國立交通大學

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碩士論文

食品流通履歷商業化營運分析

Analysis for Commercializing the Food Distribution Traceability System

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摘要

隨著科技之進步與消費者意識高漲，人們對於食品之要求由原先量的滿足，延伸至品質與安全衛生。因此，能讓消費者充分了解成分來源與加工流通過程，儼然成為重要課題。基於上述，本研究將分析食品流通履歷系統的商業模式，以及其商業化後所提供之服務項目，提供相關單位建立食品追蹤制度之參考。流通履歷系統中，內含許多資料需要詳實記載，諸如食品名稱、食品批次、流通途程等特定資訊，因此應用無線射頻身份識別系統（Radio Frequency Identification, RFID）技術，可自動讀取產品資料與隨身辨識之效果，達成上述之要求。此外，流通履歷系統結合了 RFID 技術後，可使得營運商對於食品供應鏈整個環節便於掌握分析，創造邊際效益。本研究亦對流通履歷系統商業化營運後，其營運公司所能獲得之利潤做實際的運算及分析，並以便利商店供應鏈為例，計算所需推廣店數與定價。

關鍵字：RFID 技術、食品流通履歷、供應鏈

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Abstract

To ensure the safety of food distribution and to protect consumers from accidentally contaminated food, the government tries to help the food industry build the system of food traceability system. The food traceability system provides the information of traceability of food so that consumers are comfortable with food safety. In addition, the system also increases the value of purchased food and enhances the food safety. The technology of Radio Frequency Identification (RFID) is an application on the food distribution system. The RFID implementation on the food distribution traceability system would open up another new business sector and help some related firms develop RFID related products or services. This research is to analyze the profits and costs incurred in implementation of a food distribution traceability system, and to propose a potential business model to implement the idea of the system of food distribution.

Key words: Radio frequency identification (RFID), Food traceability system, Supply chain

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Chapter 1. Introduction

In the past decade, due to the increasing number of food safety problems and rising consumer concerns, food safety has become an important public health issue. The public sector pays much attention on improvement of the food safety (WHO Media Centre, 2007). For instance, since the bovine spongiform encephalitis (BSE, commonly known as mad-cow disease) has happened in United Kingdom in 1985, the Euro-Retailer Produce Working Group (EUREP), a private party consisting of several European supermarket chains and their major suppliers, has developed an EurepGAP (Good Agricultural Practice[1]) standard to set voluntary standards for the certification of agricultural products around the world (GLOBALGAP, 2009). In 2008, there was a food safety incident in China involving milk and infant formula, which is known as Chinese milk scandal, in which many related products such as milk, ice cream and yoghurt were found to be contaminated with toxic compound. At the meanwhile, countries across the world recalled these related products (BBC News, 2009), but it is difficult to track and trace the food distribution channel in the current practice.

To enhance food safety and to prevent the food products in the market from the occurrence of such incidents, the associated governmental departments may proceed to two aspects as described in the followings. One is to manage food supply chains through some standards or certifications such as ISO 22000, HACCP (Hazard Analysis and Critical Control Point) and food GMP (Good Manufacturing Practices). Note that ISO 22000 is an international standard designed to ensure safe food supply chains worldwide (Frost, 2005). The other is to record all logs of logistics operations of products and steps within production processes by a food distribution traceability system. The main purpose of a food distribution traceability system is to provide the members in food supply chains with visible product

[1] EurepGAP has changed its name to GLOBALGAP in September 2007.

information. To do so, members can know well the status and quality of goods. In addition, if there is a food incident, the traceability system offers the service of *tracing back* and *tracking forward* in supply chains. In general, the associated parties in a food supply chain include feed producers, primary producers, food manufacturers, transport and storage firms and subcontractors to retail and food service outlets. The other related organizations include producers of equipment, packaging materials, cleaning agents, additives and ingredients (Frost, 2005). It is possible that food safety hazard appears in any stage of food supply chains. In other words, one weak link in food supply chains may result in unsafe food, which is harmful to health of consumers. It is essential to set some critical control points in food supply chains to record the information such as ingredients, weight and timing of manufacture, transportation and sales. Using Taiwan as an example, the Council of Agriculture (a governmental unit in Taiwan) carries out the Taiwan Agricultural Food Traceability System (TAFT) that customers can inquire the production record of agriculture food they purchased. Consumers can login the TAFT website, type in the tracing code which print in the pack to inquire some agriculture products such as Taiwan tea, rice, vegetable and fruit. On the other hand, the food which is recorded in the system is under the control of quality certification (TAFT, 2008).

To reach the goal of recording the trace and track of the entire supply chains, the technology of Radio Frequency Identification (RFID) is commonly used since the RFID is capable of identifying the particular object by the code embedded in the chip. The RFID is an automatic identification technology using a wireless sensor which identifies items and gathers data on items without human intervention. An RFID system consists of two major components: tags and readers (Tajima, 2007). A tag comprises of a microchip and an antenna to store identification data of the items and to transmit these data via radio waves. It comes in a variety of shapes and sizes. In addition, the size of tags significantly drops due to the advanced technology. An RFID reader communicates via radio waves with RFID tags and delivers the information in a digital format to a computer system.

The original use of RFID was initiated in military applications during World War II (Domdouzis et al., 2007). In recent years, with a mature technology development, the RFID is commonly used especially in supply chain management. For example, one of leading retailers, Wal-Mart, requests its suppliers to replace barcode with RFID in 2003 (Roberti, 2003). The reduction of cost, time and labor are resulted from implementing advantages such as reducing out-of-stock losses and speeding customers through checkout lines. Developing an RFID-based food traceability system not only improves the safety in food supply chains by its tracking and tracing features, but also promotes the development of RFID industry. In Italy, there is a traceability system which adopts both RFID and alphanumerical code to monitor and to protect a famous and expensive cheese, which is named Parmigiano Reggiano (Regattieri et al., 2007). The complete supply chain of Parmigiano Reggiano can be traced by the traceability system. As a result, both manufacturers and customers can check the origins and production processes of concerned products.

Several studies aim to develop a traceability system and the related software with RFID technology. As a traceability system is developed, members in food supply chains need a particular consultant to help them in adopting RFID technology. As mentioned earlier, because implementing RFID brings advantages in food supply chains, the government in Taiwan tends to establish this system by the proper authorities then transfers it to an application service provider (ASP) to run the daily operations in an RFID-based food distribution traceability system. The ASP may play a role of consultant to serve the members in food supply chains who intend applying the food traceability system. In this research, we are interested in how an ASP promotes the traceability system to members in food supply chains and brings profit to itself by offering consultant services. We analyze the profits and costs in the application of RFID technology in a food supply chain industry, and develop an approach to estimate a reasonable service fee paid by the associated members in food supply chains. Then, we can take the financially viable practice on operating this traceability system.

The remainder of this research is organized as follows. In section 2, we present a review of relevant literature including RFID development and food traceability system. The participants of the traceability system and implementation procedures of operating the food traceability system are introduced in section 3. Section 4 develops a promotion process and a pricing strategy in this newly adopting system. Then we conduct a field study of convenience stores chain in Taiwan to examine an implementation analysis in section 5. In section 6, we outline the conclusions and future research.

Chapter 2. Literature Review

The RFID technology has been developed for several decades. There are many successful applications especially in logistics and retail businesses for the potential benefits to track materials, goods and assets across the chain. In a construction industry, an automated traceability system of pipe spools and location of buried assets has been implemented by using the RFID technology (Domdouzis et al., 2007). It follows that the RFID technology can be implemented in this case in order to request pipe spools to be located successfully. In the engineered-to-order (ETO) construction, the ETO components are usually in the critical path of a construction procedure and have long lead times because they are highly customized. Thus, the RFID technology plays an important role to collect the status information automatically and to store the maintenance information of the ETO components. To manage the ETO construction components and their related location information, the RFID technology provides a vision of intelligent components, which know their identities, locations, history and communicate information to the facility environments (Ergen et al., 2007).

