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A CASE ANALYSIS OF ADOPTION OF AN RFID-BASED GARMENT MANUFACTURING INFORMATION SYSTEM

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Abstract

A case study approach was used to explore the adoption of an RFID-based garment manufacturing information system in a garment factory in China. The findings indicate that both the technology push factors and need pull factors influence the intention of the garment factory to adopt RFID technology. Technology push factors include relative advantage, compatibility, complexity, extendibility, and cost of the technology while need pull factors comprise competitors and customers pressure. We have identified eight factors for successful adoption of the RFID-based garment manufacturing information system, namely vendor selection, organizational motivation, cost/benefits evaluation, top management support, user involvement, extent of progress supervision, staff competence and training and policy, structure and operation process compatibility.

Keywords: *Radio frequency identification (RFID), garment manufacturing information system, case analysis*

1. INTRODUCTION

Following the abolishment of the World Trade Organisation Quota System in 2005 and the increased challenges of globalisation, the textiles and clothing industry of Hong Kong has been starting to adopt new technologies to enhance and excel in high-value-added manufacturing. Advances in Information Technology (IT) present many opportunities for companies, including garment and textile industry, to enhance and transform their work processes and business relations (Sambamurthy et al. 1999). IT is proven to have potential impact on organizational operational efficiency and competitive advantages (Melville et al. 2004). In recent decade, radio frequency identification (RFID) has attracted the attention of many organizations. It has been increasingly used in the business and industry (Ngai et al. 2007), and also in the industry sector which has lower profit margin, such as garment manufacturing industry (Ngai et al. 2008).

In the textile and garment industry, while RFID technology has been applied in stocktaking operations, strengthening customer relationships, facilitating promotional activities, and allowing retailers to allocate resources more effectively (Moon et al. 2008), the use of RFID technology in garment manufacturing, has not been fully investigated. In traditional garment manufacturing processes, it was under the manual tracking system that once the materials were sent to the production shop floor, they were entered into a “black hole” and production visibility was not available to management until becoming a finished product. Most of the garment manufacturers are still using “paper ticket” to manage their operation. Each bundle is tied with a paper ticket which is printed with bar-code label for different operation steps. When the sewer completes his/her part of work, he/she will tear off his/her part in the paper ticket. At the end of the day, the supervisor will collect all the tickets, a clerk will enter the sewer staff identity and scan his/her tickets. Operations information is collected and input into the system at this point at the day-end. Aiming to benefit the garment manufacturing process with the RFID technology and to motivate the manufacturers in deriving the full benefits from RFID, this paper presents a case analysis of the adoption of an RFID-based garment manufacturing information system. This exploratory case study investigates the phenomenon of RFID technology and how it affects service delivery in a garment company.

The rest of the paper is organized as follows. In the next section, we review the business value of RFID on garment industry and the perspective “technology-push and need-pull” of adoption decision. Then, we present our experience of actual implementation of an RFID-based garment manufacturing information system in a garment factory. We summarize the motivation factors of the adoption of RFID technology. Finally, we present the critical success factors derived from the case experiences.

2. LITERATURE REVIEW

RFID is a wireless technology that uses transmitted radio signals to tag, recognize, track and trace the movement of an item automatically (Loebbecke et al. 2006; Moon et al. 2008). It is one of the members of auto identification technologies, which also includes magnetic strips and ubiquitous barcodes (Delen et al. 2007). Basically, RFID infrastructures are composed of three principal components (Shepard 2005): (1) a transponder which is a reusable tag with a tiny computer chip to identify the object; (2) a reader which serves as a communication channel between the tag and the RFID-based information system; and (3) data collection application comprising a software solution and an antenna.

According to Ngai et al. (2008), the application of RFID technology is diverse and has been applied in at least 14 different industries, such as retailing, library services, and logistics and supply chain management. Despite the rising recognition of RFID technology, the garment manufacturing industry, which is a labour intensive industry that can hardly be automated and has not adopted such technology widely yet. Most of the organizations within the garment manufacturing industry are using manual or partially bar coding system to keep track of production line.

