

**THE DETERMINANTS IMPACTING THE
ADOPTION OF RADIO FREQUENCY
IDENTIFICATION (RFID) TECHNOLOGY IN
SABAH FORESTRY DEPARTMENT, SABAH,
MALAYSIA**

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DECLARATION

I hereby declare that the material in this study is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

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ABSTRACT

Radio Frequency Identification (RFID) is one of the most promising technological innovations that provide Sabah Forestry Department the tool for improving forest management activities in a systematic manner. However, it has yet to see the adoption of this technology in forest industry. Due to this, effort has to be required to identify the determinants impacting its adoption. For this study, it was carried out based on the technology-organization-environment model (TOE) framework of Tornatzky and Fleisher's 1990. Six variables namely relative advantage, compatibility, complexity, costs savings, security, perceived benefits are presented to help predict RFID adoption. Data were collected from 121 respondents from the Sabah Forestry Department officers who voluntarily participated in the exercise. Based on the result of this study, it has contributed to the enhancement of understanding on the determinants impacting the adoption of RFID in forest industry.



ABSTRAK

KAJIAN TENTANG PENENTU KEPADA PENGGUNAAN "RADIO FREQUENCY IDENTIFICATION" (RFID) TEKNOLOGI DI JABATAN PERHUTANAN, SABAH, MALAYSIA

"Radio Frequency Identification" (RFID) adalah satu inovasi teknologi yang berpotensi sebagai satu alat yang boleh digunakan oleh Jabatan Perhutanan Sabah untuk mengurus aktiviti pembalakan secara sistematik. Walau bagaimanapun sehingga kini, masih belum ada penggunaannya dalam industri perhutanan. Oleh itu, usaha hendaklah diperlukan untuk mengenalpasti penentu kepada penggunaan RFID. Kajian ini dilaksanakan berasaskan kepada kajian terdahulu oleh Tornatzky dan Fleisher's 1990 iaitu "technology-organization-environment model" (TOE). Sebanyak enam (6) jenis pembolehubah iaitu kebaikan berbanding, kesesuaian/kesepadanan, kerumitan, menjimatkan masa, keselamatan dan andaian manfaat telah dikaji bagi membantu meramal penerimaan penggunaan RFID. Data telah diambil daripada 121 orang responden daripada Pegawai-Pegawai Jabatan Perhutanan Sabah yang secara sukarela menyertai kajian ini. Berdasarkan kepada kajian ini, telah menambahkan kefahaman tentang factor-faktor yang mempengaruhi penerimaan penggunaan RFID di dalam industri perhutanan.



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LIST OF ABBREVIATIONS

RFID	RADIO FREQUENCY IDENTIFICATION
EU	EUROPEAN UNION
FSC	FOREST STEWARDSHIP COUNCIL
COC	CHAIN OF CUSTODY
YS	YAYASAN SABAH
SFD	SABAH FOREST DEPARTMENT
LOGTRAMS	LOG TRACKING AND MONITORING SYSTEM
TDP	TIMBER DISPOSAL PERMIT
CHP	COMPREHENSIVE HARVESTING PLAN
RIL	REDUCED IMPACT LOGGING
EIS	ECONOMY, INDUSTRY AND STATISTICS
MCEE	MONITORING, CONTROLLING, ENFORCEMENT AND EVALUATION
DFO	DITRICT FOREST OFFICER
FR	FOREST RANGER



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CHAPTER I

INTRODUCTION

1.1 Introduction

The component of chapter one for this research will comprise of; the problem statement, research objectives, and questions that are going to be addressed, significance and scope of the study and the definitions of key terms used.

1.2 Background of the Study

Radio frequency identification (RFID) is a data collection technology that uses radio waves to automatically read and identify individual physical objects. When goods are attached with RFID tags, their movements can be tracked by radio readers, providing greater inventory record, improving business, controlling and monitoring processes, and enhancing the supply management efficiently. Although RFID has been around for over five decade (Jervis, 2005), but its potential for improving business processes and activities has only been recently taken interests by organizations (Angeles, 2005; Hardgrave & Miller, 2006; Reyes *et al.*, 2007). Due to that, many businesses in various industries are applying the advantages of RFID to experimental projects in order to improve operational efficiency and to gain competitive advantage.

