CHAPTER 2

LITERATURE REVIEW

2.1 Chapter Overview

This chapter introduces an overview on the adoption of RFID technology and how this piece of technology assists the organisations to achieve competitive advantage among the competing rivals. It initiates with the extents of RFID applications in the logistic industry; focusing on how the RFID is being adopted by other LSPs to improve the overall efficiency in an organisation globally. The benefits of adopting the RFID technology in logistic industry are discussed as well follow by the challenges faced by the LSPs during the adoption of the technology. The Model of Technology Appropriation (MTA) is discussed at the later section and the summary will conclude the chapter.

2.2 Introduction

In the competitive edge, LSPs cannot afford to put on hold on any processes within the fast moving supply chain as any delay would cause losses to them. Many researchers have proven that RFID would be an ideal technology to be implemented in logistic industry. It serves as automated input mechanism that eliminates human physical interaction that soon will be disruptive innovation towards the legacy Universal Product Code (UPC) or commonly known as Barcode (Wyld, 2006). Align with company strategic move, owning RFID

technology would give them competitive advantage over the competitors. Organisation may adopt new technology if it presents a potential benefits and competitive edge towards a company although there might be non-monetary benefits. For instance, firms adopting the RFID technology can manage their corporate assets better (Conneely, 2009). Therefore, exploring RFID applications in logistic area, understanding the benefits gained and challenges faced by the LSP upon the adoption of the technology would be a significant factor influencing the firms' decision towards the adoption of RFID technology.

2.3 The extents of RFID adoption in logistic industry

RFID technology has obtained the interest from variety of industries in recent years such as hospitality, pharmaceutical, logistics, and retails (Floerkemeier et al., 2007). The technology hold a promise of eliminates most of business problems by bridging the costly gap and allow smoother business flow. RFID technology has been adopted in many of the business applications to enable more effective and efficient business flow depicted in Table 2.1. Firms would expect benefits such as cost reduction, supply chain visibility and the creation of new business which direct or indirectly affect the adoption decision (Roh et al., 2009).

References	Type of Application	Organisation
Poon et al. (2009)	Order Picking (Allientechnology)	GSL
Martinez-Sala et al. (2009)	Reverse Logistic	ECOMOVISTAND
Wang et al. (2008)	Inventory Management	Taiwan LCD Manufacturer
Wadhwa et al. (2008)	Sorting Conveyor	Sanacorp Pharmahandel
Zhang et al. (2006)	Theft Identification (TrueMobile)	Posten Logistik

Table 2.1: RFID applications in logistic industry

2.4 Benefits gained through the adoption of RFID technology

The adoption of RFID technology offer direct and indirect benefits to an organisation. The direct benefits would be measured in-term of cost savings and reduction in processing time. On the other hand, indirect benefits are those linked with intangible advantages such as the creation of new business processes. Many studies have been done to measure the benefits of adopting RFID technology such as supply chain efficiency, reduction in labour costs, inventory obsolescence reduction and rich information exchange among the participants in supply chain. According to Roh et al. (2009), RFID's expected benefits can be derived into three categories: (1) cost savings, (2) supply chain visibility, and (3) new business creation.

The primary reason for any organisation to adopt the RFID technology in their business process would be cost saving. Through the literature review on the

inventory inaccuracy issue has highlighted these discrepancies may initiated due to several reasons such as theft, product misplaced, and extensive labour cost. The scale of shrinkage in fast moving consumer goods sector is estimated 24 million Euros in 2003 (465 million Euros is lost irreparably within fast moving consumer goods turnover weekly), which is 2.41% of the whole turnover value of the sector. The process errors present 27% of the whole shrinkage value, 7% deceptions, 28% internal thefts and 38% external thefts (Rekik et al., 2008). Therefore, effective tracking mechanism via the RFID has the ability to reduce such shrinkage. Effective inventory control would contribute to cost saving as the average inventory level is decreased, the inventory holding as well as the labour cost are decreased (Ustundag and Tanyas, 2009). For example, War-Mart hypermarket has thousands of products on the shelves and it is not easy to ensure each product's safety stock level is adequate prior to the implementation of RFID supply chain system. The introduction of RFID has eliminate most of the manual ways of handling inventory as the collaboration and integration of system between Wal-Mart and its supplier enable replenishment of stocks when preset reorder quantity is reached.

