11. Iacover et al. [1995]		×	×				×	×										
12. Ramamurthy [1995]		×					×											
13. Rogers [1995]							×	×				×	×	×	×	×		×
14.Premkumar and Potter [1995]			×				×	×					×			×		
15. Bensaou [1996]			×															
16. Premkumar et al. [1997]		×			×	×							×					
17. Chau and Tam [1997]	×															×	×	×
18. Sauer and Lau [1997]													×					
19. Thong [1999]													×					
20. Premkumar and Roberts [1999]		×	×			×							×			×		
21. Chwelos et al. [2001]		×	×				×	×								×		
22.Kuan and Chau [2001]																		
23. Mirchandani [2001]													×		×	×		
24. Patterson et al. [2003]	×	×	×			×			×	×								
25.Lyytinen [2003]												×		×				×
26. Hwang H.G et al. [2004]		×				×						×	×					
27. Grandon and Pearson [2004]		×	×											×		×		

A - uncertainty of environment, B - degree of competition in the marketplace, C - pressure of transaction partners, D - inter-organizational dependency, E – suppliers' industry environment, F - organizational scale, G – fundamental establishment of IT, H -burden of cost, I - integration of supply chain strategy, J – centralized degree of organization, K – degree of formalization, L – users' cognition of demands, M – support and participation of top executives, N - complexity, O - compatibility, P -visible profit, Q - visible obstacle, R - mutual standard

The research subsequently inferred the related hypotheses with regard to the factors that affect RFID adoption in the logistics industry. Pertaining to the collection of research data, this research mainly employed the questionnaire survey as the vehicle to explore the facts and current situations. This study's main objective is to collect and accumulate basic data from each property of scientific education of a certain target group. One reason why the authors believe the questionnaire to be a suitable research method, aside from evidence presented in the literature [Babbie 1990], is that people attempt to utilize questionnaire surveys with the intention of recognizing something. In line with this, the questionnaire's return rate, reliability, and validity should also be considered. Inferences or attempts to explain certain issues require deliberation of the questionnaire's limitations as well. Attempts to prevent the scenario in which the developed dimensions were incomplete were likewise undertaken by including open questions for the participants. After pretesting the questionnaire and after analyzing the results, the authors then finalized the formal questionnaire and proceeded with distribution and subsequent collection. Finally, the authors analyzed and organized the data obtained from the returned questionnaires and proceeded to verify the hypotheses to obtain the model which would present how the adoption of RFID in the logistics industry of Taiwan is being affected.

Research Framework

To ensure that the model based on the encoding process is a potential factor in adopting RFID, this research used the expert questionnaire in collecting the opinions of five academic field experts, as well as Lawshe's approach to upgrade the validity of the variables of the model proposed in the framework. With the presence of five experts (N=5), the CVR value of each factor satisfied the minimal demand of 0.99. The CVR value of the degree of centralization of organization, degree of formalization, and users' cognition of demand were 0.6 and less than 0.99, respectively- values that should then be deleted. Apart from the factors discussed above, the rest fulfilled the standard of Lawshe's approach. The research framework was thus established (Fig. 1).

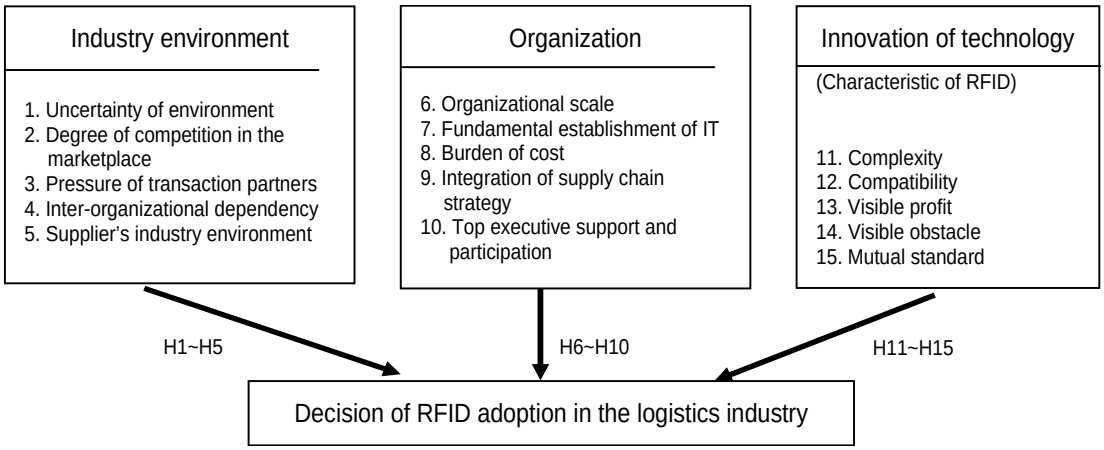

Figure 1. The Research Framework

Research Hypotheses

According to the research framework, the aspects of "environment of industry," "organizational characteristics," and "characteristics of RFID" would create an impact on the decision regarding RFID adoption in the logistics industry. The following discussion refers to the hypothesis of each dimension.

External Environment Dimension

Globalization and rapid change in customer preferences brought fiercer market competition, along with the accompanying change in the industry environment. Therefore, the organization requires IT assistance to reduce this uncertainty. However, as the application of the RFID system relies on the "accumulation" and "sharing" of data by upstream and downstream companies toward an ideal system performance, the beneficial result of RFID's introduction in the single enterprise would prove to be limited. Therefore, the authors placed particular emphasis on the category referring to the dimension of the industry environment. In this dimension, the study mainly explored the factors of "uncertainty of environment," "degree of competition in the marketplace," "pressure of transaction partners," "interorganizational dependency," and "suppliers' industry environment."