As garment manufacturing is a labor intensive industry, output quality and under/over production problems happen frequently. Manufacturers require real time information of the production line to have a better management of the operation and solve operational problems occurred before it is too late. China is the global manufacturing center of textiles and garments and one of the largest manufacturing bases in the world. However, the operating cost of China’s garment manufacturing industry is increasing rapidly due to the strict product quality requirement, increasing unit labor cost and harsh regulations on labor right and working hours. Garment manufacturing industry needs to enhance the efficiency and effectiveness of the production system so as to remain competitive in the market. RFID technology is a possible solution for it.

2.1 The Perspective of “Technology-push and need-pull”

In this study, we adopted the “technology-push and need-pull” perspective in investigating the underlining motivation of the garment manufacturing industry to invest in RFID technology. The concepts of “technology-push and need-pull” were borrowed from the engineering/R&D management discipline for studying the key factors in the adoption decision of a new technology (Shih et al. 2008). Technology Push (TP) and Need Pull (NP) represent two schools of thought which support two different arguments.

TP factors result from the recognition of the business value the technology could bring to the industry while NP factors result from the user’s needs (Chau and Tam, 2000). Under this perspective, the adoption decision of RFID in garment industry could arise from recognition of the business value of RFID, performance gap or both. As such, technology and need factors serve as the basic framework when investigating the motivation of adoption decision in the case study.

3 THE CASE STUDY

Case study can be used for many purposes – exploring (new areas), describing (complex events or interventions) and explaining (complex phenomena) (Kohn, 1997). This study describes a unique case investigation providing the details of adoption of the RFID-based garment manufacturing information system (exploring a new area) which explains a complex phenomena in garment manufacturing processes. As a research method, case study generally scores low on generalizability of findings (Akkermans et al. 2002), but its richness of data lends itself well for the understanding of the unique characteristics of the RFID based system development within the garment manufacturing industry. We collected information about the case study that took place at the organization by referring it to the internal document; interview the key people who had participated in the implementation of the system. One of the co-authors participated as part of the implementation team in the system development and the other co-authors conducted interviews with the users and management and prepared the case analysis in this study.

The case study object (noted as “the company” in the rest of the article) is one of the largest manufacturers headquartered in Hong Kong who produces apparel products for internationally renowned brand names for a number of US and Europe retailers. The company is principally engaged in the manufacture of knit tops for men, women and children, according to specifications and designs supplied by the customers, under the customers' own brand names. In 2007, the group set up a manufacturing enterprise, located with the Guangdong Province of China that mainly produces and sells knit products.

The company relies on the traditional manual and a partial bar coding system (which scans the bar on the paperwork that accompanies some of the parts of the product) to manage their production operation. Operations information is collected and input into the system until the end of one day operation. Traditional manual system and a partial bar coding system create certain performance deficiency and disadvantages. The most obvious disadvantage is the lack of real time data. It is difficult for the production line manager to keep track of the production process and promptly discover operational problems such as sewing errors or deviation from cloth design. Also, competitors in garment manufacturing industry in China started to adopt the RFID technology. On the other hand, the company had experienced pressures from clothing design to manufacture of variety of styles in each season with increasing demand for shorter lead times and more timely and fashionable products from retailers. These pressures lead the company to look for a means of real-time monitoring of the manufacturing process with capability to control each production step and react more quickly to the changes of order.

3.1 Research Questions and Objectives

With regard to the potential RFID capability and performance gap of garment manufacturing process, this study aims to investigate the motivations of the RFID adoption decision in garment manufacturing industry and the success factors of the RFID-based garment information manufacturing information system. We learned from companies that have implemented RFID system; it is a complex

process. Companies implementing RFID systems want to know the motivations, the actual benefit, and the success factors for implementing the systems. Specifically, this study aims to answer:

1. What are the motivation factors, from technology push and need pull perspectives, which drive the garment manufacturer to the RFID technology adoption?
2. What are the actual benefits to the business of RFID-based garment manufacturing information system to the garment manufacturing factory?
3. What are the success factors for implementing RFID-based garment manufacturing information system?