On the other hand, Tajima (2007) suggests that adopting RFID technique in supply chain management may reduce the management costs and may increase the efficiency of product flows. It follows that the usage of RFID in supply chains can improve the firm's competitive advantages through improving supply chain efficiency and innovation capacity. Based on an empirical study, a Spanish logistics company has implemented an active RFID tag into product platform, which is called MT, for a grocery supply chain (Martínez-Sala et al., 2009). The active RFID allows an MT to store associated products content and exchange it without human participation. Subsequently, it may help the MT become an adequate platform on which to build the paradigm of intelligent products. As a result, it tracks MTs over the entire supply chain, provides customers with value-added services, and improves management of containers. Wamba et al. (2008) show that using RFID in a retail industry can improve shipping, receiving and put-away processes corresponding to supplier, distribution center and retailer respectively. As above, it is clear that the RFID technology may help retail companies to enhance product availability and improve the chain's end-to-end visibility.

Because of an increasing concern of food safety problems, it is important to develop a traceability system to provide a safe food supply chain and to link producers with consumers. In the past few years, traceability in food supply chains plays a key role in the food supply chain. A dependable traceability system is based on procedures that ensure all requested information is recorded. All the recorded information is a clear and accurate reflection of the production process, being a useful tool in any food company (Ruiz-Garcia et al., 2010). The whole production process and its distribution history record have been stored into the traceability database system so that customers can check and confirm the real information of food products (Imura, 2006). Gandino et al. (2007) propose a traceability system which is based on RFID technology for a fruit warehouse. In the warehouse, fruit comes in from different farmers and then be sold to distributors. It enables operators to use a hand-held RFID reader to read and update data on tags to the central database. Subsequently, the downstream distributors can check the information about the fruit that they have received on tags.

We summarize some studies of food traceability system in recent years in Table 1. The studies can be categorized to "system design", "industry overview" and "benefit analysis" by their related issue(s). The system design shows that a typical traceability model in food supply chains could keep and establish secure food distribution situation (Gandino et al., 2007; Ruiz-Garcia et al., 2010; Thakur and Hurburgh, 2009; Bevilacqua et al., 2009; Regattieri et al., 2007). The industry overview proposes some general situations and industry overview of food traceability system (Jedermann et al., 2007; Lin, 2009; Prater et al., 2005). The benefit analysis indicates the benefits of traceability system enhancing the food safety (Karkkainen, 2003; Bertolini et al., 2006; Martínez-Sala et al., 2009).

Table 1: Studies of food traceability systems in the literature

Categories	Literatures	Scope of study
System design	Gandino et al. (2007)	Agriculture food chain
	Regattieri et al. (2007)	Expensive cheese
	Bevilacqua et al. (2009)	Vegetable products
	Thakur and Hurburgh (2009)	Bulk grain supply chain
	Ruiz-Garcia (2010)	Agricultural batch products
Industry overview	Prater et al., (2005)	Grocery supply chain
	Jedermann et al. (2007)	Temperature monitoring
	Lin (2009)	An integrated framework
Benefit analysis	Karkkainen (2003)	Perishable grocery supply chain
	Bertolini et al. (2006)	Pasta production
	Martínez-Sala et al. (2009)	Grocery supply chain

Some literatures indicate that the usage of RFID brings more advantages than the barcode (Jedermann et al., 2009; Tajima, 2007) on food traceability. Regattieri et al. (2007) analyze the economic advantages among the alphanumerical codes, bar codes and RFID in a product traceability system. They state that although the RFID is relatively expensive compared to the others, it is still a very promising system because it does not need physical contact or particular alignment with RFID readers. In addition, the reading phase of RFID is very fast and fully automated. With these advantages, when the costs of tags are reducing, food processing companies can regard the traceability as an opportunity for system growth because RFID can enhance the efficiency of goods transaction.

The most commonly mentioned advantage of the RFID over bar codes is supply chain visibility. Supply chain visibility would enable faster and automated processes at the supply chain level such as exception management and information sharing (Tajima, 2007). However, it is typically considered as a long-term benefit of the RFID because realization of visibility requires the mass adoption of RFID, trading partner collaboration and establishment of technology infrastructure for information sharing. Lin (2009) identifies five dimensions and 24 factors to construct the integrated framework of the RFID promotion procedure so as to implement the RFID technology in logistics and supply chain management. Lin (2009) proposes a sequence of companies to adopt the RFID technology, where cost and infrastructure are two key dimensions considered in the system establishment. As expected, the RFID technology becomes a popular technology internationally, but most applications are restricted in a single process or single division (i.e., a particular product such as vegetable, cheese and agricultural food). In fact, not many large-scale applications are applied in supply chain management until now. It implies that implementation of the RFID-based food traceability system in the entire food supply chain is a challenging work. Based on the preceding statement, the government plays an important role to support a pilot research to investigate the promoting strategy in the initial RFID implementation stage. There should be some guidance and incentives for firms to invest or to operate the food traceability system.

This research aims to establish a viable business model of food distribution traceability system. To do so, we propose a practical framework guidance to gather the related contractors and associations. Then, we estimate a financially viable practice on operating this traceability system. By drawing up an adopting process and setting the pricing strategy of the traceability system, it can provide a suggestion to investors who consider the viability of operating a traceability system.

Chapter 3. Introduction of the Traceability System

To promote the food distribution traceability system in food supply chains, it is appropriate to provide the industry with some guidance and instruction. This section would introduce the food distribution traceability system and offer an example to some service provider in investment. The service provider in this pilot project may cooperate in advance with members in food supply chains and RFID research developers.

3.1 The participants in the food traceability system

Implementation of the RFID technology in food supply chains may have influence on both the food industry and RFID industry. For a food industry, using RFID may bring more advantages than the conventional barcodes due to its large storing capacity, speedy reading rate, non-line-of-sight transmission, unique identity and difficult counterfeit. For an RFID industry, implementing RFID technology to construct a food traceability system can enhance the research and development of relative RFID applications, such as intelligent-packing and real-time control. As expected, with this pilot project, the food traceability system may extend another new RFID application and create a new business for food safety in food supply chains.

Table 2: The participants in the food traceability system of RFID implementation

<table>
<tr><th>Planning and Developing</th><th>Pilot Run</th><th>Implementing</th></tr>
<tr><td colspan="2">Government</td><td></td></tr>
<tr><td colspan="2">Third Party Research Organization</td><td></td></tr>
<tr><td colspan="3">Members in Food Supply Chains</td></tr>
<tr><td colspan="3">RFID Equipment and IT Developers</td></tr>
<tr><td></td><td colspan="2">Certification Organizations</td></tr>
<tr><td></td><td></td><td>Application Service Provider</td></tr>
</table>

In order to commercialize the food distribution traceability system and to reduce the investment risk, the government plays an important role in the beginning of implementation stage. This research aims to construct a viable way to drive the food traceability system and to improve the food safety by using RFID technology. There are sets of participants in the food traceability system of RFID implantation as shown in Table 2. The sequence of implementation follows three stages: planning and developing stage, pilot run stage, and implementing stage. In the planning and developing stage, the government gives support to some third-party research organizations to initiate the pilot project about the RFID technology. The third-party organization sponsored by the government would conduct experiments and initiate pilot runs to provide the industry with a customized service. In the mean time, the members in food supply chains (i.e., food manufacturers, distributors and retailers) and RFID equipment providers are collaborated with the third-party organization in the developing stage. It results in a situation where a food distribution traceability system suited for the demand of the real market. In addition, since there are a variety of standards of RFID applications, the members of food supply chains need a specific standard that can satisfy the industry demands. Thus, in the pilot run stage, a certification organization may formulate a typical standard to RFID developers to follow. As the system is developing maturely, the government would transfer the associated intellectual properties (IP) to an application service provider (ASP) to run the business of a food traceability system. In the implementing stage, the ASP owns the technique of the traceability system and provides consumers with computer-based services including hardware/software, information analysis and database. The main purposes of the ASP are providing technical assistance and data analysis of traceability system to members in a food supply chain. In practice, the RFID equipment is offered from RFID developers and solution provider. On the other hand, the members in a food supply chain and RFID developers would invest capital to the ASP to run the operations of traceability system. In the end, when the food traceability system is implemented successfully, it makes a safe food supply chain and profits from this novel service.