With regard to the "uncertainty of environment" factor, Kwon and Zmud [1987] pointed out that in more turbulent and unstable environments, a more rapid adoption of innovative technology should be carried out. Meanwhile, Gatignon and Robertson [1989] believed that the more uncertain the demand was, the more new technology should be adopted to satisfy these changes. As a result, enterprises would have to implement new technology as soon as possible. In addition, Chau and Tam [1997] stated that the more uncertain the environment and market were, the more likely would innovative technology be adopted. In other words, a definite need to seek IT assistance arises when the environment becomes complicated and rapidly and dynamically altered. Conversely, an organization remaining in a stable environment could potentially handle the demand of data processing. Yet, in the study of Patterson et al. [2003] with regard to the adoption of supply chain technology, the uncertainty of the environment and the adoption of the supply chain technology revealed a positive correlation. Based on the above discussion, this research assumes that uncertainty is a factor that can affect the adoption of RFID in the logistics industry.

Regarding the "degree of competition in the marketplace," Kwon and Zmud [1987] stated that a positive correlation existed between competition in the environment and the adoption of information. In fact, Gatignon and Robertson [1989] believed that market competition was transformed from an oligopoly to a monopoly, and that in order to supervise the actions of other companies, adopting a new technology to establish barriers of entry into the marketplace was easier. Upon studying the issue of customer-oriented and interorganizational information systems, Grover [1993] likewise revealed that the pressure of industry competition also encouraged organizations to accelerate the adoption of information systems. Related to this, by studying the saving of online information,

Premkumar and Roberts [1999] found that the pressure of industry competition, social pressure, and technology adoption of other companies all affected the adoption of technology. Meanwhile, in a study on data storage, Hwang et al. [2004] mentioned that the degree of enterprise competition was also a factor which mostly influenced the adoption of data storage. On the basis of the above discussion, this research assumes that the degree of competition in the marketplace could be a factor which can affect the adoption of RFID in the logistics industry.

As for the "pressure of transaction partners," Patterson et al. [2003] suggested a positive correlation existing between the pressure of supply chain members and supply chain technology in their study. Especially with a global retailing giant such as Wal-Mart leading the way, there is now an emerging trend to apply RFID technology more readily. For example, as the upstream supplier of Wal-Mart, Yuen Foong Yu Paper Mfg.Co., Ltd. in Taiwan also initiated an investigation on RFID technology, with plans to attach an RFID chip to each package. Therefore, this research assumes that the pressure of transaction partners can affect the adoption of RFID in the logistics industry.

Concerning "interorganizational dependency," Kwon and Zmud [1987] stated that there was a positive correlation between information sharing and experience exchange of the organization and other enterprises, in the adoption of technology. Gatignon and Roberson [1989] meanwhile confirmed that the degree of the new technology's data flow in the industry would affect its adoption. Moreover, a study regarding EDI adoption, undertaken by Premkumar et al. [1992], stated that the more information the enterprise received about new technology, the more likely it was to adopt new technology earlier on. As a consequence, this research believes that interorganizational dependency may yet be another factor which can affect the adoption of RFID in the logistics industry.

The "suppliers' industry environment" received much attention from Gatignon and Robertson [1989], who stated that the suppliers' competitive industry environment would affect the adoption of new technology. The suppliers' competitive industry environment included the following items: (1) Vertical coordination with the customers, wherein the closer the relationship between the suppliers of new technology and the customers, the faster the information flow would be. Thus, adoption of new technology would be easier to achieve. (2) Suppliers' incentive, wherein if suppliers proceeded with some stimulus policy (e.g., discount and samples), this would encourage the customers to implement the new technology. (3) Reputation of the industry: the reputation establishes reliability in the mind of the consumer. When a product comes as a result of experience and when its quality might become too complicated to distinguish (such as products of new technology), the reputation of the industry and company would become relatively important. Finally, this research assumes that the suppliers' industry environment could be a factor which can affect the RFID's adoption in the logistics industry.

Based on the above discussions, the hypotheses on the dimensions of industry environment are summarized as follows:

H1: "Uncertainty of environment" can affect the decision of the logistics industry in the adoption of RFID.
H2: "Degree of competition" in the marketplace can affect the decision of the logistics industry in the adoption of RFID.
H3: "Pressure of transaction partners" can affect the decision of the logistics industry in the adoption of RFID.
H4: "Interorganizational dependency" can affect the decision of the logistics industry in the adoption of RFID.
H5: "Suppliers' industry environment" can affect the decision of the logistics industry in the adoption of RFID.

Organizational Dimension

Many scholars [Rogers 1995; Gatignon and Roberson 1989; Tornarzky and Fleischer 1990; Grover and Goslar 1993] stated that organizational characteristics would affect the adoption of new technology. In this research, the authors mainly focused on the factors of "organizational scale," "fundamental structure of IT," "burden of cost," "integration of supply chain strategy," and "support and participation of top executives."

With regard to "organizational scale," various literature demonstrated that the larger the organization scale, the more likely will the organization adopt new technology [Rogers 1995; Tornarzky and Fleischer 1990; Grover and Goslar, 1993]. Grover and Goslar [1993] likewise verified that a larger organizational scale would possess more resources, a better foundation, and better capacity for undertaking the risk. These will, in turn, encourage the espousal of new technology. Hence, this research subjectively believes that organizational scale can affect the adoption of RFID in the logistics industry.