3.2 The RFID-based Garment Manufacturing Information System

The major components of the RFID-based garment manufacturing information system include: (1) RFID Token, which is a low frequency (13.56 MHz) and passive tag. Its unique ID is associated with the bundle of cut-row materials (such as sleeves, cuffs and hoods) which are to be used to fulfil each order; (2) RFID Readers, which are installed in the cutting department, next to each sewing machine and QC tables; (3) PC workstation, which connects 40 sets of RFID readers in business structure (Figure 1). Data were collected to a PC workstation before uploading to the computer server; (4) Ethernet system which is used to transmit data from PC station to server.

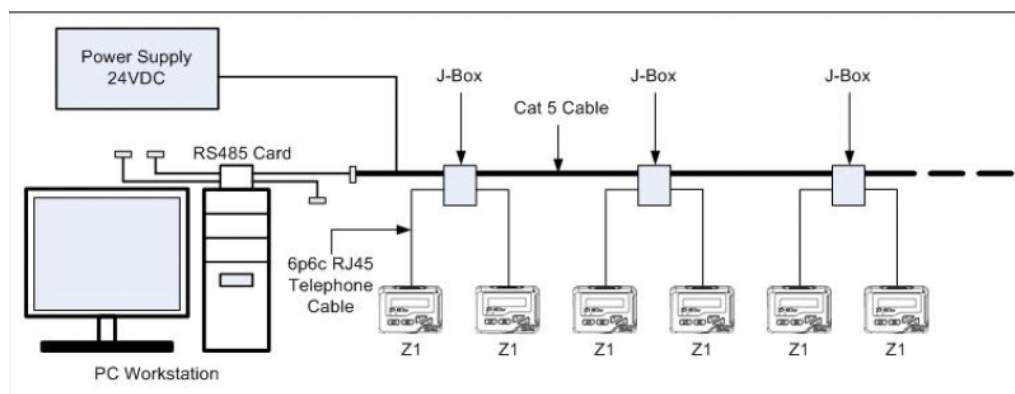


Figure 1 – Set up of Smart Term Z1 Network and Cabling Connection

4 SYSTEM IMPLEMENTATION

After the trial run period, all sewing lines were installed with the RFID based manufacturing management system. A new department, support team (Figure 2), was set up and staff from Industrial Engineering Department (IED) were involved to manage and analyze the data collected. IED has three member team responsible for analyzing the data collected like measuring the before using RFID system and after using RFID system for the monitoring in line-balancing.

Project Committee				
Project Manager (Vendor)	HR Manager	Project Manager (In-House)	Production Manager	Senior Management
Support Team				
Assistant Project Manager		Support Team Supervisor		Support Team Staffs (3)

Figure 2- Project Team Structure

The results of the study show that the actual time of individual steps in manufacturing process can be recorded and the factory floor managers can easily do a better line-balancing with the availability of the real time RFID-based garment manufacturing information system. Without the real-time information, factory managers can only guess based on his/her experience the estimated time for completing each step of the work. With real-time information, managers can know exactly how much time is needed in each step of the manufacturing process, so that they can assign sewers according to the real-time data from the RFID system and the managers can quickly response to the production needs. Individual sewers' performance can also be monitored using the real-time date provided by the system. Figure 3 shows a comparison of the efficiency of some sewers on a particular date in the factory. The employee efficiency report provides daily production performance data of each employee. Companies that have multiple employees (e.g. sewers) performing the same operation on a given part number, this can track the employee's production efficiency compared to production standards for a particular part/operation and to other employee's (sewer) performance.