The Department of Commerce, Ministry of Economic Affairs (MOEA) in Taiwan plays the role of government sponsor. In addition, the Industrial Technology Research Institute (ITRI) is a research organization whose missions are to expedite the development of new industrial technology and to strengthen the technological competitiveness of Taiwan. The MOEA gives supports to the ITRI with this pilot project for detailed implementation steps of applying the RFID in a food industry. The goal of government is to run the food traceability system to serve the food supply chain in the initial stage. In other words, the ITRI may transfer the IP to a non-governmental institution or a business firm for daily operations after the food traceability system has been developed in a mature manner.

3.2 Features of the food distribution traceability system

The operations of a food distribution traceability system can reveal the information of food processing available to the public. The distribution information is uploaded to a database where food supply chain members have access to this information. In addition, the food distribution traceability system allows consumers to inquire whether the goods are certified with a GMP certification or not. In other words, one may utilize the kiosk in a retail store to know the relative information of goods before he/she buys the goods. Therefore, the visibility of food supply chains may be enhanced by the enquiry of certification. Furthermore, the price of goods may rise because of this value-added service with the RFID technology. Moreover, there is a trend that consumers tend to buy food with non-contaminated, organic and high quality. As a result, the applications of the RFID technology may help the public to push the food industry toward the development of high quality food products.

To provide the food supply chain members with the information of goods, this pilot project tends to operate an RFID-based traceability system that offers the services listed in Table 3. The major services can be categorized as "information services", "technical support" and "educational training." The information services include offering information in traceability system to clients in food supply chains and sharing experiences with other foreign countries. In addition, the technical support includes software and hardware installation assistance. This pilot project offers not only the services about food information, but also the innovative research of RFID applications (e.g., design the package of commodities for customized use). The educational training service is to help clients in design, development, construction and adaptation of traceability system.

Table 3: Major services and features of a food traceability system

Information services
– Provide the members in food supply chains with food distribution information.
– Offer the additional information of food distribution such (e.g., data analysis).
Technical support
– Establish the system of hardware and software for clients who adopt the food traceability system.
– Establish the standards of RFID equipment and guide the relative research (hardware and software).
– Develop innovative applications of the food traceability system.
– Examine the RFID software and hardware of traceability system.
– Design the package for commodities (e.g., tag-embedded bottles).
– Lease the equipment for a traceability system including kiosks and readers.
Educational training
– Help clients in design, development, construction and adaptation of traceability system.

In the initial stage, the system may offer essential services including system establishment (hardware), information offering and educational training (software). At the same time, it would set up and launch the relative equipment at every distribution point firstly.

3.3 Operations in the food distribution traceability system

A food supply chain may follow three stages: food processing, distribution of goods, and then selling the goods. There are different needs of facilities for different stages in a food distribution traceability system. In addition, each stage consists of three steps as shown in Figure 1. In a stage, three steps indicate particular control points in the operations of food manufacturers, distribution centers and retailers. In other words, RFID equipment is installed at these control points to record the information about food transactions.

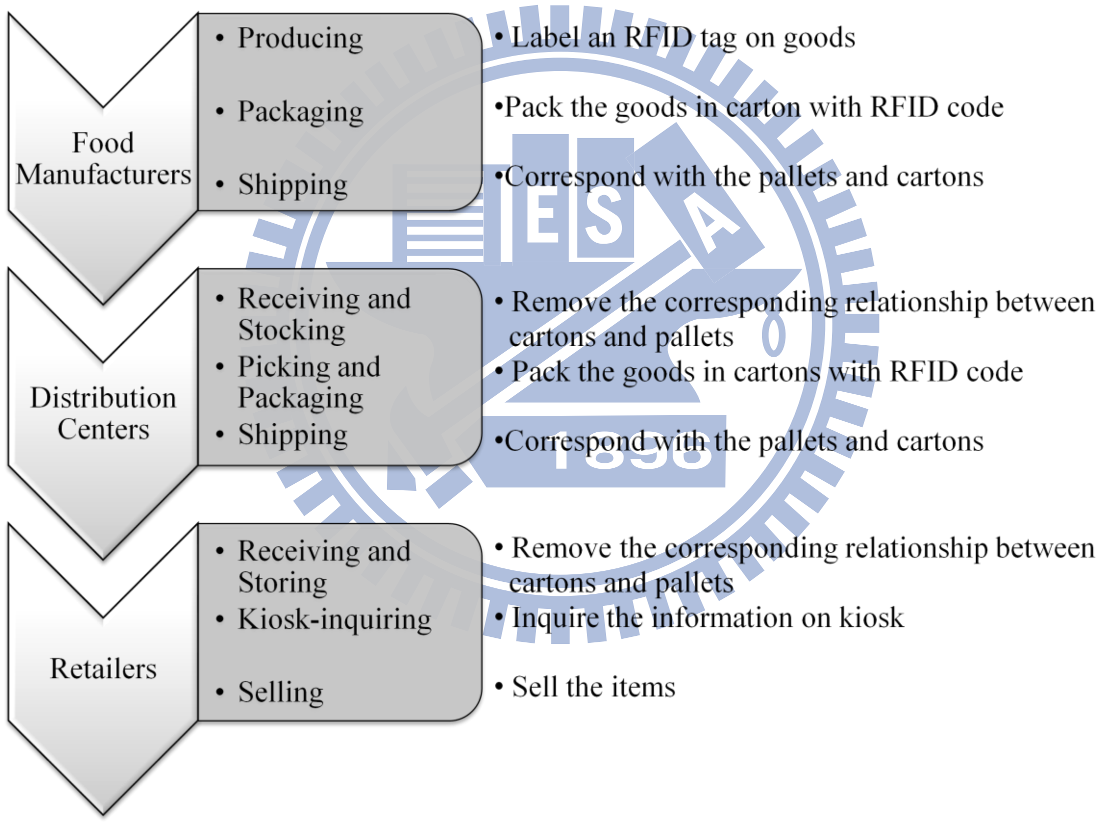


Figure 1: Operations of food distribution traceability system

In the following, we introduce the operations in these three stages involving food manufacturers, distribution centers and retailers. For the first stage, there are three steps implemented by food manufacturers; that are producing, packaging and shipping. At the producing step, the package of the processing food is labeled an RFID tag to record its production data (e.g., the attributes such as manufacturing date, ingredient contents and weight). Manufacturers pack products into the carton that is labeled an RFID tag as well. In the packaging step, the identity of specific products would correspond with the carton. Consequently, the carton would be put on the pallet. Because the shipping data is needed to record in the system, the pallet is labeled an RFID tag in order to upload the relative information to the traceability system. These tags would let the operations be visible in the first stage.

From Figure 1, the second stage is delivery of goods in a distribution center. The operations include three steps: receiving and stocking, picking, repackaging and shipping. Once the goods pass through an RFID reader, the stocking data and the merchandise data would be read and recorded. At the same time, the corresponding relationship between the cartons and pallet in the first stage would be removed because the goods would be allocated to different cartons at the next step. Meanwhile, the information about goods with the cartons would be connected with each other again. Subsequently, operators put the cartons on the pallet that is labeled an RFID tag. It allows users to track the corresponding relationship between cartons and pallets. In addition, the shipping data would be uploaded to the traceability system. The distribution center, of course, should have the information about operation date, stocking position and the routing path.