In relation to the "fundamental structure of IT," when an organization introduces new technology, it would consider its capacity to create a sufficient fundamental structure to successfully introduce it and realize all of its benefits. In addition, any new IT application proves a huge risk. It is for this reason that an organization with a solid fundamental establishment would face less risk when introducing new IT [Premkumar and Ramamurthy 1995]. Thus, this

research subjectively believes that the fundamental IT structure can affect the adoption of RFID in the logistics industry.

While studying EDI, Premkumar et al. [1992] revealed that the burden of cost of new technology would affect the adoption of EDI. Along this line, Lacover et al. [1995] also found that the organization's preparation of financial resources would affect EDI adoption. Rogers [1995] and Premkumar and Potter [1995] likewise agreed that the benefit of cost for investing technology would affect the adoption of new technology. As such, this research then subjectively believes that the "burden of cost" can affect the adoption of RFID in the logistics industry.

In their study, Patterson et al. [2003] stated that the "integration of supply chain strategy" would affect the adoption of supply chain technology. In other words, if the company has the capability and strategy to integrate, it will have an easier time taking advantage of the operational efficiency in the logistics industry, adopt new technology easily, and hence achieve success. Thus, this research subjectively believes that the fundamental IT structure of an organization can affect the adoption of RFID in the logistics industry.

Taking into consideration the "support and participation of top executives," several studies have proven that the support of top managers would also affect the adoption of new technology [Gatignon and Roberson 1989; Rogers 1995]. In addition, most companies in the logistics industry in Taiwan are categorized as small- and medium-sized enterprises. The introduction of IT in their system would heavily reply upon the support and participation of top executives. Thus, this research subjectively believes that the support and participation of top executives can affect the adoption of RFID in the logistics industry.

Based on the previous discussion, we present the following hypotheses with regard to the organizational aspect of RFID adoption:

H6: "Organizational scale and participation" can affect the decision of the logistics industry in the adoption of RFID.
H7: "Fundamental structure of IT" can affect the decision of the logistics industry in the adoption of RFID.
H8: "Burden of cost" can affect the decision of the logistics industry in the adoption of RFID.
H9: "Integration of supply chain strategy" can affect the decision of the logistics industry in the adoption of RFID.
H10: "Support and participation of top executives" can affect the decision of the logistics industry in the adoption of RFID.

Dimension of RFID's Characteristics

Many scholars [Rogers 1983; Kwon and Zmud 1987; Premkumar et al. 1992; Chau and Tam 1997] believed that the related characteristics of IT would influence the adoption of innovative technology. Moreover, the characteristics of RFID, in terms of contact tracking of skill and application, resulted in the business enterprises' expectations regarding this application. It is for this reason that the characteristics of RFID would affect its adoption. In the following section, this research focused mainly on the factors of "complexity," "compatibility," "visible profit," "visible obstacle," and "mutual standard" for further exploration.

Concerning the "complexity factor," Rogers [1983] explained that product complexity would affect the adoption of technology. Complexity of products refers to the degree of professional knowledge the members of the organization possessed. The more professional knowledge the members had, the more likely will the members be encouraged to generate new ideas. However, execution of ideas might present an inconsistency since it would be difficult for the users to understand this innovative technology based on their experience. This lack of skill and knowledge would, in turn, generate difficulty when they use the new technology, thereby affecting the organization's adoption of innovative technology [Kwon and Zmud 1987; Premkumar et al. 1992].

Meanwhile. "compatibility" among innovative technology and its user, as well as the system, and operational procedure of the organization, can also influence the organization's adoption of innovative technology [Kwon and Zmud 1987]. Premkumar et al. [1992] also clarified that if new technology was highly compatible with the current system, then it would more likely be adopted.

With regard to "visible profit," Kwon and Zmud [1987] stated that the introduction of innovative technology would allow more advantages, and that there was a positive correlation between the related advantage of technology and its adoption. Cooper and Zmud [1990] likewise believed that the higher the value of new technology or the more the organization saved, the earlier the enterprise's adoption of technology would be. In line with this, Chau and Tam [1997] studied the factors of adoption in an open system and verified that, compared with a more closed information system, its open counterpart could offer the organization more options for increased flexibility and integration. Hence, the visible profit of an open system can enhance the decision in adopting innovative technology.

As for "visible obstacle," Chau and Tam [1997] believed that the decision maker's understanding of the obstacle presented by any type of IT application would affect the organization's adoption of innovative technology. This obstacle included high cost of transfer and incompatibility with the current system, among others. As for the obstacles enterprises faced while adopting RFID technology, this research earlier discussed that some technical and cultural reasons might prolong or hinder the evolution of RFID technology. Therefore, current obstacles enterprises face when using the RFID system could be a factor that can affect the adoption of RFID in the logistics industry.

Regarding "mutual standard," Rogers [1995], Chau and Tam [1997], and Lyytinen [2003] studied the issues of innovative technology, open system, and innovation of system procedure. They confirmed that using a similar pattern for IT as that used in business standards would affect the adoption of the system. The introduction of RFID, after all, required the consistency of governmental standards and regulations, connection with the original system, and integration with the data exchange system. Thus, after introducing RFID, the organization would find it easier to proceed with product tracking and inventory control in the entire supply chain.