Supply chain visibility refers to the ability of a firm to identify the physical flow of particular goods and associated information from origin to the final destination through the supply chain flow. A firm who own the technology integrated in the supply chain system allow inventory monitoring, efficiency measurement; reduce bottle-neck and real time inventory visibility. For instance, Pacific Cycle Inc, a

supplier of bicycles and recreational products to Wal-Mart has invested $3 million dollars into integrating the RFID into its SAP Weaver software to enable the real time inventory visibility which allow the firm to identify any delays, proof of delivery and product identity within the movement from warehouse to the destination (Powanga et al., 2008).

Introduction of RFID technology in the business world has invented new ways of doing thing. This new business process has eliminates the legacy ways of inventory handler obtaining product information as these processes can be automated. According to Powanga et al. (2008), Wal-Mart has mandated its top 100 suppliers to installed RFID tags at cases and pallets level to improve the safety stock efficiency. The enforcement of RFID tags in Wal-Mart's operations allowed auto products replenishment by the engaged suppliers has eliminate the stock out issue which estimated to cost Wal-Mart $5.78 billion dollars annually. Apart from supply chain, the technology has gained significant traction from other are such as the embedded chip in passport for immigration process. Passport in USA (Conneely, 2009) and ePassport in Malaysia (Ismail, 2007) are among the countries that adopted it in the determination to battle terrorism.

RFID technology provides easy use and flexibility to organisation that adopted the system such as non-line-of-sight characteristic of technology. Its allow tags to be read through different angles and environmental conditions for instance freeze

condition, under high temperature, fog, grime, inside containers and vehicles and while in storage (Tarapata et al., 2009). The ability of the RFID reader to read several hundred tags simultaneously in less than 100ms would be a plus point for organisation to adopt the system.

2.5 Challenges of RFID adoption

Despite plethora of promising benefits for adopting RFID in supply chain logistic industry such cost savings, supply chain visibility and new business creation (Roh, et al., 2009), there are still a number of challenges come along for the adopter to solve the puzzle as below:

a. RFID standards are not finalised (Li et al., 2006; Wu et al., 2006).
b. Costs impede the progression of RFID adoption and lack of justification on ROI for firms (Luo et al., 2007; Tajima, 2007).
c. Technological challenges yet to be improved (Powanga et al, 2008).
d. Collaboration among the supply chain members for system integration (Li et al., 2006).
e. Efficiency in data management (Li et al., 2006)

2.5.1 Standards Challenges

According to Wu et al. (2006), the standardisation of RFID has the chain effect on the costs of owning the technology. First, a common RFID standard will

ensure the tags and readers communicate well regardless of whom or where they are manufactured. Second, the demand for RFID components and equipments will increase as they reach compatibility which will drive down the cost (Li et al., 2006). Lastly, internationally accepted RFID standard will boost the RFID market growth. Currently, ISO and EPC Global are the two competing organisation that develop the RFID standard system. ISO was driven by the RFID manufacturers while EPC Global was driven by large users such as Wal-Mart and Tesco (Lai et al., 2005). There is a need for these two rulers to collaborate together in the RFID development to address the interoperability issue which will lessen the adopting firm's burden to own one common standard instead of multiple systems to operate globally.

2.5.2 Costs

Top Management Team (TMT) always perceives the deployment of new technology in an organisation would be a cost rather than an investment to improve the process efficiency and effectiveness. Strong and promising ROI justification needed to ensure the RFID project obtained approval from TMT. Building the RFID systems require expenses such as tags, readers, middleware, software, hardware and system maintenance which would be an impediment towards the RFID adoption (Lai et al., 2005; Jones et al., 2005).