In the following, we move to the third stage, selling goods in a retail store. Similarly, there exist three steps: receiving and storing, kiosk-inquiring and selling the goods through an RFID-POS (point of sale) system. Note that RFID-POS is a system that records sale information with the RFID technology. When retailers receive the goods from distribution centers, the corresponding relationship between cartons and pallets would be removed. Retailers then read and write the merchandise data. On the other hand, retailers use the RFID reader to record the stocking data and sell the goods by an RFID-POS system. With the high speed reading rate of the RFID, the availability and reliability of checkout process can be promoted. In addition, there is a kiosk in retail store for consumers to inquire the food distribution information. An RFID-based traceability system allows staffs and managers to retrieve the useful information of merchandise of the shop (e.g., the expired food or shortage of products). Indeed, the traceability system gives the advantages of knowing well the inventory of a retail store so that it enables the inventory management to be efficient. For clerks, it is convenient to utilize the RFID-POS system to record the sales information that would be useful to analyze the market demand.

In order to satisfy the requirement of RFID use, food supply chain members have to set up the RFID facility in the beginning. However, as implementing the system to the whole food supply chain is a large scale and is not easy to put into practice, it should follow in proper sequence and make steady progress. This research proposes a tentative plan starting with the convenience store system including the promotion strategy and pricing plan of the pilot project.

Chapter 4. Financial Plan of Implementing the RFID

4.1 Implementation of RFID in food supply chains

In this section, we intend to predict the number of firms which possibly adopt the RFID technology in food supply chains. Because the food traceability system is a new technology, it takes a relatively long time for firms to make the adoption decision. In order to predict the number of firms implementing a food traceability system, we focus on the theory – diffusion of innovation (Kolter, 1994). Innovation diffusion theory has been widely used to understand technology adoption in organizations (Ranganathan and Jha, 2005; Lee and Shim, 2007; Sharma, Thomas and Konsynski, 2008). The theory provides a useful perspective on how to improve technology assessment, adoption and implementation (Matta and Moberg, 2006). Rogers (1995) indicates that when the numbers of consumers who adopt a new technology are plotted over time on a frequency basis, they follow a normal and bell-shaped curve. In addition, when the cumulative numbers of adopters is plotted over a length of time, they follow an S-shaped curve. The diffusion of innovations is shown in Figure 2. The bell-shaped curve shown in Figure 2 is simply divided into five sections with the different standard deviations of the normal distribution. As the S-shaped curve shown in Figure 2, with consumers adopting the new technology, its market share eventually reaches the saturation level.

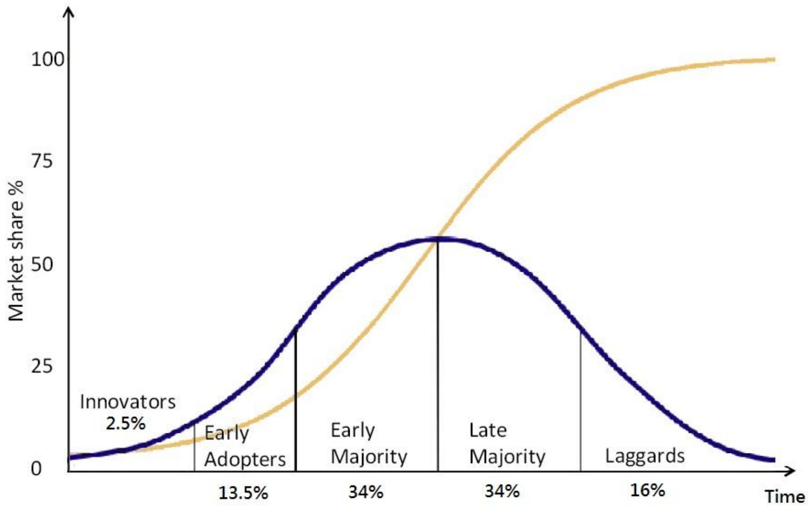


Figure 2: The diffusion of innovations (Rogers, 1995)

Rogers (1995) suggests that one may utilize an S-shaped curve to illustrate the diffusion of innovation. The S-shaped curve rises slowly when there are few adopters at initiation. It then accelerates to a maximum until half of the individuals in the system have adopted the new technology. Then the S-shaped curve increases at a gradually slower rate as fewer and fewer remaining individuals adopt the innovation. In practice, the logistic distribution gives a nice looking S-shaped curve with a relatively simple mathematical formula (Stockute et al., 2006). It follows that our study utilizes the logistic distribution to approximate the S-shaped curve.

Balakrishnan (1992) indicates that the logistic distribution is applied to various growth models especially in describing the population and organismic growth. The cumulative function of logistic distribution has been used as a growth curve. As a result, we utilize the logistic distribution to estimate the growing number of firms in this paper. Let $F(x)$ denote the cumulative distribution function (cdf) of the logistic distribution with variable x, which is stated as follows (see Stockute et al., 2006):

$$F(x) = \frac{e^x}{1+e^x}, \quad x \in \mathbb{R}. \tag{1}$$

In addition, the probability density function (pdf) of the standard logistic distribution is given by

$$f(x) = \frac{e^x}{(1 + e^x)^2}, \ \ x \in \mathbb{R}. \tag{2}$$

Furthermore, we have the standard deviation as

$$\sigma = \frac{\pi}{\sqrt{3}}. \tag{3}$$

The conventional food supply chain includes food manufacturers, distributors and retailers. As soon as the goods are produced, they should be labeled an RFID tag and the production information should be recorded, so the plants of each food manufacturer and the distribution centers have to install the RFID equipment in the beginning. On the other hand, there is a large number of retailers in the market. It would take a certain time to promote the RFID technology to the entire food supply chain. We assume that the retailers would adopt RFID following an S-shaped curve in T time periods. We let N denote the total numbers of food manufacturer plants, M denote the total number of distribution centers, and L denote the total number of retailer stores. We consider that there are l_t retailer stores adopting the RFID technology in the t^{th} time period. To estimate l_t and consider the fluctuation, we use the standard logistic distribution within the variation of 3 standard deviations. We let $\mathrm{R}(t;T)$ denote a function of the proportion in the cumulative distribution function of the logistic distribution.

$$\mathrm{R}(t;T) = \mathrm{F}\left(-1.5\sigma + \frac{t}{T}3\sigma\right), \ \ t = 1, 2, \dots, T. \tag{4}$$

The number of retailer stores which adopts the RFID technology increases in proportion of $\mathrm{R}(t;T)$ in time period 1 to time period T-1, and then achieve to L in time period T.

$$l_t = \begin{cases} L \times \mathrm{R}(t;T) & , \quad t = 1, 2, \dots, T-1 \\ L & \quad\quad t \geq T \end{cases} \tag{5}$$

According to the above estimation procedure, we can derive the number of adopters including food manufacturers, distributors and retailers in food supply chains within T time periods.

4.2 The pricing strategy

In order to commercialize the food distribution traceability system in food supply chains, we work out a plan of pricing strategy. The adopters of food distribution system are thought as clients who install RFID equipment. In practice, there are three common approaches to pricing: cost-based pricing, customer-driven pricing and competition-driven pricing approaches (Collins and Parsa, 2006). Cost-based pricing simply means that the price is based on the costs of the product and an equitable profit. Customer-driven pricing is a pricing approach that is determined by market demand and the different reaction of consumers. Competition-driven pricing is a market driven pricing approach that is determined by the market price of similar products of the competitors and production conditions. Among these three pricing approaches, cost-based pricing is relatively easy to implement because it requires little information and is easy to calculate. In addition, the cost-based pricing can be further divided into several pricing approaches. One of the approaches is breakeven pricing, which is usually used when the number of sales is established. In breakeven pricing approach, prices meet some certain standards in order to achieve the breakeven point. In this pilot project, we adopt the breakeven analysis to pricing because it could determine a breakeven point for firms to a balance between receipts and payments.