According to a new RFID sector survey by IDTechEx Research, global RFID market will increase from \$6.98 billion in 2012 to \$7.88 billion, and will reach \$23.4 billion in 2020 thus making RFID technology, a rapidly growing market. While RFID has been discussed in the literature as a technology that can provide several advantages, both strategic and operational to its adopters, the RFID adoption rate is not growing as fast as expected. This suggests more effort is necessary to understand the process of adoption of the technology and to identify factors affecting the RFID adoption decision.



Malaysia and the European Union (EU) have been negotiating a voluntary partnership agreement based on EU-issued regulations for the production of logs and wood products. The EU wants countries that export wood products to adhere to a set of rules providing guarantees that the trees used to make those products were harvested legally, and in an environmentally sustainable manner. The European Union also wants control and monitoring processes to be transparent. Once those controls and processes are put into place, the Malaysian government will be able to issue export licenses that meet EU standards while combating illegal logging. One requirement of the agreement is a national timber-tracking system to improve transparency and traceability in the timber supply chain.

In the state of Sabah, part of the requirement to obtain the Forest Stewardship Council (FSC) accreditation for logs extracted from the Yayasan Sabah concession is to have a well-designed Chain of Custody (CoC) system for the tracking of the logs from their points of origin in the forest to the facilities where they are processed into primary wood -products. To implement the CoC system effectively, labelling of logs is essential.

In April 2007, the Forestry Division of Yayasan Sabah tested the use of RFID technology on logs, whereby a pilot project was done at block YS4/04 in Sandakan and about 400 trees were felled for that purpose. As a result of the successful implementation of the RFID pilot project and to convince SFD that the labelling of logs using RFID tags and the scaling of logs using handheld data logger are feasible, a pilot project using RFID technology was jointly carried out with SFD to test all the SFD requirements inclusive of the access of data from the regions to the central server.

Based on the successful implementation of the Forestry Division's RFID LOGTRAMS pilot project with SFD in 2009 in the Kuamut Forest Reserve (120 hacters), SFD has agreed to expand this RFID LOGTRAMS to coupe YS1/07(5) of 3,000 hacters in Sandakan region. At the same time, the Forestry Division has also earmarked coupe YT2/08 of 7,000 hacters in Tawau region to apply this RFID LOGTRAMS. Unfortunately, there was no final report regarding this RFID LOGTRAMS project available. Therefore the conclusions from this project were not known with certainty. Nonetheless, it seems that the project could not find the

satisfying solutions that could have solved the practical problems which hindered the adoption of LOGTRAMS in Sabah Forestry.

The role of this concept is crucial because it plays a very important role in influencing not only to SFD as the department entrusted to manage forests and regulate forestry activities in Sabah but also to timber licensees to adopt RFID technology. RFID LOGTRAMS is almost a paperless system utilizing RFID tags which enable it to trace a piece of log from its stump to the point of sales and vice-versa. Therefore, all logs that are produced from a particular coupe using this system are accounted for. The information captured using the handheld data loggers are stored online in a main server which can be accessed using the Internet browser. This will enable the top management to view the production reports and logs status online.