According to Wu et al. (2006), the tag cost can be further divided to the chip cost and the assembly cost; the chip cost depends on the die size and fabrication yield while the assembly cost would be the challenge to ensure the error rate is minimise in the fabrication process due to the chip can be as tiny as 0.4-1.0 mm^2. Customisation of RFID system is crucial for specific working environment and application such as operating in different radio frequency spectrum licensed by the country's regulation. Therefore, the high cost associated with owning the RFID technology would prevent firm from adopting the technology although many had said that the tags prices is decreasing in future (Jones et al., 2005; Lai et al, 2005).

2.5.3 RFID's components and equipments

Many technical issues do exist in RFID applications today which need to be solved in order to ensure the proliferation of RFID adoption worldwide. Selection of idle tags and readers would be crucial as environment factor would be affecting the reading rate of the tagged item. For example, Goodyear Tire & Rubber Corporation is the supplier to both Wal-Mart and U.S. Department of Defence (DOD) and is subject to RFID mandates from both. Tagging a tire would be a challenge for the firm as the slickness of the tire makes ordinary RFID label difficult to stick on it and it is difficult to read due to the tires are made from reinforced carbon for durability which the latter will absorb the radio frequency energy.

More common phenomena would be the tagged items being placed in a dense environment resulting in tag collision as the electromagnetic waves generated by the tags interferes with other tag when being interrogated by the reader (Powanga et al., 2008). To resolve the problem, tagged items are placed at a specific distance from each other and equipped with reader that has the multi-read capability throughout the scanning process. According to Wu et al. (2006), anti-collision procedures and binary search method able to prevent the tag signal collision.

Working environment could also be one of the factors that affect the read rate accuracy. For instance, during the items load on to the conveyor or being transported to the warehouse, some incidents such as tag antenna was bent or damage due to the movement which cause readers unable to intercept or read the tagged information (Powanga et al., 2008). To eliminate this deficiency, the strategic placing of tag on item would be crucial. In addition, RFID manufacturers have to improve the durability of their tags and antennas to improve the reading rate.

2.5.4 Infrastructure and System Integration

Deployment of RFID in supply chain does not occur in isolation. Instead, it involved the participation of the entire supply chain members ranging from the local to internationally. They need to enjoy the benefits of RFID for the implementation to be successful. Based on the multi-agent-based RFID supply chain simulation model study conducted by Wang et al. (2008) in one of the largest Taiwan LCD monitor manufacturer, the industry supply chain begin with LCD panel producer will assembles the panel whereby the components obtained locally or internationally. Ready panels will be transported to LCD monitor manufacturers via trucks to resume the assembly process into a finished LCD monitor. The supply chain movements are then resumed with regional distributers, branch warehouses, retailers and lastly the consumers. Information being collected real-time at each station and the movement of the products can be traced at any level within the supply chain boundary could increase the efficiency and effectiveness of the entire chain. The participation and collaboration among the supply chain members would be a challenge in order to achieve this objective.

The establishment of the entire RFID infrastructure would require the supply chain members to integrate their disparity systems to be uniformed in order to allow smoother communication. The challenge of RFID implementation arises from integrating RFID systems and data being generated with other functional

databases as well as the applications (Jones et al., 2005). It is a complicated process which would need expertises, experiences, time-consuming and high cost incurred to proceed.

2.5.5 Managing Data

The whole idea of having the RFID technology in placed is to provide useful information for the decision maker to analyse, forecast or prevent any unwanted incidents from happening as they can access information of particular product in the supply chain in real-time mode. According to Li et al. (2006), firms experienced the RFID devices sending false reads or repeating reads on an identical tag which cause by the synchronisation of data retrieval. It is undeniable that data are valuable assets to a company, but excessive amount of data would be difficult for an organisation to organise or makes sense of. For instance, Wal-Mart has generated 7 terabytes of operational RFID data daily and they are not ready to handle this volume of data based on their traditional backbone (Kapoor et al., 2009). Redundancy data and unnecessary information are filtered out at later stage to ensure the accuracy and validity of the data.