Breakeven analysis is a technique used to identify the sales volume at a price that covers costs. The breakeven point is the level of sales at which total revenues equal total costs. In order to find the breakeven point, we estimate the total costs and the revenues that would be earned at various quantities at a given price. Both the total cost and revenue are linear functions based on the simplifying assumptions that (i) each unit is sold at the same price, and (ii) the costs of producing each additional unit is the same.

$$\text{Breakeven Point} = \frac{\text{Total Fixed Costs}}{\text{Price} - \text{Unit Variable Cost}} \quad (6)$$

In (6), the Total Fixed Costs are the costs that do not vary with the level of production quantity. In other words, for example, the total fixed costs are the same whether a firm produces one unit of their product or one million units. Fixed costs typically include the expenditures such as the rent on the building in which the firm produces its products. On the other hand, Unit Variable Cost is the cost varying with the level of production quantity. When we estimate the breakeven point, the sales volume needs to cover costs at a specific price. In addition, it is necessary to consider whether the firm is likely to sell the quantity at the given price. Therefore, we combine breakeven analysis with knowledge of consumer demand. With considering a desired profit into the estimated breakeven point, we can incorporate a specific profit objective into breakeven analysis to generate a desirable profit. Thus we can determine the sales volume to achieve the desired profit level.

$$\text{Sales Volume to Achieve Desired Profit} = \frac{\text{Fixed Costs} + \text{Desired Profit}}{\text{Price} - \text{Unit Variable Cost}}. \quad (7)$$

Consequently, from (7), we can set price as (8) which simultaneously considers cost, demand factors and produce valuable input.

$$\text{Price} = \frac{\text{Fixed Costs} + \text{Desired Profit}}{\text{Sales Volume}} + \text{Unit Variable Cost}. \quad (8)$$

In addition, we assume that there are start-up cost and regular operations costs of the ASP for promoting the RFID technology. The start-up cost only occurs in the beginning, and operations costs are taken into consideration in the each following time period. The start-up cost includes fixed assets such as fixtures, equipment, decoration, office supplies and installation of equipment. The operations costs include rent, payrolls, insurances and utilities. We let TC_t denote the total cost of time period t. Similarly, the TSC denotes the total start-up cost and TOC_t denotes the total operations cost of time period t. Thus, the total cost at the first period is the sum of the total start-up cost and total operations costs of the first time period. In the remaining periods, the start-up cost does not take place from the second period. More specifically, the total cost can be stated as

$$TC_t = \begin{cases} TSC + TOC_t, & t = 1 \\ TOC_t, & t > 1 \end{cases}. \quad (9)$$

Based on (9), we can calculate the resulting costs of the ASP for promoting the RFID to each member in a food supply chain. Both the start-up cost and operations costs are classified as fixed costs because they do not vary with the different number of customers. At the same time, this ASP provides customers with the service of hardware installation and consulting service. Compared to a manufacturing industry, a service industry makes profits by offering service to customers. It is difficult to formulate the variable cost with a new customer, so a service industry usually does not mention the variable cost.

Based on breakeven pricing of (8), we can set a price on the RFID service. The RFID hardware is provided by the RFID developer and installed by the ASP. In this research, we focus on the cost and profit analysis of the ASP. The procurement cost of the RFID hardware is eventually transferred to clients installed the traceability system. In this pilot study, we charge the customers an initial fee, named $P_{initial}$, paying for installing the RFID-related hardware or equipment. On the other hand, charging $P_{initial}$ is to make the breakeven point of start-up cost of the ASP. As a result, $P_{initial}$ can be derived from dividing the start-up cost by the total number of clients, which consists of food manufacturers, distribution centers and retailer stores. That is, the $P_{initial}$ can be generally stated as

$$P_{initial} = \frac{TSC}{N + M + L}. \quad (10)$$

In addition to the initial fee, we may charge customers a service fee after the first installing period. We let $P_{service}$ denote the service fee. For the purpose of making profits, we multiply operations costs by a proportion of desired profit *x%*, and then divide it by the number of accumulated clients for service period *T*. For instance, if *x%* is equal to zero, the business would reach breakeven. As above, the service fee can be formulated as

$$P_{service} = \frac{\sum_{t=1}^{T} TOC_t \times (1 + x\%)}{\sum_{t=1}^{T}(N + M + l_t)}. \tag{11}$$

We charge customers an initial fee in the first installing period and service fee in the following periods. In the following, with the information of price and number of clients, we can calculate the profit of this pilot project. The purpose of calculating profits is to understand the potential revenue of a food traceability system.

4.3 The expected profitability

In the preceding sections 4.1 and 4.2, we illustrate the method of setting price and forecasting number of customers. Now we can estimate the profit of this pilot project. We simply set that the total revenue is price multiplied by quantity. The profit is calculated by revenue minus costs, which is stated as shown below

$$\text{profit} = P_{initial} \times \text{newly adopting clients} + P_{service} \times \text{accumulated clients} - TC.$$

We note that the RFID equipment of hardware is offered by the RFID developer and supplier. The ASP simply provides the service of installing the system and information services. Because the ASP simply transfers the procurement cost of the RFID equipment to its clients, the procurement cost is not included in the analysis in this study. According to our study, the food manufacturers and distribution centers adopt the RFID technology in the first time period. On the other hand, the adopting number of retailer stores would increase from l_1 to l_T in T periods. As a result, profit of each period can be stated as follows:

$$profit_t = \begin{cases} P_{initial} \times (N + M + l_t) - (TC_t), & t = 1 \\ P_{initial} \times (l_t - l_{t-1}) + P_{service} \times (N + M + l_{t-1}) - (TC_t), & t = 2, \ldots, T. \\ P_{service} \times (N + M + l_t) - (TC_t), & t > T \end{cases} \tag{12}$$

From (12), we can calculate the profit of this pilot project in each period. In each period, only newly adopting clients are charged an initial fee. In addition, the clients adopting the RFID in the preceding period are charged a service fee. Because the service fee is charged from the second period for a single client, the price would make the breakeven point in period $T+1$.

In this section, we develop a method to forecast the clients and set the pricing strategy of this pilot project. In the next section, we apply these developed methods to a field study. In our opinion, the chain convenience stores in Taiwan may be a suitable choice to run the traceability system in the beginning because of their standardized business methods. In addition, these convenience stores usually have their own distribution centers to support the goods delivering. As mentioned earlier, to improve the viability in commercializing the food distribution traceability system, we conduct a field study for chain convenience stores in Taiwan.

Chapter 5.   The Field Study

5.1   Data collection from the chain convenience stores

The distribution traceability system serves a role to help us enhance the food safety in a food supply chain.   To implement the task, the pilot project runs the food distribution traceability system to link itself with a set of suppliers, distribution centers (DCs) and retailers including convenience stores, supermarkets and warehouse stores.   For the reason of viability, we restrict the study range to chain convenience stores in Taiwan.   They have adopted the electronic commerce system so that it is easier for them to implement the food/product traceability system by using RFID technologies.   As expected, launching the RFID technology results in customers with convenience and security.   In addition, we note that the major groups of chain stores in Taiwan are 7-Eleven, FamilyMart, Hi-Life and OK-mart. The target markets for the RFID are convenience stores whose main customers expect fresh, convenient, nutritious and inexpensive products.

The goal of this pilot project is to promote RFID systems to chain convenience stores, including the retailer stores, distribution centers and food manufacturers.   Once the goal of implementing RFID system to convenience stores is successfully reached, it can be extended to the next stage of supermarkets and warehouses to apply the RFID system.

For analyzing purposes, we have to measure the market size and the demand of RFID hardware/software in two aspects: one is to estimate the number of equipment needed in food supply chains, the other is to verify the target market to promote the RFID technology.   We first calculate the number of required instruments of RFID readers and tags by the following estimated approach.   Note that there are different types of RFID readers including the fixed reader, the hand-held reader, the RFID-POS system and the kiosk.   In a similar manner, the demand of readers can be discussed in two sides: manufacturers and retailers.   For a manufacturer, fixed readers are needed in order to record the information of products. For retailers, each retailer store has an RFID-POS at checkout counter to record the selling information and a kiosk for consumers to inquire the relative data of their purchases. The retailers and distribution centers also need hand-held RFID readers for stocktaking. For a systematic analysis, an integrated procedure is proposed and contains three stages as shown in Figure 3. The first stage is to investigate the chain of convenience stores in Taiwan. In the second stage, we sample and inquire the convenience stores for estimating the number of purchases. On the other hand, we investigate the number of convenience stores, major food suppliers and their related distribution centers. Applying the analyzing process, we can estimate the consumption of RFID tags and the requirement of RFID equipment in the convenience store chain.