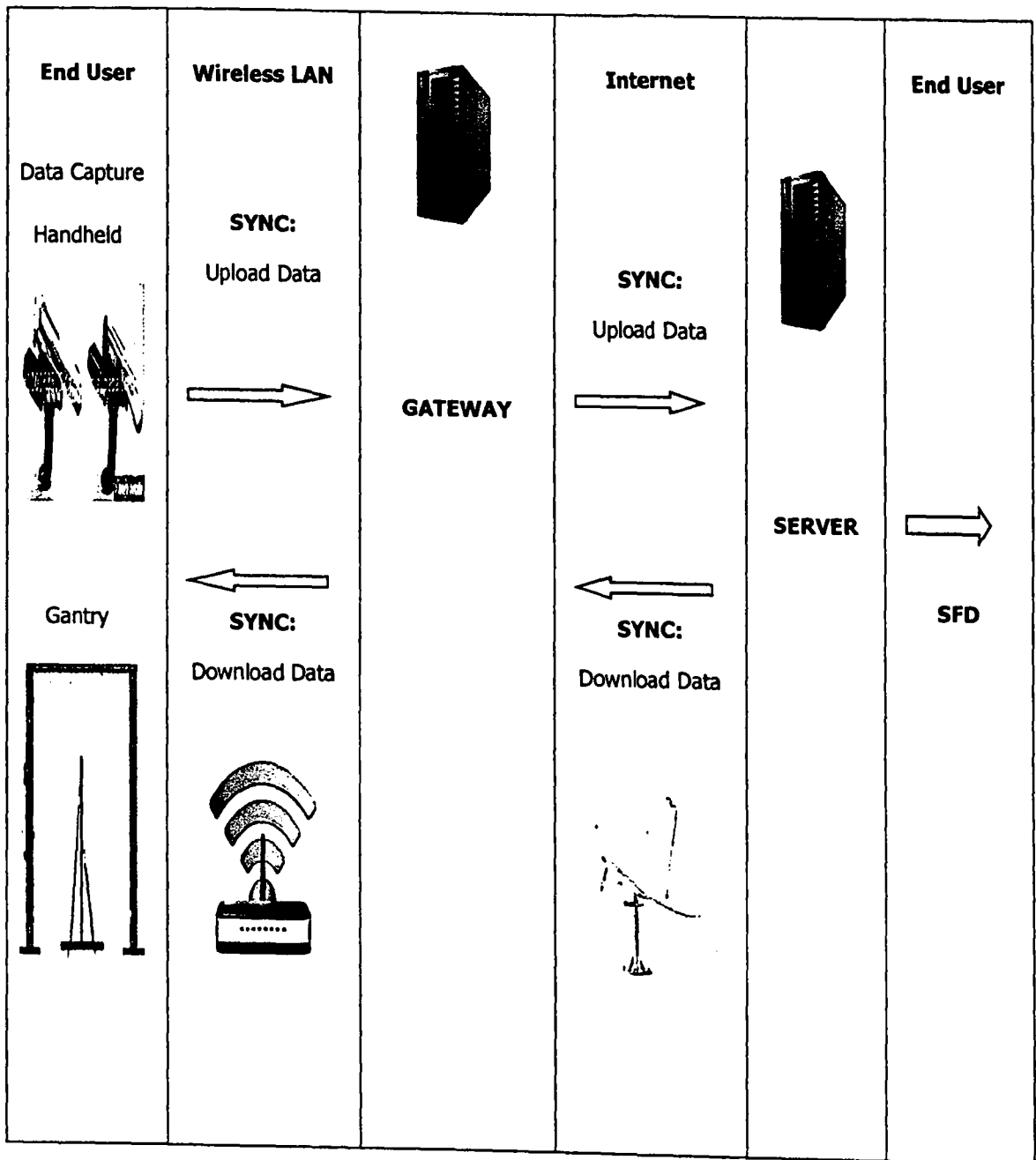


Figure 1.1: System Infrastructure of LOGTRAMS

Source : Log Tracking and Monitoring System User Manual (LOGTAMS) YS (2009)

In addition to that, the advantages of adopting RFID LOGTRAMS are outlined as follows:

- New format for timber disposal permit (TDP) document has been introduced whereby other information important for reconciliation had been included in

the new TDP format. This digital TDP format was developed under LOGTRAMS which include Licensee Account No., Forestry Department's Royalty Hammer Royalty No. stamped on the barrels of each log indicating that the royalty payment has been made, Receipt No., Letter of Undertaking (LU)/Cashier Order No., LU expiry date and LU/Cashier's Order issuing Bank. All these details available in one form enable reconciliation process to be conducted much easier.