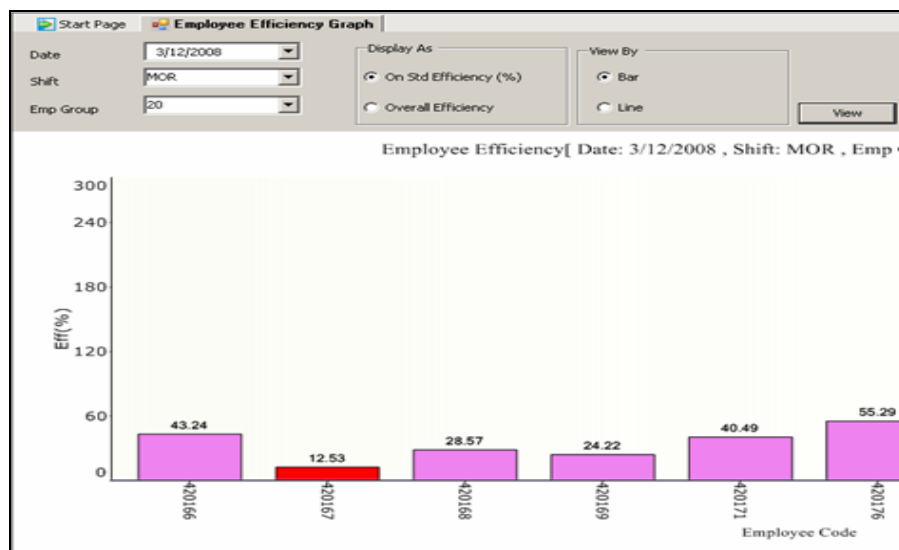


Figure 3 Employee Efficiency in Production

4.1 Empirical Source and Data Collection

As pointed out by Stake (1995), interviewees should adequately cover the various actors and management levels that were involved in the system development and implementation processes being studied. Therefore, in this study, we have selected the project manager, representatives of top management, user support team member, different levels of users and the software vendor as the sources of information. Face-to-face interviews (with factory/project managers, supervisors, sewer, system support staff), which last for around 45 to 60 minutes, were conducted. Shorter telephone interviews were acted as complementary on certain aspects and more informal discussion. Reliability was achieved by using a standardised interview protocol for each case, in which a series of "how" and "what" types of research questions were asked.

The questions in the interview protocol were translated from English into Chinese by a bilingual professional translator and were then back-translated to English independently by another bilingual professional. The following structured protocol was used to guide the interviews for case study.

- 1) What are the features of the RFID product using in your factory?
- 2) What is the impact of RFID implementation to your company performance?
- 3) What are the success factors of implementing RFID system in your company?
- 4) Can you see any factors (both positive and negative) affecting the implementation of RFID technology in the company?

5) Is there anything you think that can improve the implementation?

5 CASE ANALYSIS

Data and information collected from multiple data sources and methods were analyzed to identify the motivation factors, system business value and success factors of the implementation.

5.1 Business Value of the RFID-based Manufacturing Information System

The RFID-based garment manufacturing information system has created various performance improvements to the company. In general, it successfully enhances the production line efficiency and effectiveness e.g. increasing production line visibility.

On top of the operational improvement, the RFID-based system helps to uncover previously hidden problems such as poor coordination among departments, create a culture of continuous improvement, and provide more accurate data for performance evaluation and payroll calculation.

The adoption of RFID-based garment manufacturing information system contributes to organization performance and profitability through both tangible and intangible ways which can be summarized in Table 1.

Tangible Benefits
<ol style="list-style-type: none">1. <i>Machine down-time</i> has reduced by 30% compared to last year's figure2. <i>'Lost time'</i> (Non working time) has reduced by 50% compared to last year's figure3. <i>Defect rate</i> has reduced by 30% compared to last year's figure4. <i>Efficiency</i> has increased by 50% compared to last year's figure5. <i>On-time delivery</i> rate has increased to 90%6. <i>Amount of over-time working hours</i> of sewers has reduced by 10% in average
Intangible Benefits
<ol style="list-style-type: none">1. Uncover previously hidden problems, such as:<ul style="list-style-type: none">▪ Co-ordination problem among departments▪ Working efficiency of maintenance department▪ Sewer's skill set deficiency and incompleteness2. Provide more accurate data for calculation of SAM which can be used for cost estimation and line-balancing3. Provide real-time production data for closer monitor of production defects, downtimes, efficiency, production line visibility and other issues such as process reengineering4. Build a culture of open discussion and scientific management, which is linked to the concept of continuous improvement

- | |
|---|
| <p>5. Improve the work motivation of staff by creating an image that the company is willing to invest in helping the employees to enhance their work efficiency and obtain a higher payroll and bonus</p> |
|---|

Table 1 – List of benefits of RFID based manufacturing process management system

5.2 Adoption Intention

Several interviews and analyses of project planning and meeting minutes were conducted to identify the factors that motivate the garment factory to adopt the new system – RFID-based garment manufacturing information management system. The analysis is carried out according to the perspective of technology push and need pull. The motivation factors are identified from the case and summarized as shown in Table 2.

