UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE IMPACT OF RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY ON SUPPLY CHAIN PERFORMANCE

This report is submitted following the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Technology Management (Supply Chain Management and Logistics) with Honours

BY

TAN YEAN LENG

B062110326

011025-10-1136

FACULTY TECHNOLOGY MANAGEMENT AND TECHNOPRENEURSHIP

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I hereby acknowledge that this project paper has been accepted as part of fulfilment for the degree of Bachelor of Technology Management (Supply Chain Management and Logistics) with Honors.

SIGNATURE :

NAME OF SUPERVISOR : PROFESOR DATUK DR. IZAIDIN BIN ABDUL MAJID

DATE : 18 JANUARY 2025

SIGNATURE :

NAME OF PANEL : TS. DR. YUSRI BIN ARSHAD

DATE : 12 FEBRUARY 2025

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DECLARATION OF ORIGINAL WORK

I hereby declare that all the work of this thesis entitled " THE IMPACT OF RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY ON SUPPLY CHAIN PERFORMANCE" is original done by myself and no portion of the work encompassed in this research project proposal has been submitted in support of any application for any other degree or qualification of this or any other institute or university of learning.

SIGNATURE :

NAME : TAN YEAN LENG

DATE : 16 JANUARY 2025

ABSTRACT

The Radio Frequency Identification (RFID) has contributed to various impacts on the supply chain performance. This research is to study the impact of Radio Frequency Identification (RFID) technology on supply chain performance. The researcher was determining the relationship between independent variables (accuracy of inventory tracking, data visibility and transparency, and operational efficiency) and dependent variable (supply chain performance). Data were collected from 100 respondents involved in supply chain industries from Malaysia. Statistical Package of Social Sciences (SPSS) is applied to analyze the data collected from the respondents. Several analysis methods had been used in this research which are Cronbach's Alpha analysis, Pearson's Correlation analysis, and Multiple Regression analysis.

Keywords*: Radio Frequency Identification (RFID), supply chain, impact, supply chain performance*

ABSTRAK

Pengenalan Frekuensi Radio (RFID) telah menyumbang kepada pelbagai impak terhadap prestasi rantaian bekalan. Penyelidikan ini adalah untuk mengkaji impak teknologi Pengenalan Frekuensi Radio (RFID) ke atas prestasi rantaian bekalan. Pengkaji sedang menentukan hubungan antara pembolehubah tidak bersandar (ketepatan penjejakan inventori, keterlihatan dan ketelusan data, dan kecekapan operasi) dan pembolehubah bersandar (prestasi rantaian bekalan). Data dikumpul daripada 100 responden yang terlibat dalam industri rantaian bekalan dari Malaysia. Pakej Statistik Sains Sosial (SPSS) digunakan untuk menganalisis data yang dikumpul daripada responden. Beberapa kaedah analisis telah digunakan dalam penyelidikan ini iaitu analisis Alpha Cronbach, analisis Korelasi Pearson, dan analisis Regresi Berganda.

Kata kunci: *Radio Frequency Identification (RFID), rantaian bekalan, impak, prestasi rantaian bekalan*

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LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
RFID	Radio Frequency Identification
SKU	Stock Keeping Unit
EPC	Electronic Product Code
LF	Low Frequency
HF	High Frequency
UHF	Ultra-high Frequency
PIC	Peripheral Interface Controller
IC	Integrated Circuit
CPU	Central Processing Unit
RO	Research Objective
AIT	Accuracy of Inventory Tracking
DVT	Data Visibility and Transparency
OE	Operational Efficiency
MRA	Multiple Regression Analysis

CHAPTER 1

INTRODUCTION

1.1 Introduction

The impact of radio frequency identification (RFID) technology on supply chain performance will be covered in this chapter. This chapter will cover the background of study, problem statement, research questions, research objectives, scope and limitation of the study, significant of study and summary.

1.2 Background of Study

Radio Frequency Identification known as RFID. It is an automatic identification and data collection technology. (Sarac, Absi and Dauzère-Pérès, 2009) Tags, antennas, readers, and communication infrastructure make up an RFID system. RFID tags and transponders are usually attached to objects. RFID tads or transponders can be active, meaning they run on batteries and actively generate radio frequency signals.The RFID reader communicates with the transponder or tag to identify the object to which it is connected. Information about the object is stored in the transponder or tag, which is utilized for identification when necessary. An object serial number, model number, or other characteristics can be stored in a transponder or tag in order to identify, distinguish it from other objects, or track its movement. (Reyes, 2011)