Based on the previous discussion, the hypotheses for the "dimension of RFID's characteristics" (dimension of technology innovation) are proposed as follows:

H11: "Complexity" of RFID can affect the decision of the logistics industry in RFID adoption.
H12: "Compatibility of RFID can affect the decision of the logistics industry in RFID adoption.
H13: "Visible profit" of RFID can affect the decision of the logistics industry in RFID adoption.
H14: "Visible obstacle" of RFID can affect the decision of the logistics industry in RFID adoption.
H15: "Mutual standard" can affect the decision of the logistics industry in RFID adoption.

Measurement of Research Variables

After the discussion of the proposed research framework, the measurement of all of the variables is then based on a five-point Likert scale. In the scale, 1 signifies extreme disagreement, 2 refers to disagreement, 3 indicates indifference, 4 means agreement, and 5 means extreme agreement. This section elaborates the measurement of all of the variables found in the three dimensions of the research framework, as well as the operational scales of each variable (Table 4).

Table 4. Evaluation of the Factors which Affect RFID Adoption in the Logistics Industry

	Variables	Item of evaluation and scale of operation	
Environment of industry	Uncertainty of environment	The competition of the products and service in the environment is severe. The industry in which the company belongs to faces extreme change and uncertainty.	Patterson et al. [2003]
	Degree of competition in the marketplace	The company has to frequently change the services it offers in order to maintain its competitiveness in the market. The company's customers tend to choose similar products or services from other factories.	Grover and Goslar [1993] Thong and Yap [1995]
	Pressure of transaction partners	The clients of the company tend to influence changes in company policies. The company adopts RFID in order to respond to the pressure brought about by the demand of transaction partners.	Premkumar and Roberts [1995]
	Inter-organizational dependency	The company considers it important to reinforce its dependent relationship with upstream suppliers. The company considers it important to reinforce its dependent relationship with downstream suppliers.	Patterson et al. [2003]
	Suppliers' industry environment	The successful cases of cooperation between RFID suppliers and other colleagues are considerably important. RFID suppliers' skills and knowledge are considerably important. It is considerably important that RFID suppliers be willing to offer training on the RFID technique.	Powell [1993] Premkumar and Robert [1999]
Organizational	Organizational scale	Number of employees in the company	Patterson et al. [2003]
	Fundamental establishment of IT	There is a fundamental communication network in the company. There is an integrated system of data application of different functions and fields in the company. The daily transaction of the company is based on the data application system of the database.	Premkumar et al. [1995]

	Burden of cost	Before adopting RFID, a company should evaluate the return rate of investment. RFID adoption requires plenty of time and money invested on the training of employees. The cost for prospective maintenance and supportive skill in RFID adoption is considerably high.	Premkumar and Robert [1999]
	Integration of supply chain strategy	The company has a clear and complete SCM strategy. The company's SCM planning is compatible with all of its existing planning strategies. The company's SCM planning is clear and it is one of the dominant strategies of the organization.	Patterson et al. [2003]
	Participation and support of top executives	I recognize and understand the related knowledge of RFID in a functional manner. I recognize the estimated benefit of RFID on SCM. I am willing to support the policy and participate in RFID application meetings. I can offer related resources to assist in the introduction of RFID.	Haley [1997]
RFID characteristic	Complexity	The process of developing (establishing) RFID is extremely complicated. The operation of the RFID system is considerably complicated. The cost of employee training for RFID adoption (in terms of time and money) is extremely high.	Grover [1994] ; Premkumar and Robert [1999]
	Compatibility	The connection between the RFID system and the data in the original computers of the company is important. The connection between the RFID system and the interface of the original system used by the company is important. The connection between the RFID operational platform and the fundamental establishment of the data system is important.	Grover [1993]
	Visible profit	The company believes that adopting RFID can reduce the cost of labor force and error. The company believes that adopting RFID can reduce the complexity of operational procedure. The company believes that adopting RFID can promote SCM.	Chau and Tam [1997] this research
	Visible obstacle	The company believes the quality of transmission and reliability of RFID is considerably important. The company believes that the issue of overly high investment costs of RFID is considerably important. The company believes that the privacy consideration of RFID is considerably important,	Chau and Tam [1997] this research
	Mutual standard	The company considers the establishment of an international mutual standard to be important. The company considers the regulation of electromagnetic wave to be important.	Chau and Tam [1997] this research

IV. DATA ANALYSIS AND DISCUSSION

Descriptive Analysis

Despite its advantages, RFID technology is still not extensively adopted in Taiwan. However, due to global trends and government support, the number of companies attempting to adopt this technology has continued to grow. This study mainly explored the factors that influenced the adoption of RFID in the logistics industry with regard to supply chain management. To accomplish this goal, this study enlisted the help of top executives in the logistics industry as the main sampling targets who answered the designed questionnaire. The main sources of targets included: (1) roster of member companies of the Chinese Logistics Association and (2) roster of companies of the Chinese Logistics Almanac. This study also utilized the companies that cooperated with the Industrial Technology Research Institute (ITRI) to perform a pretest prior to sending the finalized questionnaires to the sampling targets. The authors mailed a total of 500 questionnaires. The initial time period to collect the responses was from May to June 7, while the second collecting time slot was from June to July 7, accompanied by follow-up phone calls. The collection period of the returned questionnaires was nine weeks in total. There were 84 returned questionnaires and 15 others were excluded due to delivery failure. The initial return rate was 17.31 percent, and upon removal of three incomplete questionnaires, a total of 81 valid questionnaires were left. As a result, the final return rate was 16.7 percent.