- Digital TDP is able to be produced with the transfer of data from the final log list after 100% verification from the RFID data base specific to SFD use. This eliminates the tedious work of transferring the final logs' detail manually to the TDP, upon 100% field verification and payment of royalty.
- Faster billing system as the RFID LOGTRAMS can be integrated with Jabatan Perkhidmatan Komputer Negeri Sabah's billing system.
- Faster generation of log production data as the manual data capture from the pre-printed TDP to the computer is eliminated. Log details are only captured once by the Forestry Division and the log list is finalized after 100% field verification by SFD staff. The same finalized data is used for TDP generation and log production data.
- Detailed data captured as the system is able to provide data up to the compartment level.
- All logs produced are accounted for including extra logs not captured in the Comprehensive Harvesting Plan (CHP) e.g. (culvert, bridges, matahari felling).
- The problem of having double log serial number is eliminated as log number was already decided while preparing the CHP and that any extra logs produced as a result of matahari felling or conversion of logs produced to other uses (example for culvert or bridges) are captured using a separate module.
- Harvesting flow is faster with computerization of data and other information.

- The detailed system complements/enhances RIL implementation.

RFID systems usually have three components consisting of the tags, readers and middleware. Its role is to support data processing of business activities which is always connected to an enterprise application system (Asif & Mandviwalla, 2005; Preradovic & Karmakar, 2007). It functions similarly to barcodes but its main advantage is that, RFID is able to track items in the supply chain without requiring a line of sight (Mehrerjedi, 2010). Companies that have successfully implemented RFID such as Procter and Gamble, Gillette, and Kraft reported to have saved costs of about \$16.7 million in labour costs, and \$6.9 million in errors due to reducing paperwork and vendor mistakes (Kwok & Wu, 2009). Although RFID potentials on benefits and costs savings are positive, but cost and risk associated with its early adoption still exists in its early adoption. According to Krotov & Junglas, 2008, the largest obstacles in RFID adoption is the large initial investment required coupled with the long payback period and time to breakeven.

1.3 Problem Statement

Today, with increasing sustainability concerns, global trade and opaque supply chains, it is difficult to distinguish the source of timber and timber products, however there might be an increasing interest to be able to track this information. The reasons why companies or governments implement tracking systems can be very varied. A company in the timber sector may simply wish to know more about their supply chain or there could be a need to reduce the risk of any illegal or unsustainable material entering the supply chain.

Log tracking and monitoring system can be used to conform to the certification schemes and it can also be implemented as part of a due diligence requirements of Chain of Custody certification for forest system and to gain knowledge of the supply chain structure. Timber tracking systems are able to link timber with new attributes such as 'sustainable sourced' or 'proof of origin'. Therefore companies that are involved in timber business can show they are being different (better) than their competitors by using tracking systems. Governments

implement timber and timber product tracking systems in order to regain control over their forest and timber sector to increase tax revenue as a positive side effect or to have trade advantages such as increased access to premium markets.

However, RFID has not been adopted as much as anticipated (Luo, 2007). There has been very limited study on the adoption of RFID in areas such as the supply chain and technology adoption as compared to numerous publications about RFID technology (Wu *et al.*, 2009). There were unique condition in each country which may impact on adoption drivers, for example a study carried by Madlberger, 2009, on the adoption of RFID in Taiwan reported that the key driving factors on RFID adoption differed from industrialized nations in the west. Although most of the previous literatures on RFID were conducted in the developed countries (Kinsella, 2003; Loebbecke & Palmer, 2006), yet there were very few numbers of empirical published studies regarding RFID adoption.

It is therefore hoped that the results of this study and related implications will enhance the existing knowledge and ideas on the determinants of RFID adoption in the timber industry, focusing on Sabah Forestry Department.

1.4 Research Objectives

Research objectives of this study are:-

- a) To examine the effect of technological innovation on the evaluations of RFID in Sabah Forestry Department.
- b) To examine the effect of technological innovations on the adoption of RFID in Sabah Forestry Department.
- c) To examine the effect of RFID evaluations on RFID adoption of RFID in Sabah Forestry Department.
- d) To examine the mediation effect of RFID evaluation towards the relationships between technological innovation and RFID adoption.