2.6 External Environment

Environment is defined as the totality of physical and social factors that are taken directly into consideration in the decision-making behaviour of individuals in an organisation (Duncan, 1972). In the context of the organisational environment, it

can be categorised as internal and external environment whereby the later play a very significant role in the adoption diffusion research as well as RFID adoption (Wen et al, 2009). Government support and globalisation trend are considered important determinant influences the LSP in RFID adoption.

Government act as an important environmental actor in the diffusion of RFID technology as their decisions have greater impact on the RFID adoption. For instance, the government is approving subsidies for purchasing RFID's equipments, standardising the policy and providing incentives as well as research grants for LSP to initiate the RFID adoption (Cheng et al., 2006). Therefore, with the regulatory set by the government would encourage the widespread of RFID adoption among the LSP.

Globalisation has raised the concerns of firms in the same industries to compete with each other. The slice of a pie is getting smaller as emerging competitors are moving fast in the fast pace business environment. Adopting technology in logistic industry such as RFID would assist LSP to regain the market share and restrain the competitor activities (Evangelista and Sweeney, 2006). According to study conducted by Cheng et al. (2006), globalisation trend is a most valued factor that influences the LSP to adopt the technology as they believed that the adoption could strengthen their self-competitiveness against the rivals.

2.7 Summarisation of the key factors

Citation	Emphasis point	Findings/Implications
• **Cheng et al. (2007)** • **Lai et al. (2005)** • **Li et al. (2006)** • **Luo et al. (2007)** • **Wu et al. (2006)**	Cost of implementation	The cost of implementation of RFID technology in logistic industry is relatively high while the reward is slow. Major costs would be reader, antenna, tag, software and customisation.
• **Lai et al. (2005)** • **Li et al. (2006)**	Labelling cost	Larger order quantity (e.g. in billions) of RFID tag allows price to be cheaper which is impossible for logistic service providers to consume that amount.
• **Li et al. (2006)** • **Tajima (2007)** • **Wu et al. (2006)**	Lack of ROI	Lack and uncertainties of ROI hinder the large-scale of RFID deployment.
• **Cheng et al. (2007)** • **Roh et al. (2009)** • **Veronneau et al. (2009)**	Reduction in direct labour cost	Automation economise labour costs and reduce processing time.

Table 2.2: The overall cost associates with RFID adoption

Citation	Emphasis point	Findings/Implications
• **Cheng et al. (2007)** • **Roh et al. (2009)**	Operation efficiency / Process automation	Automation able to reduce error rate and increase accuracy.
• **Roh et al. (2009)** • **Veronneau et al. (2009)**	Supply chain visibility / Tracking movement of goods	The ability to trace the movement of product via information sharing among supply chain members enable easier coordination and improve operation efficiency.
• **Li et al. (2006)** • **Tajima (2007)** • **Veronneau et al. (2009)**	Line of sight	Scanning at any dimension prevent any movement of stagnant goods for information gathering and able to operate under harsh environment.
• **Roh et al. (2009)**	Improve customer service	Offer quality services and excellence experiences to customer.
• **Roh et al. (2009)**	Exchange information in real time mode	Real time exchange of information among supply chain members allow better coordination and faster decision making by logistician.