Among the questionnaires collected for this study, basic information about a company included the position held by the participants, year of establishment for a company, size of capital, number of employees, number of employees in the information department, and information budget spent for one year (including computer software and system

development expenses). Looking at the positions held by the participants, logistics executives took the lead (29.6 percent) while general manager/deputy general managers (27.2 percent) placed second. Yet, there were 16.0 percent of the respondents filling out "others" in the positions category. Consequently, it drifted slightly from the estimated targets of the proposed study. In reference to the year of establishment, most of the companies have existed for 20-24 years (39.5 percent), with 24.7 percent of the companies being established from 15-19 years. The companies which returned the questionnaires were the ones with a reasonable number of years of operation in the logistics field.

According to the definition by the Small and Medium Enterprise Administration (MOEA), Taiwan, companies with less than NT$ 80 million actual capital or with a number of employees less than 200 are considered as small- and medium-sized enterprises. As for our collected questionnaires, companies with over 80 million in capital comprised 74.1 percent of the total respondents, and the ones with more than 200 employees comprised the remaining 46.9 percent. Thus, the returned samples were mostly from large enterprises. This result is in contrast with that presented in the 2003 logistics yearbook of MOEA, in which it is stated the companies in Taiwan's logistics industry consist mostly of small- and medium-sized enterprises. One possible explanation could be that, compared to small and medium enterprises, the larger enterprises were more interested in the adoption of new technology. As a result, the return rate from larger enterprises was more than that of small and medium enterprises. Meanwhile, companies with more than 10 people and with 5-10 people in the information department comprised 32.1 percent and 17.3 percent, respectively, of the total respondents. In summary, around 49.4 percent of the respondents had a reasonable size of employees in the IS department (more than five people). The companies with more than NT$1.51 million in terms of information budget (including computer software and system development) made up 51.9 percent of the respondents. Therefore, IT spending in the logistics industry has gradually increased and improved in recent years.

From Tables 5 and 6, we can see that 60 logistics companies did not adopt RFID. This figure was a greater than the 21 logistics companies that were identified as adopters. Nevertheless, the result was reasonable owing to the RFID technology's infancy stage in Taiwan's logistics industry. As such, there were limited companies that employed RFID technology. In order to proceed with multiple variables analysis, this study treated the broad sense of "planning" as one of the categories. By doing so, 21 samples of "planning" the adoption were actually obtained. Out of the 21 samples, three companies had actually adopted the RFID technology into their daily operation, while the other 18 companies had been planning to adopt this technology in the future. Meanwhile, among the companies that were identified as non-adopters, the ones who planned to adopt RFID technology in the future amounted to 53.3 percent, revealing the logistics companies' extreme interest in the adoption of RFID. However, there was still a distinct 46.6 percent of companies that did not contemplate this issue. The authors must then perform further investigation to trace the reasons for their non-adoption.

Table 5. Adoption of RFID

Items of data	Category of data	Frequency	( )	Accumulated ( )
RFID adoption	Non-adopter	60	74.1	74.1
	Adopter	21	25.9	100.0
Situation for not adopting	Plans to adopt it in the future	32	53.3	53.3
	Has planned to adopt it recently	0	0	53.3
	Never thought of it	28	46.6	100.0

Table 6. Overview of the Situation for not Adopting RFID

Items	Category of data	Frequency	( )
Reasons for not adopting the RFID system	Unclear about the operation of RFID hardware (such as the interference of signal)	8	9.9
	Reading of data is not accurate	17	21.0
	Cannot connect with other systems	10	12.3
	Cost of investment is too high	33	40.7
	Unclear scale of beneficial result	32	39.5
	Consideration of privacy	4	4.9
	Security consideration of data transmission	6	7.4
	Companies in supply chain are not willing to cooperate	22	27.2
	Political consideration of labor organization	0	0
	Others	16	19.8

The survey was developed with multiple choice questions. This study found the top four reasons cited by non-adopters for not using RFID technology, and these include: the "cost of investment is too high (40.7 percent),"

"unclear scale of beneficial result (39.5 percent)," "companies of supply chain are not willing to cooperate (27.2 percent)," and "reading of data is not accurate (21.0 percent)" These presented the real challenges perceived by non-adopters, which in turn, affected their decision not to adopt the application. Interestingly enough, there were no companies citing political concern of labor organizations as the reason for non-adoption. It further suggested that for the logistics companies in Taiwan, the issue of labor was not the main concern in non-adoption of RFID technology. To obtain more details, this study further examined the data collected from three companies, which have already incorporated RFID into their daily operation. Of these, two companies have recently adopted RFID technology within the last six months. Extensive use of the RFID technology (everyday) was also observed in these two companies. Based on the results, we found that all of them considered the adoption of RFID as critical for their operation after its implementation. As to the expected benefit of RFID technology in terms of SCM, the logistics companies that adopted RFID technology revealed that the benefit realized falls in the "ordinary" category (three points) in the five-point Likert scale. This meant that the logistics companies were still in the stage of exploring the benefits of RFID application. For this reason, the benefits were, as of yet, unknown. This was the main basis for these non-adopters who were more concerned about the "unclear scale of beneficial result" issue.