Technology Push	Need Pull
• Relative advantage	• Competitors
• Compatibility	• Customer
• Complexity	
• Extendibility	
• Cost	

Table 2: Technology push and need pull factors for adoption of an RFID-based garment manufacturing information system

5.2.1 Technology Push

Technology push factors are those which result from the recognition of RFID benefits to the organization. From the case study, we found that the relative advantage, compatibility, complexity, extendibility, and cost of the technology are factors that are influential to the adoption decision.

- **Relative advantage**

Relative advantage is identified as the key influence factor on new technology adoption (Brown et al. 2007; Sharma et al. 2005). All interviewees, except for sewer, recognize the relative advantages of RFID system. However, interviewees with different position perceive different advantages that could be arise from the RFID system.

- **Compatibility**

Compatibility is defined as the degree to which a technology is perceived to be consistent with organization's strategic objective, infrastructure, practices and needs (Brown et al. 2007). In this case, the company does not want the sewers to see the piece rate and quantity when adopting the RFID technology, which is the standard feature provided by the RFID reader. Also, the company expected that the new system could be compatible with the current information using within the company. These two requirements were supported by the vendors of different information systems and enhance the adoption intention of the company to adopt the new technology.

- **Complexity**

In garment manufacturing industry, the major type of labor (sewer) does not have high education background. It is difficult for them to learn new technology which is very complex and technical. RFID-based garment manufacturing information system, which is very easy to be learnt and used, suit the needs of the sewers and enhance the company confidence in the degree of successfulness towards the adoption of new technology. Therefore, the complexity of the technology affects adoption intention through the usability and acceptance of the technology to the potential users, which is in compliance with the result of Brown et al (2007).

- **Extendibility**

The extendibility of the new technology to support other operational requirement affects the adoption decision. As mentioned by Project Manager (Vendor), the system can be plug-in with other sub-modules e.g. Industrial Engineering Execution System (IEES). IEES is a centralized repository solution designed to optimize the process of standard time development and management of the garment production process through an Industrial Engineering approach.

- **Cost of Technology**

While cost is believed to be a major consideration in the technology adoption decision (Brown et al. 2007), we found that cost is not the major concern in this case study. As the price of tags are going down and can be re-cycled, cost is not the main concern in this case.

5.2.2 Needs Pull

Factors related to needs pull result from the needs of the garment manufacturing industry to adopt the new technology. In this study, we identified competitors and customers pull as factors which affect the new technology adoption in garment manufacturing industry.

- **Competitors**

Garment manufacturing industry needs to enhance the efficiency and effectiveness of the production system so as to remain competitive in the market. As such, competitors' decision towards new technology adoption would affect an organization's adoption decision. As mentioned by project manager (in-house), "Some of our key competitors have started to use RFID which push us to catch up with them."

- **Customer**

Customers' pressure on price is another driver for organization to lower the production cost by means of new technology. As factory manager mentioned, "owing to the economic downturn of US, there is high price pressure from customer. Also, because of appreciation of Renminbi (RMB), cost increase in materials and payroll, our production cost is getting higher and higher. The only way we can survive is to increase our efficiency".

5.3 Success Factors

Based on our experience at the company, we have identified the eight success factors that we consider relevant to our successful adoption of the RFID-based garment manufacturing information system. These are summarised in Table 3, and are follow by further elaboration for each factor.