Table 2.3: Benefits gained from the adoption of RFID technology

Citation	Emphasis point	Findings/Implications
• **Li et al. (2006)** • **Wu et al. (2006)**	Standards	Lack of unified RFID standards (EPC & ISO) and different allocation of radio spectrum in different countries impede the diffusion of RFID technology globally.
• **Powanga et al. (2008)** • **Tajima et al. (2007)** • **Wu et al. (2006)**	Reading accuracy and collision	Reading large number of tags simultaneously may cause collision interference to the receiver and 100% accuracy cannot be achieved although anti-collision technique being applied.
• **Li et al. (2006)**	Data management	Massive amount of data has been captured by the reader throughout the entire supply chain occupied the available storage. This includes useful, noise and dirty data.
• **Li et al. (2006)**	System integration	The complexity and data redundancy generated by other functional databases and applications after integration are the primary concern of the RFID adopter.

• **Powanga et al. (2008)**	Tag durability	Tags become defective due to damage sustained from abrasion, extreme changes in temperature, pressures and electro-discharge as products travel along the supply chain.

Table 2.4: The challenges faced on the adoption of RFID technology

Citation	Emphasis point	Findings/Implications
• **Cheng et al. (2006)**	Government support	Government plays an important in promoting the RFID technology by standardising the policy and providing incentives to subsidise on initial system cost and tag cost.
• **Cheng et al. (2006)**	Globalisation trend	Logistic service providers believed that the adoption of RFID technology able to strengthen their self-competitiveness against the rivals.

Table 2.5: External influences on the adoption of RFID technology

2.8 Model of Technology Appropriation (MTA)

Carroll et al. (2002) developed a theoretical framework on the appropriation process of mobile technologies which illustrate the technology adoption and appropriation on teenagers' (Age of 16 to 22 years old) phone usage. Others studies adopting the Model of Technology Appropriation (MTA) are also to be found conducted in mobile technologies (Carroll et al., 2002; Karim et al., 2009) and Open Soft Software (Rahim and Alias, 2006). The framework (Figure 2.1) has been conceptualised into 3 levels of and will go through the evaluation stage which will generate 3 possible outcomes: non-appropriation, disappropriation and appropriation (Carroll et al., 2002).