Examination of Reliability and Validity

The basic measuring model of reliability in this study was as follows: 1 (reliability) (error). Reliability refers to an indicator with respect to the consistency or stability of the results of multi-copy tests or error of estimated test in order to reflect the real numbers. When the error rate of test scores is reduced, the rate of real characteristic increases. The common reliability test of the Likert scale is Cronbach's Alpha factor. In relation to this, Hair [1998, p.88] determined that the Cronbach's Alpha factor between 0.6 and 0.7 was the lowest acceptable range. According to Table 7, the Cronbach's Alpha factor of burden of cost is less than 0.6, and the rest of the independent variables possess reliability. However, if option 1 of burden of cost was removed, then the Cronbach's Alpha factor would increase and exceed the value of 0.6 (Cronbach's Alpha factor of burden of cost increased to 0.676), thereby enhancing the increasing trend of the reliability factor. Thus, the researcher deleted option 1.

Table 7. Examination of Reliability

Items	Variable	Number of options	Non-adopter (n=60)		Adopter (n=21)		Cronbach's Alpha
			Mean	S.D.	Mean	S.D.	
1	Uncertainty of environment	2	4.00	0.59	4.26	0.64	0.76
2	Degree of competition in the marketplace	2	3.63	0.82	4.02	0.76	0.61
3	Pressure of transaction partners	2	3.27	0.77	3.38	0.94	0.66
4	Inter-organizational dependency	2	4.03	0.74	4.36	0.57	0.70
5	Suppliers' industry environment	3	3.97	0.66	4.25	0.60	0.91
6	Organizational scale	1	3.52	1.55	3.90	1.33	N/A
7	Fundamental establishment of IT	3	3.81	0.68	4.06	0.65	0.81
8	Burden of cost	3	3.71	0.56	3.38	0.72	0.67
9	Integration of supply chain strategy	3	3.53	0.66	4.11	0.59	0.93
10	Participation and support of top executives	4	3.38	0.75	3.75	0.51	0.84
11	Complexity	3	3.57	0.66	3.17	0.76	0.85
12	Compatibility	3	4.29	0.58	4.46	0.46	0.91
13	Visible profit	3	3.93	0.63	4.03	0.63	0.86
14	Visible obstacle	3	4.21	0.53	4.31	0.45	0.70
15	Mutual standard	2	4.20	0.69	4.14	0.63	0.83

Validity refers to the accuracy of test scores; this indicates that a test can manage the degree of psychological characteristics for examination. Given that the questionnaire was modified based on similar studies of previous literature, and because the pretest of the questionnaire was modified by experts and scholars, it should therefore possess a certain level of validity. Moreover, this study employed factor analysis to examine and establish validity. Factor analysis is a skill of conjoint analysis. The objectives of the technique could then be divided into an exploratory factor analysis and a confirmatory factor analysis. The objective of the former was to identify the mutual property from a set of messy variables in order to establish a new hypothesis or new theoretical structure. The latter, however, aimed to examine the preexistent theoretical structure. According to the encoding and expert questionnaire, this study was considered as a confirmatory factor analysis. Hence, progression toward the hypothesis of mutual factors could be undertaken, and the principal component analysis and Varimax of Orthogonal Rotation could be used to rotate the factors. Based on this hypothesis, the factors could then be introduced. In addition, the authors adopted the "Kaiser-Meyer-Olkin measure of sampling adequacy" (KMO) indicator so as to distinguish if the variables of the scale were suitable for factor analysis. The KMO value was between 0 and 1. When the value was close to 1, the variable correlation was higher, suggesting better suitability for factor analysis. If the

KMO value of the scale was under 0.60, the scale was not suitable for factor analysis. The KMO values of the three dimensions of industry environment, organization, and innovation of technology of this research were over 0.60. Therefore, they were all suitable for factor analysis.

Hair [1998] stated that the factor loading of the principles for judging factor analysis should be over 0.5. As to the analysis of the dimension of industry environment, except for option 1 ("degree of competition in the marketplace") the loading of other factors were over 0.5. After examination of option 2 in the questionnaire, the degree of competition in the marketplace could then be established. Meanwhile, on the basis of the experts' judgment, one should delete option 1 of the factor, after which factor analysis should be carried out. The loadings were now over 0.5. With respect to the analysis of organizational dimension, the loadings of all factors were over 0.5. As a result, the fundamental structure of IT, burden of cost, integration of supply chain strategy, and participation and support of top executives all satisfy the requirement of establishment of validity. Regarding the analysis of dimension of innovation technology, except for option 3 ("visible obstacle"), the loading of all other factors were over 05. Following examination of options 1 and 2 of the visible obstacle of innovation technology in the questionnaire, the complete degree of formalization could be established. Nevertheless, upon the experts' judgment, option 3 was still deleted. The deletion of options was again followed by factor analysis. The loadings were over 0.5.

Discriminant Analysis

Discriminant analysis is a dependent method of single response variable, in which the category was established in advance. This analysis could likewise manage the statistically prominent difference among averages of a set of variables of two or more groups defined in advance. Table 8 is presented to examine the prominence of discriminant function. Among discriminant functions, the Wilks' Lambda value was 0.620 ($p=0.003<0.05$), indicating that this study can distinguish the two groups with or without the adoption of RFID. Tables 9 and 10 can be referred to for the result of the Discriminant Analysis.