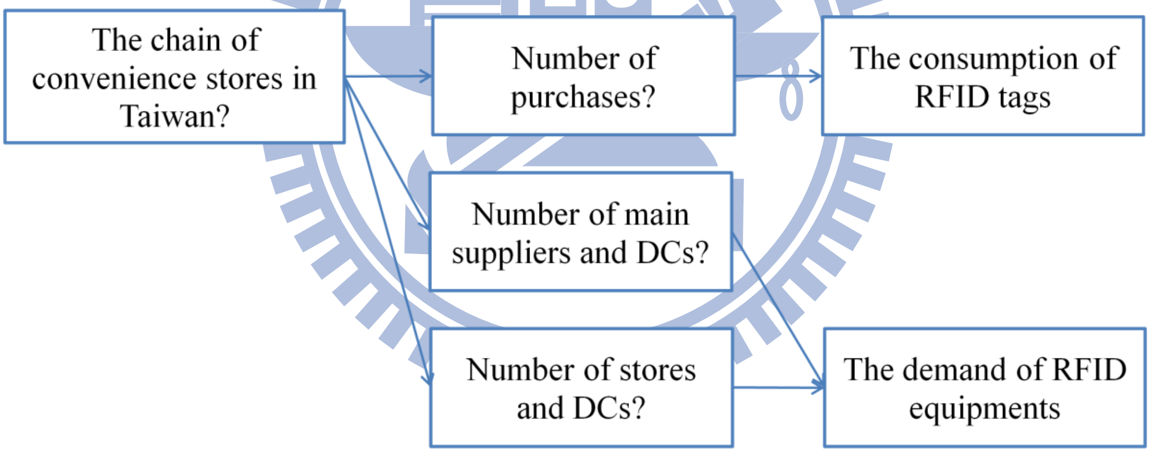


Figure 3: The procedure of estimating the number of RFID equipment

It is worth to mention that each chain of convenience store has its own logistics system. Obviously, the needed numbers of readers, RFID-POS and kiosks can be estimated by the firm of convenience stores. With the information gathered from each convenience store, the number of stores and related distribution centers in each convenience store chain is shown in Table 4. In addition, some larger food manufacturers and the distribution centers of each firm are summarized in Table 5 as well.

Table 4: The number of stores and related DCs of each convenience store

Firm	Number of stores	Number of DCs
7-Eleven	4,800	9
FamilyMart	2,300	4
Hi-Life	1,250	5
OK-mart	850	2
Total	**9,200**	**20**

Table 5: The number of plants and related DCs of major food manufacturers

Firm	Number of plants	Number of DCs
Uni-President	6	6
Wei Chuan	4	4
Laurel Enterprise	2	4
Taisun	2	3
Hey Song	2	3
Bolife	2	3
Lian Hwa	4	0
Kuang Chuan	3	0
Yeswater	2	0
Kingcar	3	2
Total	**30**	**25**

It is reasonable to assume that each retailer store has at least one hand-held reader to record the information of inventories of merchandise, two RFID-POS systems at counter for clerks to checkout and a kiosk for customers to inquire the information about goods. In addition, each food manufacturer has at least two fixed readers to record the production and transportation process. Moreover, two fixed and one hand-held reader assumed to equip in a distribution center. As above-mentioned statement, the requirement of RFID equipment is shown in Table 6.

Table 6: The requirement of RFID equipment to each member

	Quantity	Fixed reader	Hand-held reader	RFID-POS system	Kiosk
Food manufacturers	30	2	1	N/A	N/A
Distribution centers	45	2	1	N/A	N/A
Retailers	9,200	N/A	1	2	1

Under this consideration, the amounts of fixed readers, hand-held readers, RFID-POS systems and kiosks can be calculated and are summarized in Table 7.

Table 7: Estimated equipment demand of distribution traceability system

	Fixed reader	Hand-held reader	RFID-POS system	Kiosk
Food manufacturers	60	30	N/A	N/A
Distribution centers	90	45	N/A	N/A
Retailers	N/A	9,200	18,400	9,200
Total	**150**	**9,275**	**18,400**	**9,200**

In Table 7, it indicates that there is a large demand of RFID equipment. This indeed gives the RFID component manufacturers strong incentives to develop the hardware for the large potential market.

In the following, we calculate the consumption of RFID tags in chain convenience stores. We can estimate the consumption of RFID tags by the field data from retailer stores. We take samples from five different locations of convenience stores in Taiwan. The purchase data are recorded in two time periods, morning and evening, which are from 10:30 to 11:30 in the morning and from 7:00 to 8:00 in the evening. There are four kinds of foods that are suitable for utilizing RFID tags. Those are beverage, instant food, packaged food and frozen food due to their characteristics. We record the number and types of purchases by observing customers of the checkout counter. In addition, we summarize the resulting data in Table 8.

In Table 8, each cell indicates the consumption of each kind of food during a specific time period.

Table 8: Records of tags consumption for firms

Package or food type	Location 1 (FamilyMart)		Location 2 (Hi-Life)		Location 3 (7-Eleven)		Location 4 (Hi-Life)		Location 5 (7-Eleven)	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Plastic bottles	11	29	48	48	25	12	17	63	20	16
Metal can		3		9	1	17	2		1	17
Glass bottles		2	1	15	1			4	2	
Tetra pack	24	34	35	19	18	31	16	12	9	37
Milk	7	12	5	11	6	3		8		2
Rice ball	7	11			1				1	
Sandwich	5	8			8		2	2	2	
Dessert	1	4							1	
Bread	7	13	3	5	3		4	4	4	
Snacks		4	6	1	3	5	2		2	5
Instant noodles	1	2	1		1	3		1		3
Crackers		4	2	1		5	2	4		4
Candy		4	3	2	4		2	2		
Frozen food	1									
Ice, Popsicle		2		1						
Total	64	~~132~~	~~104~~	112	71	~~76~~	47	100	~~42~~	84

From the available data, we summarize the whole number of items in each specific store given the time period. Some outlier statistics are deleted as shown in the cross-out marks in Table 8 (i.e. 132, 104, 76 and 42); that is, we delete the highest and the lowest number of morning and evening respective. With the field study data, we can estimate the day consumption of tags in each retailer store by

$$(64 + 112 + 71 + 47 + 100 + 84) \div 6 \times 24(\text{hrs}) = 1{,}912(\text{tags/day}).$$

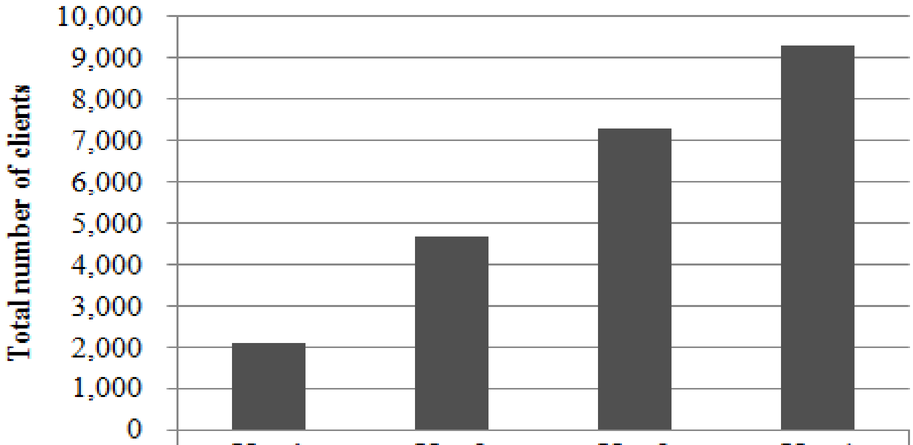
Thus, the total annual number of tags used can be approximated as

$$1{,}912(\text{tags/day}) \times 365(\text{days}) \times 9{,}200(\text{stores}) = 6{,}420{,}496{,}000(\text{tags/year}).$$

With the former estimations of required RFID readers and predicted amounts of tags, the potential market of hardware is large according to our analysis. Because the number of tags consumption is 6,426,079,040 per year, it is worthy of investing in this field.