1.5 Research Questions

- a) Does technological innovation elements have a positive relationship towards the RFID evaluation of RFID technology?
- b) Does the RFID evaluations have a positive relationship with RFID adoption?
- c) Does technological innovative elements have a positive relationship with RFID adoption?
- d) To what extent is the relationship between technological innovation elements and RFID adoption is mediated by RFID evaluation?

1.6 Scope of the Study

RFID technology is gaining interests in various businesses nowadays (Balloco *et al.*, 2011). Although knowledge about the implementation of RFIDs is continuously growing, yet there is still not enough information about the factors that influence its adoption. Currently, there are few conducted empirical studies with regards to RFID usage and its influential determinants (Madlberger, 2009). Thus, the scope of this study was focused on the officers of the Sabah Forestry Department who have been involved in the pilot project of RFID LOGTRAMS which has been tested in their organization.

1.7 Significance of the Study

The purpose of this study is to develop and to empirically test a theoretical model of RFID adoption in the context of log tracking system, using the technology-organization-environment (TOE) framework model. A questionnaire survey was conducted to study the determinants impacting the adoption of RFID in Sabah Forestry Department. The survey data were then transferred into statistical software (SmartPLS 2) for further analysis. The findings regarding the determinants impacting RFID adoption were derived based on the results of this analysis.

The managerial implications from this research were beneficial to forests managers to enhance their knowledge on how the technological innovations determine RFID adoption in the forestry sectors. For decision makers in the forestry organization considering RFID based technology initiatives, the findings will provide a sound basis for gauging the direct and indirect effects of the innovation characteristics of RFID technology as well as the literature related to its adoption in varying industries.

1.8 Definition of Variables

For better understanding on the definitions and descriptions of terminologies are best described as below:

1.8.1 Antecedents

- a) **Relative advantage:** According to Rogers, (1983) relative advantage is defined as the degree to which an innovation is perceived as providing greater organizational benefits than the idea it supersedes or the status quo. Due to its advantages, organization should take the opportunity to consider adopting these new innovations. RFID relative advantage is expected to be able to give organizations greater competitive advantage. Companies which perceive higher relative advantages in RFID technology tend to be more likely to adopt the technology.
- b) **Compatibility:** Compatibility is the degree to which an innovation is perceived as being consistent with the needs or the existing hardware and software of an organization (Premkumar & Roberts, 1999).
- c) **Complexity:** Complexity is the extent to which an innovation is perceived as relatively difficult to understand and use (Rogers, 1995). A complex innovation like RFID involves different levels of managerial complexity, technical and operational depending on the level usage of RFID (Brown & Russell 2007).

- d) **Costs Savings:** Refers to the cost reductions that are achieved, associated with labour costs, inventory costs, operating cost, etc. (Curtin et al., 2007). Joshi, (2000) in his study claimed that RFID adoption might increase visibility of item – level unit costs as well as reducing inventory costs in the supply chain integration. Fleisch & Telkamp, (2005) reported that RFID system provide superior inventory control over the present information system.

- e) **Security:** Ranasinghe, Engels, and Cole, (2004) defined RFID security as the components of confidentiality or message content security, authentication of sender and recipient non-repudiation by the sender, integrity of message content, and availability.

- f) **Perceived Benefits:** The anticipated benefits of a technology innovation considered by an organization as a valuable technology and the basis for adoption decision (Brown & Russell, 2007; Premkumar *et al.*, 1997; Rogers, 2003; Tornatsky & Klien, 1982).

1.8.2 Consequences/Mediators

a) **Evaluation:** The initiation stage is the evaluation phase in which the organization experiences pressure from their internal and external environment (Grover & Goslar, 1993). An organization intention to adopt a technology is being signalled by the initiation process.

1.8.3 Outcome

a) **Adoption:** The adoption and adaptation stages include committing resources to engage in the pilot test of the technology (Grover & Goslar, 1993).