Table 8. Wilks' Lambda Value

Test of function	Wilks' Lambda	chi-square	Degree of freedom	Significance
1	0.620	34.184	15	0.003

Table 9. Summary of Discriminant Analysis

Variable	Discriminant loadings	Significance	Non-adopter		Adopter	
			Mean	S.D.	Mean	S.D.
Uncertainty of environment	0.244	0.094	4.00	0.59	4.26	0.64
Degree of competition in marketplace	0.278	0.056	3.63	0.82	4.02	0.76
Pressure of transaction partners	0.079	0.586	3.27	0.77	3.38	0.94
Interorganizational dependency	0.260	0.075	4.03	0.74	4.36	0.57
Industry environment of suppliers	0.252	0.084	3.97	0.66	4.25	0.60
Organizational scale	0.146	0.312	3.52	1.55	3.90	1.33
Fundamental establishment IT	0.209	0.149	3.81	0.68	4.06	0.65
Burden of cost	-0.313	0.032(a)	3.71	0.56	3.38	0.72
Integration of supply chain strategy	0.507	0.001(a)	3.53	0.66	4.11	0.59
Support and participation of top executives	0.293	0.045(a)	3.38	0.75	3.75	0.51
Complexity	-0.320	0.029(a)	3.57	0.66	3.17	0.76
Compatibility	0.164	0.257	4.29	0.58	4.46	0.46
Visible profit	0.088	0.540	3.93	0.63	4.03	0.63
Visible obstacle	0.112	0.440	4.21	0.53	4.31	0.45
Mutual standard	-0.048	0.742	4.20	0.69	4.14	0.63
a: $p<0.05$						

Table 10. Result of Classification

	Each member for estimation		Total
	Non-adopter (%)	Adopter (%)	
Non-adopter	58 (96.7%)	2 (3.3%)	60
Adopter	10 (47.6%)	11 (52.4%)	21

Research Findings and Discussion

Through descriptive statistics, this study obtained 60 samples that did not adopt RFID technology, a lot more than the 21 companies adopting RFID technology. It revealed that the promotion of RFID technology in Taiwan's logistics industry is still in its infancy stage. In fact, the companies actually using RFID technology in their daily operation are still limited. All of the companies that adopted RFID technology, however, valued its importance upon its implementation in their operations. It is unfortunate though that there is no concrete estimated benefit of RFID on the Supply Chain Management. In other words, logistics companies are still trying to explore the application of RFID technology. They also replied that RFID technology adoption may be based on the promotion and assistance of governmental departments and information companies. As for the enterprises that did not adopt RFID technology, 53.3 percent of them planned on using the technology, signifying high interest in its utilization. Nonetheless, 46.6 percent of the respondents had never considered this issue. One must therefore proceed and undertake another further survey in the future to determine the reasons for this. The survey was based on multiple options, and the authors found that the top four reasons for not using RFID technology are the following: "cost of investment is too high (40.7 percent)," "unclear scale of beneficial result (39.5 percent)," "companies of supply chain are not willing to cooperate (27.2 percent)," and "reading of data is not accurate (21.0 percent)" This indicates that the aforementioned reasons are the issues that concerned companies the most during the process of RFID technology adoption.

There is no doubt that RFID is an innovative technology. In terms of SCM, RFID technology played an important role with regard to data sharing among the members. Moreover, RFID technology could not only distinguish the products and the information of manufacturers, but it can also track the production process and activities path from material production to the ultimate distribution of upstream and downstream factories. The logistics industry therefore expects that the application of RFID technology could improve the data visibility of the SCM. Nevertheless, even with RFID technology offering many benefits for the whole supply chain system, according to the results, there were only 21.6 percent of logistics companies that adopted (or planned to use) RFID technology. It meant that the application of RFID in Taiwan was still in its infancy stage. Given that the initial phase performance would influence the following results of each phase, not to mention the fact that the characteristics of RFID technology were different from other IT, this study focused on the factors that affected the logistics industry's efforts in adopting RFID in order to proceed with an in-depth exploration.

According to the verified results of the hypotheses, this study determined that for the RFID technology to be applied to the SCM, the logistics companies not only had to take into consideration the IT aspect of RFID, but also comply with the regulations of the enterprise and industry environment so as to enhance the expansion of RFID usage. The authors, as a consequence, further elaborated on three dimensions: industry environment, organization, and innovative technology.

External Environment Dimension

With regard to the dimension of the industry environment, the factors which affected the logistics industry's RFID adoption were "pressure of competition in the market," "pressure of transaction partners," and "suppliers' industry environment." Due to the fact that the logistics companies in Taiwan have matured in recent years, the new participants might not obtain as high profits as before due to fierce competition. It is also widely expected in the future that the number of new participants would be reduced. Once the clients of upstream companies required the introduction of RFID technology due to the "pressure of transaction partners," logistics companies would be forced to adopt this aforementioned technology for cooperation. The maturity of this technology, in addition, is fully dependent upon the "suppliers' industry environment."

Organizational Dimension

The organizational dimension exhibited the factors affecting the adoption of RFID in the logistics industry, namely, "burden of cost" and "integration of supply chain strategy." Currently, RFID technology is too costly, with the most common cost categories of RFID including hardware, software, training, integration, and testing. The companies would indeed spend much to implement this kind of innovation technology investment. If adoption abandonment happens, it may result in the company's huge financial loss. Worth mentioning as well is that for the logistics companies, the supply chain included a broad variety of complicated members from suppliers to customers. With regard to applying RFID to facilitate the implementation of SCM, this complexity calls for improvement of the integration of supply chain activities as well as integration of the mechanism of cooperation in order to reduce the bullwhip effect, size of inventory, and time of operational cycle, thereby resulting in quality improvement [Levary 2000]. Accordingly, the "integration of supply chain strategy" is considered the main factor which would affect RFID's adoption in the logistics industry.