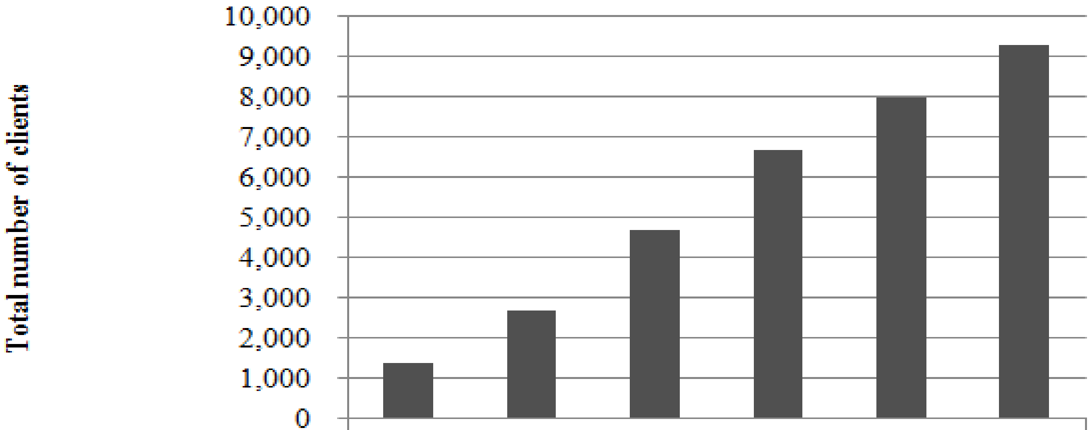
5.2 Promotion scenarios of food traceability system

By the illustration of section 4.1, the adopting process of the RFID technology in chain convenience stores would follow a specific sequence. In this field study, we take a year as a planning time period. The food manufacturer and distribution centers should install the RFID equipment in the first year. The retailer stores may install the hand-held readers and kiosks in sequence. Following industry experts' opinions, we investigate two scenarios in the study: 4- or 6-year promotion schemes. The adopting numbers of retailer stores follow the standard logistic distribution as shown in (5) in section 4.1. We let M denote the number of food manufacturers, N denote the number of distribution centers, and L denote the number of retailers, where M is 30, N is 45, and L is 9,200 in the field study respectively. This helps us derive the result shown in Figure 4 and Figure 5. For 4-year promotion scheme, the accumulated clients of retailer stores installed the RFID-based traceability system through the first year to fourth year are 2,000, 4,600, 7,200 and 9,200. On the other hand, for 6-year promotion scheme, the accumulated clients of retailer stores installed the RFID-based traceability system through the first year to sixth year are 1,300, 2,600, 4,600, 6,600, 7,900 and 9,200. This allows us to approximate the suggested price in a reasonable manner. As expected, once the pilot project is successfully promoted throughout the entire convenience store chain, the RFID traceability system then may be expanded to other fields.



	Yaer1	Year2	Year3	Year4
■ Total number of clients	2,075	4,675	7,275	9,275
Plants of food manufacturers	30	30	30	30
Distribution centers	45	45	45	45
Retailer stores	2,000	4,600	7,200	9,200

Figure 4: 4-Year promotion scheme



	Yaer1	Year2	Year3	Year4	Year5	Year6
■ Total number of clients	1,375	2,675	4,675	6,675	7,975	9,275
Plants of food manufacturers	30	30	30	30	30	30
Distribution centers	45	45	45	45	45	45
Retailer stores	1,300	2,600	4,600	6,600	7,900	9,200

Figure 5: 6-Year promotion scheme

5.3 The cost and profit analysis

To set the price of implantation of RFID, we estimate the annual expenditure including start-up cost and operations costs. Because salary cost is one of the most important parts of operations costs, we also estimate the personnel plan and total payroll as shown in Table 9. According to industry experts, 20 employees are expected to be recruited in the first year, 28 employees in the second year, and 35 employees in the third year and remaining years. A small-sized firm with 35 employees would be launched for promotion and operation business in this pilot project. We also list the estimated expense of the pilot project in Table 10. Note that the technology transfer fee is the maximum part of the expense in the first year. The total expense would be summarized by start-up cost in the first year and operations costs in each year. From the second year, the total cost includes operations costs without start-up costs.

Table 9: Personnel plan of the pilot project

	Year 1	**Year 2**	**Year 3**	**Payroll(year/person)**
President	1	1	1	$1,147,500
Vice-President	0	1	1	$675,000
Manager	1	1	2	$810,000
IT engineer	6	9	10	$607,500
Accountant	2	2	4	$472,500
Sales	6	8	10	$337,500
Technician	4	6	7	$405,000
Total people	**20**	**28**	**35**	
Total payroll	**$10,192,500**	**$14,175,000**	**$17,617,500**	

Table 10: The estimated expenses

	Year 1	Year 2	Year 3	Year 4
Start-up cost				
Technology transfer fees	10,000,000			
Refundable deposit for office rent	546,000			
Interior decoration	1,800,000			
Office equipment	3,054,500			
Office supplies	52,000			
Total start-up costs	15,452,500			
Operations costs				
Payroll	10,192,500	14,175,000	17,617,500	17,617,500
Insurance	2,400,000	2,400,000	2,400,000	2,400,000
Rent	3,480,000	3,480,000	3,480,000	3,480,000
Utilities	300,000	300,000	300,000	300,000
Miscellaneous	340,000	340,000	340,000	340,000
Total operations costs	16,712,500	20,695,000	24,137,500	24,137,500
Total costs	**32,165,000**	**20,695,000**	**24,137,500**	**24,137,500**

We can now use the pricing method illustrated in section 4.2 to set the initial fee and service fee respectively. From (10), we state 15,452,500 as the total start-cost *TSC*, 30 as the number of food manufacturers *M*, 45 as the number of distribution centers *N*, and 9,200 as the number of retailers *L* respectively. As a result, we have the initial fee as

$$P_{initial} = \frac{15,452,500}{30 + 45 + 9,200} = 1,666.$$

In addition to the initial fee, this pilot project charges its clients a service fee for the years after the first installing year. The pricing strategy of the service fee that is employed in 4- and 6-year promotion scheme is discussed separately in the followings.

4-year promotion scheme

According to (9) and estimated expenses in Table 10, the total costs can be estimated as follows:

$$TC_1 = 15{,}452{,}500 + 16{,}712{,}500 = 32{,}165{,}000,$$

$$TC_2 = 20{,}695{,}000,$$

$$TC_3 = 24{,}137{,}500 \text{ and}$$

$$TC_4 = 24{,}137{,}500.$$

Note that the total costs would be 24,137,500 after the third year. From (11), suppose that the pilot project is expected to make 20% profit. Given that the accumulated numbers of installing clients are 2,075, 4,675, 7,275 and 9,275, the price should be

$$P_{service} = \frac{(16{,}712{,}500 + 20{,}695{,}000 + 24{,}137{,}500 \times 2) \times (1 + 20\%)}{2{,}075 + 4{,}675 + 7{,}275 + 9{,}275} = 4{,}413.$$

As the computations above, the clients implementing the RFID pay an initial fee $P_{initial}$ = 1,666 in the first year and $P_{service}$ = 4,413 from the second year. Similarly, we can analyze the other promotion scheme in the following.