1.9 Organization of Dissertation

The dissertation was constructed in five chapters as is depicted in figure 1.2 below. Chapter 1 presents the background of the study, problem statement, research objectives, significance of the study, the scope of the study and definitions of the variables. Chapter 2 presents the literature review of RFID technological innovativeness dimensions and adoption. Chapter 3 provides the methodology adopted by this study, consisting of theoretical framework, research design, population and sampling, research instruments, data collection procedures and data analysis procedures. Data analysis and findings were presented in chapter 4. Last, but not the least discussions and conclusions as in chapter 5.

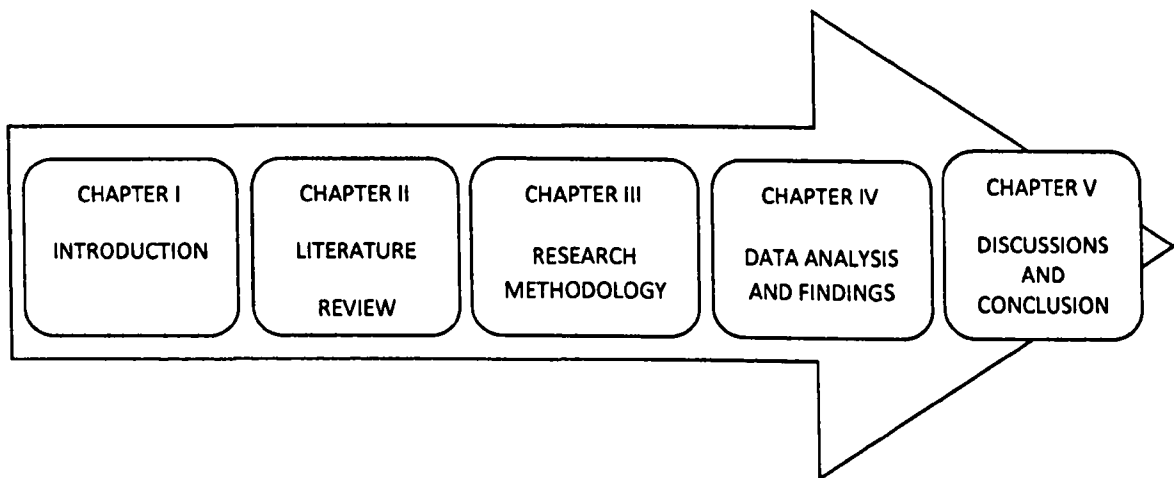


Figure 1.2: Flow of each chapter

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide the insightful view of the literature parallel to the research objectives. The earlier sections discussed on the past studies of antecedents of technological dimensions, consequences of the antecedents on RFID evaluation, the outcome of the antecedents effect towards the RFID adoption and the mediating effect on RFID evaluation on the relationship between technological dimensions and the RFID adoption. The final section of this chapter discussed about the propose research hypothesis.

2.2 RFID Adoption

The importance of "Log Tracking" adoption includes improved logistics and stock control management (Evanson, 1998, Dykstra et al., 2002), particularly in the niche markets. Knowing the origin of logs and how they are being moved and how long they have taken to various intermediate points will help to identify where the bottlenecks are located in the supply chain. Revenue increases e.g. log freshness when they are efficiently supplied to the appropriate destinations. The ability to track, allocate and identify logs from stands or trees with specific species will be improved for example, wood with high density characteristics (Amishev, 2008). Currently, technology exists only to estimate wood properties in the field however this cannot be passed along the chain of custody. This information will be lost if a log is only visually sorted and labelled by grade. Environmental certification of forest products such as Forest Stewardship Council, (FSC) requires a system to tag individual logs with certification status (Ozanne and Vlosky, 1995). Surveys on value-added wood manufacturers in 2002 and 2008 by Vlosky *et. al.* in 2009 found out that the primary motive for business owner to get involved in certification include commitment to environment, growing markets and increasing sales and market shares.



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