It is important to note that we found "organizational scale" and "fundamental establishment of IT" to be excluded from the main factors in RFID adoption. Yet for the adopter and non-adopter groups, both revealed a similar viewpoint. Furthermore, the examined result of "support and participation of top executives" did not comply with the findings of prior literature. This study believes that it is not the main factor in that the role of different participants resulted in the error that influenced the completeness and accuracy of the hypothesis.

Innovative Technology (Characteristic of RFID) Dimension

As for the dimension of innovative technology, the factors which affected the adoption of RFID in the logistics industry were "complexity" and "mutual standard." There were several reasons identified, such as some technical restriction of RFID technology and its frequency, which varied from the actual application. Moreover, the government should actively establish related standards and regulations in order to reduce the complexity and associated uncertainty of RFID technology adoption.

Although RFID is a popular issue from the perspective of enterprise management, enterprises should obtain sufficient return from any IT investment. For the professional suppliers that managed the promotion of RFID technology, they should pursue maximum "visible profit" and minimum "visible obstacle" to establish the common consensus. This is to establish much value for the enterprises and gradually fulfill the potential benefits of investment. The logistics companies that adopted RFID technology, however, indicated that the beneficial result of its application was still not clearly articulated. In contrast, the companies that did not adopt RFID presented problems with the "unclear scale of benefit." Consequently, the two groups (adopter versus non-adopters) revealed some doubts toward the visible profit that can be generated through RFID technology. As discussed earlier, the visible profit of RFID's application could not be considered discriminant for these two groups in this study.

Regarding the "compatibility of RFID," a decision could not be made if it has any effect on the logistics industry's RFID adoption. One possible reason is that Taiwanese logistics companies were not familiar with the RFID technology. As a result, the two groups (adopter vs. non-adopters) revealed a similar perspective in terms of this factor. In order to reduce the limitation of the adoption of RFID, the promotion and assistance of government departments and information companies should be implemented, along with the establishment of standardized regulation.

V. CONCLUSION

This research employed encoding to explore the proposed model and its factors. Utilizing a questionnaire survey, the factors which can affect the adoption of RFID in the logistics industry were verified. According to research findings, the main factors which influenced its adoption in the logistics industry included "pressure of competition in the market" for the dimension of industry environment; "pressure of transaction partners," "suppliers' industry environment," "burden of cost," and "integration of supply chain strategy" for the organizational dimension; and "complexity" and "mutual standard" for the innovation technology (RFID's characteristics) dimension. The dominance of several factors (i.e., companies faced an environment with severe pressure of competition in the market, strong pressure of transaction partners' adoption of RFID technology, the burden of cost in the organization was less, and the integration of supply chain strategy was highly valued) resulted in the logistics companies' adoption of RFID technology. For the logistics companies, the supply chain, including all processes and activities from suppliers to customers, would even be more critical upon consideration of other adoption factors. With the application of RFID on SCM, the integration and cooperation mechanism of the supply chain should also be considered. Moreover, the introduction of RFID in a single enterprise would generate limited benefits in an SCM environment. The application of an RFID system must rely upon "accumulation" and "sharing" of information of upstream and downstream companies in order to obtain the most beneficial effect. This study, as a result, recognized "integration of supply chain strategy" as one of the important factors.

On the basis of this study's results, the authors suggest that prior to RFID adoption, logistics companies should assess related knowledge, as well as the current situation of RFID development within their respective industries. The past two years for example revealed MOEA's authorization of the Industrial Technology Research Institute to carry out a number of activities and events, such as RFID technology application and promotion that includes pre-introductory test and implementation in the logistics industry, RFID application and technology seminars, and international forums on the impact of RFID technology and associated business applications and operation models upon application or adoption. Companies should not only participate in seminars and exchange application lessons and experiences with foreign experts, officials, and academic representatives knowledgeable in RFID technology and the industry, but to actively pursue the adoption or implementation of this technology as well. With the government's assistance, companies can first proceed with its application among enterprises and then incorporate daily operational procedures through an interfacing platform with the upstream and downstream supply chain partners in the area of containers with RFID Tags. With the exception of the professional knowledge obtained from

the government, logistics companies can also actively participate in private organizations to access more knowledge. One example is the first “EPC Global Taiwan” established in March 5, 2004, in which 40 industrial and related players, including hardware manufacturers, software suppliers, system integration manufacturers, industry application companies, governmental units, and academic research units met to promote RFID standards, industrial applications, and integrated systems based on the EPC Network. Boasting of free registration to gain membership, this organization encouraged any industry, unit, or group to participate. The interactive discussion and dialogue among the group members were constantly maintained in the topic areas, such as fulfilling efficient operation, resolving urgent problems, discussing further suggestions, and encouraging the new members’ assessment of the technology’s application.

Finally, this study anticipates that the factors discussed above would be beneficial to the adoption of RFID for any new company interested in its future implementation. Companies can also gain benefits in terms of improving SCM and the existing decision-making process, and in reducing time and cost related to the introduction of RFID technology. The study, however, was not without limitations. First, the effective samples of this study were too small. Future research could thus verify this study’s results. In addition, this study was focused on the logistics industry, rendering the generalization of these results limited in addressing the needs of practitioners in a different industry. Finally, a broad range of literature has already discussed the issue of RFID, and as such, future investigations could produce discussions of more factors of adoption not addressed in this study.

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