Vendor Selection	Vendor's experience trusts, extents of follow up work and evaluations after installation are important. A project manager (in-house) said "the support of the vendor is important. It is not just a one-off support for installation. It is a long-term partnership. Vendor's experience on the RFID technology and follow-up support is essential to the success of the project".
Organizational Motivation	Motivate each level of the employees to commit to the adoption of RFID-based system by present them the

	<p>emerging needs for improvement and potential benefits the RFID technology</p> <p>A factor supervisor mentioned that “managers should motivate the employees to perform better, helping employees adapt to and use RFID technology to increase their productivity”.</p>
Cost/Benefits Evaluation	<p>Management needs to evaluate and justify the cost and benefits of the adoption of RFID technology and how the change can align with the company IS strategic direction</p> <p>A project manager said “the management considers cost/benefit evaluation is important and treat cost/benefit analysis as a long-term evaluation strategy”</p> <p>An assistant project manager said “intangible benefits, such as creating a culture of continuous improvement, which can indirectly enhance the business value”.</p>
Top Management Support	<p>Top management support is required to provide better access to information and resources and enhance user supports which lead to smoother implementation process</p> <p>A project manager said “senior manager’s support is essential for this project in order to get moral support as well as the financial and other resources support for the implementation of the project”.</p>
User Involvement	<p>Involve the users in the design and development process so as to understand their expectations and attitude towards the new technology in a more throughout sense</p> <p>A factory manager said “user involvement is crucial in the design and development process as the developed system will be used by the potential or current users of the system”.</p>
Extent of Progress Supervision	<p>Organization needs to keep a close supervision and investigate how well the RFID technology interacts with existing organizational settings</p> <p>A factory supervisor said “to assess the nature and extent of using the new system, a closer monitoring of existing organizational settings in which workers and system interacts are necessary”.</p>
Staff Competence and Training	<p>Choice of the RFID technology should be compatible with the staff capability and regular training programs should be provided so that the potential users would not have problems to adapt to the new system.</p> <p>The project manager (vendor) said “conducting training programs for enhancing staff’s capability and job competence in using RFID technology. Most of the people in the factory do not know about the new technology”.</p>
Policy, Structure and Operation Process Compatibility	<p>Changes in organizational policies, structures or even operation process could bring higher business value to the organization</p> <p>The production manager said “policy changes including payroll policy are critical as the new RFID system can capture the real-time production information, so sewers are not able to “cheat” under the new system. In order to maintain a stable change, payment policy needs to adjust (i.e. piece rate) so that most of the sewers would not suffer as the introduction of the RFID system in the factory”</p>

Table 3. *List of Success Factors for RFID-based System Implementation*

- **Vendor Selection**

We found that the cost was not the major concern in the selection of vendors. From our experiences, we found that the experience of vendor in implementing the system under the operational environment of adopting company, trusts between the vendor and adopting company, extents of vendor follow up and evaluations after installation are important factors in vendor selection which could lead to adoption success. Selecting an appropriate vendor could help the adopting company to design and develop a more customized system according to the specific characteristics of the adopting company and its operating environment; build a trustful relationship which lead to smoother implementation process; and create a culture of open discussion and continuous improvement.

- **Organizational Motivation**

Organizational needs and motivations for performance improvement is one of the success factor identified. It is important for the organization to motivate each level of the employees to commit to the adoption of RFID-based system by present them the emerging needs for improvement and potential benefits of the RFID technology. These could help to raise the employees supports and commitment to the organization adoption decision. In this case, the company explains to the employees the potential benefits (such as the increase in sewers' payroll and their productivity without any human counting errors for their work done and production line visibility which help production manager to have better management) that the system could bring to different position, role and to organization in details.

- **Cost/Benefits Evaluation**

Management needs to evaluate and justify the cost and benefits of the adoption of RFID technology and how the change can align with the company IS strategic direction. Cost effectiveness should be a key issue in judging the business value of the RFID technology. It is important to note that the cost/benefit evaluation is not on financial factors only. As indicated in the case study, the adoption of the RFID technology brought to the company many intangible benefits, such as creating a culture of continuous improvement, which can indirectly enhance the business value.

- **Top Management Support**

Similar to any other new technology adoption project, top management and users support and commitment are influential to the adoption decision and successfulness of the RFID technology implementation. Top management support provides better access to information and resources and enhances user supports which lead to smoother implementation process.