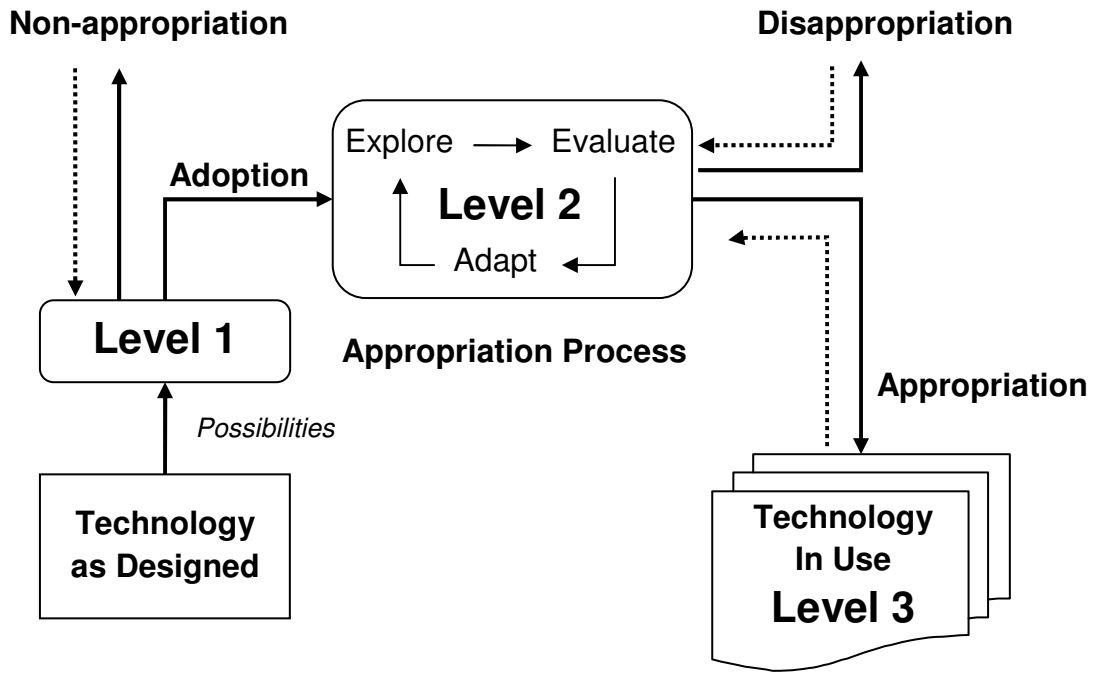

Figure 2.1: Model of Technology Appropriation (MTA)

As showed in Figure 2.1, there are three possible outcomes when users meet technology-as-designed:

- Non-appropriation – users are not interested in the technology or partial of its features. They do not proceed to the appropriation process. According to Carroll et al. (2002), technology affordability significantly affects users' decision in accepting or rejecting the technology.
- Appropriation – user will explore, evaluate and adapt the technology by selecting some of its attributes and capabilities to satisfy their needs (Carroll et al., 2001).
- Disappropriation – users are decided to stop using the technology due to its capabilities does not meet or satisfy user needs. This may happen at the early or later stage of the appropriation process. Having a technology in used is not one-off activity as if the technology does not address the user needs, it will be disappropriated. Therefore, continuity assessment and improvement on the technology must be made to ensure the sustainability of the technology in an organisation.

Level 1 of the MTA is when the related party encounter the technology, for instance the Top Management Team (TMT) of an organisation initially exposes to the technology via vendor's presentation. This generates the first impression or general overview of what the technology can do in the logistic industry. At the end of this stage, the outcomes can be either the party are not interested in the

technology which leads to non-appropriation (Repellents) or the party would proceed to the next level (Attractors); the entry point of the process of appropriation.

Level 2 is reached when the participants are interested in the technology provided which makes them eager to explore in depth what benefits they may obtain from pursuing this technology. Results obtained from the pilot test on the new technology will justify the outcomes. Two possible outcomes will be generated at this stage. Appropriation happen when the appropriate criteria are met and having the intention to put the technology in use. Disappropriation occurs when the organisation decided to stop pursuing the technology as the appropriation criteria are not meet.

Level 3 emphasise on the persistence of the technology. According to Carroll et al. (2002), appropriation is not a one-off activity but rather is subject to ongoing reinforcement such as accommodating the ever changing needs. Without continuously reinforcement, it will lead the technology to the disappropriation stage whereby the entire project will be phased-off.

2.8 Summary

Although the RFID technology has been invented and put in used by the military more than five decades ago, but the current RFID's usage has shifted to the commercial line to improve organisation's operation efficiency. Considerable of studies and researches on RFID's usage have been conducted in prime area such as healthcare (Bahri, 2009), logistic (Evangelista and Sweeney, 2006), library (Yu, 2008), retails (Rekik et al., 2009; Prater et al, 2005), and assets management (Conneely, 2009).

The present chapter provides the literatures on the varieties of RFID application in the logistic industry such as order picking system, reverse logistic, inventory management, sorting conveyor and theft identification which have been highlighted in the earlier section. This generates an overview of the RFID capabilities in the logistic industry where manager able to select the application that address their needs.

List of benefits gained and challenges faced by the existing adopters in the same industry were highlighted from existing literatures to provide manager an assessment on the RFID technology. Information gathered is crucial for the manager to justify whether the technology fit in the industry and address the needs of their needs.

The Model of Technology Appropriation (MTA) was originally developed by Carroll et al., (2002) to studies the appropriation of mobile phone by young Australian with the age between 16 and 22. No studies found using this model in evaluating the appropriation of RFID technology in logistic industry which is the significant of the study.

Therefore, this dissertation is conducted with the objective to fulfil the research gap. In the next chapter, the research methodology which includes research design, data collection method and data analysis will be discussed.