6-year promotion scheme

It is the same as 4-year promotion scheme, so we calculate the resulting total costs that would occur within six years in the following

$$TC_1 = 15{,}452{,}500 + 16{,}712{,}500 = 32{,}165{,}000,$$

$$TC_2 = 20{,}695{,}000,$$

$$TC_3 = 24{,}137{,}500,$$

$$TC_4 = 24{,}137{,}500,$$

$$TC_5 = 24{,}137{,}500 \text{ and}$$

$$TC_6 = 24{,}137{,}500.$$

Suppose that the pilot project is expected to make 20% profit. Given that the accumulated numbers of installing clients are 1,375, 2,675, 4,675, 6,675, 7,975 and 9,275. Therefore, we have the service fee for 6-years promotion scheme as calculated below.

$$P_{service} = \frac{(16{,}712{,}500 + 20{,}695{,}000 + 24{,}137{,}500 \times 4) \times (1 + 20\%)}{1{,}375 + 2{,}675 + 4{,}675 + 6{,}675 + 7{,}975 + 9{,}275} = 4{,}923$$

Because of the same reason, the price that the clients would pay is $P_{initial}$ = 1,666 in the first year and $P_{service}$ = 4,923 from the second year.

Profit analysis

In the following, we would utilize the estimated prices to calculate the resulting profits for 4- and 6-year promotion schemes. From section 4.1, the prices can be derived according to the cost-based pricing approach. For 4-year promotion scheme, we charge $P_{initial}$ = 1,666 for 2,075 clients in the first year. As a result, the profit of the first year can be computed as follows:

$$profit_1 = 1{,}666 \times 2{,}075 - 32{,}165{,}000 = -28{,}707{,}972.$$

For the following years, we charge $P_{initial}$ = 1,666 for each client who installs the RFID equipment and $P_{service}$ = 4,413 for the accumulated number of clients. Thus, the profit of each year can be obtained as

$$profit_2 = 1{,}666 \times 2{,}600 + 4{,}413 \times 2{,}075 - 20{,}695{,}000 = -7{,}206{,}674,$$

$$profit_3 = 1{,}666 \times 4{,}035 + 4{,}413 \times 4{,}675 - 24{,}137{,}500 = 824{,}191,$$

$$profit_4 = 1{,}666 \times 569 + 4{,}413 \times 7{,}275 - 24{,}137{,}500 = 11{,}297{,}933 \text{ and}$$

$$profit_t = 4{,}413 \times 9{,}275 - 24{,}137{,}500 = 16{,}791{,}523 \quad \text{for } t > 4.$$

As above, it can be seen that we would have a positive profit from the third year and would earn 16,791,523 (NTD) from the fifth year.

On the other hand, the profitable condition of 6-year promotion scheme also can be derived as below.

$$profit_1 = 1{,}666 \times 1{,}375 - 32{,}165{,}000 = -29{,}874{,}198,$$

$$profit_2 = 1{,}666 \times 1{,}300 + 4{,}923 \times 1{,}375 - 20{,}695{,}000 = -11{,}759{,}476,$$

$$profit_3 = 1{,}666 \times 2{,}000 + 4{,}923 \times 2{,}675 - 24{,}137{,}500 = -7{,}635{,}330,$$

$$profit_4 = 1{,}666 \times 2{,}000 + 4{,}923 \times 4{,}675 - 24{,}137{,}500 = 2{,}211{,}469,$$

$$profit_5 = 1{,}666 \times 1{,}300 + 4{,}923 \times 6{,}675 - 24{,}137{,}500 = 10{,}892{,}042,$$

$$profit_6 = 1{,}666 \times 1{,}300 + 4{,}923 \times 7{,}975 - 24{,}137{,}500 = 17{,}292{,}462 \text{ and}$$

$$profit_t = 4{,}923 \times 9{,}275 - 24{,}137{,}500 = 21{,}527{,}032 \quad \text{for } t > 6.$$

As above, we would have a positive profit from the fourth year and earn 21,527,032 (NTD) per year after the seventh year. In summary, resulting profits of 4- and 6-year promotion schemes can be arranged in Table 11.

Table 11: The resulting profits of 4-year and 6-year promotion schemes

	4-year scheme		6-year scheme	
Initial fee	$1,666		$1,666	
Service fee	$4,413		$4,923	
	Total clients	Profit	Total clients	Profit
The 1st year	2,075	-$28,707,972	1,375	-$29,874,198
The 2nd year	4,675	-$7,206,674	2,675	-$11,759,476
The 3rd year	7,275	$824,191	4,675	-$7,635,330
The 4th year	9,275	$11,297,933	6,675	$2,211,469
The 5th year	9,275	$16,791,523	7,975	$10,892,042
The 6th year	9,275	$16,791,523	9,275	$17,292,462
The 7th year	9,275	$16,791,523	9,275	$21,527,032

We can see the comparison of 4- and 6-year promotion schemes in Table 11. The initial fee of these two promotion schemes is the same, but the service fee of 6-year promotion scheme is higher than 4-year promotion scheme. On the other hand, in the first five years, because the adopting number of clients of 4-year promotion scheme is more than 6-year promotion scheme, the profits of the former are higher than the latter. However, when the number of clients reaches to the same, the profit of 6-year promotion scheme is higher than 4-

year promotion scheme from the sixth year because the higher service fee. It seems that the 6-year promotion scheme is a better scenario than 4-year's in long-term. Nevertheless, in the view of serving the RFID technology to the entire supply chain, the shorter promotion scheme would be better to the industry.

In this section, we analyze the estimated cost and profit of this pilot project that operates the food distribution traceability system for chain convenience stores in Taiwan. It is clear that the pilot project makes an incremental profit according to our project. We charge the clients who install the RFID hardware/software with an initial fee in the first year. In addition, we charge the clients with service fee per year for technical support and maintaining those related hardware/software. The retailers have incentives to implement the RFID food distribution system because the technology may enhance customer service. The food distribution traceability system may protect consumers from the fear of food accidents and satisfies consumers in a safe food supply chain.

Chapter 6. Conclusions and Future Research

In recent years, because of concerns in food safety issue, many researches focus on the food traceability system. The food traceability system may provide members in food supply chains and customers with a visible transaction process. However, not much research indicates the utility of operating a food traceability system. In this study, we propose a framework of promoting the food distribution traceability system. Our study provides an essential way to commercialize the food distribution traceability system and to perform operations in a food supply chain. The proposed system is based on RFID technology, which is applied in improving supply chain management and asset visibility in recent years. With the implementation of RFID technology, a food traceability system would be reliable and efficient because RFID enables a higher reading rate than traditional bar code.

In this study, we develop the promotion schedule to know the adoption of a new technology for supply chain members. In this paper, we assume that the members in a food supply chain composed of food manufacturers, distributors and retailers adopting the RFID technology follow the logistic function. In addition, we propose a pricing strategy for clients who adopt the RFID infrastructure and service. The tentative plan is to charge clients an initial fee for installing RFID equipment in the first year; and then charge clients service fee for technical support from the second year. As a result, we can analyze the cost and the profitability of this pilot project.

The chain convenience stores in Taiwan have adopted an electronic commerce system for years. With the existing institution, chain convenience stores would be easier to implement a food traceability system than other food supply chains. In addition, chain convenience stores have become a popular choice of grocery shopping. To successfully implement the RFID technology in food supply chains, we focus on the chain convenience stores in Taiwan for a field study. The computing result provides a suggestion to investors who consider the viability of operating a traceability system.

In this study, we focus on commercializing the food distribution traceability system. We predict that the adoption process of members in a food supply chain would follow a cumulative logistic function. However, there are many influences to market growth in reality. We may consider using another growth function to sketch the adoption process of a new technology in future research. In addition, the promotion scheme can be extended to more scenarios to observe the variation. We may improve the way to estimate the expected profit of this pilot project according to the precision investigation. In practice, there is variety of food supply chains. We may extend the range of this study to other food supply chains instead of confining in chain convenience stores.

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