- **User Involvement**

While top management support lead to more strategic impact on the RFID technology implementation, user supports in accepting and using the system actualize the potential business value of the RFID technology. Therefore, it is crucial to involve the users in the design and development process so as to understand their expectations and attitude towards the RFID. This can help to develop a system which is more user friendly in the user aspect and promote a higher user acceptance.

- **Extent of Progress Supervision**

The close supervision of the implementation process forms another success factor. RFID technology adoption is not a one-off installation project. Organization needs to keep a close supervision and

investigate how well the new technology interacts with existing organizational settings. Organization may build a special department to keep track of the system implementation process and make evaluation regularly. In this case, the company held operation review meeting regularly and work with the system vendor to improve the system continuously.

- **Staff Competence and Training**

The choice of the RFID system should be compatible with the staff capability so that the potential users would not have problems to adapt to the new system. In this case, the major type of potential users is sewers who are not well educated. RFID technology, which is easy to use, should be a good choice. Nevertheless, it is important to provide training to the users to make them familiar with the use of new technology and functionality of new system.

- **Policy, Structure and Operation Process Compatibility**

Lastly, it is essential that each aspect of the organization, such as organization policy and structure, match with the implementation of the RFID technology. RFID technology adoption is an interactive process. Of course it is important for the RFID technology to be customized and fitted with the organization, but sometimes changes in organizational policies, structures or even operation process could bring higher business value to the organization. In this case study, the RFID technology adoption came along with the changes in organizational structure and payroll policies.

6 CONCLUDING REMARKS

It is likely that RFID technology will increasingly be used in both business and manufacturing sectors. More and more companies are trying out this technology. This study can act as a reference framework for them to adopt RFID technology in their business operation. This study provides the major factors in adoption intention, business value and success factors of RFID system implementation in a garment factory. Research and development practitioner can learn from the experience we gain from this case study. These help them to justify the benefit of RFID technology to their organization, strengthen the motivation factors of the organization to adopt the RFID technology and pay attention to the success factors and critical issues in adoption of RFID technology.

We have studied the adoption intention of implementing RFID system through the theoretical lenses of the push and pull perspective and provide a case analysis of RFID system adoption in a garment manufacturing company which was one of the early adopters of the full RFID system. We found that both technology push and need pull factors influence the adoption intention of the garment factory to adopt RFID technology. Technology push factors include relative advantage, compatibility, complexity, extendibility, and cost of the technology while need pull factors include competitors and customers pressure. Technology push forces stem from a well recognition and proven RFID technology which can improve manufacturing process as well as its efficiency and accuracy and can enhance a firm's performance. As the price of RFID tags are going down as well as the hardware, cost will not be a matter for RFID implementation in the near future. Need pull forces, in the context of RFID applications in garment manufacturing process, stem from competitors and customers pressure. The former tends to affect organization's adoption decision pushing them to catch up with their competitors in RFID technology while the latter is more concerned with the price which drives for organization to lower the production cost by means of new technology – RFID.

There are eight factors which are influential to the successfulness of RFID technology adoption in garment manufacturing companies. They are (1) vendor selection, (2) organizational motivation, (3) cost/benefits evaluation, (4) top management support, (5) user involvement, (6) extent of progress supervision, (7) staff competence and training, and (8) policy, structure and operation process compatibility.

It is encouraged to conduct more RFID-based garment manufacturing information system to examine the success factors in different manufacturing sectors. If these factors are supported in the future research, they suggest that the success factors for implementing RFID system may be the same across different manufacturing sectors. Identifying common success factors of implementing RFID system across cases will be an important step toward building a theory of implementation of RFID innovation in manufacturing companies.

We believe that this case study could be beneficial to practitioner and academics who are interested in implementing RFID system in manufacturing companies. However, this study only provide one case study, it limits the generalizability of case analysis result to other contexts. Therefore, more in-depth case study can be conducted to analyze the differences in implementing RFID system across industries and empirical studies in both macro- and micro-level can be conducted to investigate the factors that drive RFID innovations. Further studies should also be extended to evaluate the business value of adoption RFID technology.

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