The military employed Radio Frequency Identification (RFID) for the first time to identify friend or foe aircraft (IFF) during World War II. RFID is a new technology in business applications but not in the field of scientific research. By the 1980s, interest in RFID began to grow rapidly. During the 1980s, people interest in RFID, especially Europe and United States. The primary areas of concentration for the first development initiatives in the US were personnel access and transportation applications. Short-range systems for animals were the main focus of efforts in Europe, followed by industrial and commercial applications. While the United States had been testing RFID for toll collection for many years, the first commercial toll

application started in Europe in 1987 and quickly spread to the United States. By the 1990s, RFID technology is popularized all over the world. In 1991, Oklahoma introduced the first open-highway electronic tolling system, enabling vehicles to travel at highway speeds past toll collection points. In 1992, Houston, Texas, implemented the first integrated traffic control and toll collection system. Subsequent advancements in RFID toll-tag technology included the ability to utilize a single tag for several purposes. RFID technology has become increasingly popular for supply chain management applications in the twenty-first century. (Reyes, 2011)

In recent years, a lot of businesses use RFID to track specific inventory items, cases, pallets, or equipment. Retail establishments, warehouses, and manufacturing facilities all employ RFID tags. Additionally, some businesses are identifying the individual components that make up the final product. Reyes (2011) Furthermore, RFID in supply chains emphasizes on environment sensors, asset monitoring, and item placement. (Seifert and Gaukler, 2007)

Nowadays, supply chain management facing a significant issue, the difference between the inventory quantities recorded in the system and the actual inventory quantities on hand. For example, empiric reports show that at one leading retailer, more than 65% of inventory records out of the over 370,000 SKUs that were looked into did not match the physical inventory at store's SKU level. (Ramen, DeHoratius, and Ton, 2001) The researcher observes that the main areas that RFID can address are inventory inaccuracy, bullwhip effect, and replenishment policy. This study aims to determine whether RFID technology affects supply chain performance.

1.3 Problem Statement

According to Attaran (2012), businesses can compete and expand rapidly through investing in cutting-edge technologies. As one of the most promising and anticipated technologies in recent years, RFID can be a solution that saves businesses capital in the short term, while improving the competitiveness of their supply chains in the long term. Additionally, Hinkka (2012) states that utilizing Radio Frequency Identification (RFID) technology can significantly increase supply chains' efficiency.

In 2005, Walmart implemented RFID-based pallet-level and case-level track system and required top 100 suppliers provide RFID-tagged products on cartons and pallets. The success of Walmart in implementing RFID technology influences the imitation of other businesses. (Fan, Tao, Deng, and Li, 2013) Although Radio Frequency Identification (RFID) technology brings positive impacts on supply chain performance, it also faces challenges. As stated by Attaran (2012), the implementation of RFID technology involves various issues beyond the technology itself. The issues become the worries of companies to implement this technology in their businesses.

Hinkka (2012) pointed out that the implementation of RFID resulted the improvement in supply chain operations and creates cost savings for businesses implementing the technology. Additionally, RFID tracking has improved many supply chain processes and even created new business possibilities. Based on the statement given, RFID technology enable to bring benefits on supply chain management if businesses use it correctly. By using RFID in businesses correctly, it enables to avoid the difficulties of implementing RFID technology on supply chain performance.

1.4 Research Questions

Three research questions were identified by the researcher for this study:

i. What is the relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance?
ii. What is the relationship between data visibility and transparency provided by RFID technology and supply chain performance?
iii. What is the relationship between operational efficiency achieved through RFID technology and supply chain performance?

1.5 Research Objectives

Three research questions were clarified by the researcher for this study:

i. To explore the relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.
ii. To identify the relationship between data visibility and transparency provided by RFID technology and supply chain performance.
iii. To examine the relationship between operational efficiency achieved through RFID technology and supply chain performance.

1.6 Scope and Limitation of the Study

The impact of Radio Frequency Identification (RFID) technology on supply chain performance is the main topic of this study. 384 respondents who work in Malaysian supply chain industries will participate in this survey. The chosen respondents will be drawn at random from these sectors.Respondents will be given questionnaires to complete as part of the research.

The research limitation faced by researcher during the progression of this study is time constraints. First and foremost, the study had to be accomplished in a limited time. In addition, the researcher took a long period to find out the suitable respondents and waiting for their responses.

1.7 Significance of Study

The study's conclusions were beneficial to Malaysian supply chain companies, particularly those looking to integrate Radio Frequency Identification (RFID) technology into their operations. They will comprehend how supply chain performance is affected by RFID technology. Additionally, this research provides researchers and practitioners with additional knowledge regarding RFID technology and the effects of RFID implementation. Additionally, by contributing to the body of knowledge already available on the effect of Radio Frequency Identification (RFID) technology on supply chain performance, the study offers empirical literature sources to future academics that do research on a related topic.

1.8 Summary

In conclusion, the study's overview was covered in this chapter. The background of the study, problem statement, research questions, research objectives, scope and limitation of the study, and significance of the study were all covered. The researcher will conduct the study's literature review in the upcoming chapter. The data will be more comprehensive and comprehensible.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review and relevant theoretical model will be introduced in this chapter. The results of earlier studies on the impact of Radio Frequency Identification (RFID) technology on supply chain performance were also included in this chapter. The dependent and independent variables were determined by reading the pertinent types of literature. By the end of this chapter, the theory and hypotheses can be developed using the conceptual research framework.

2.2 Supply Chain Performance

Supply chain performance is the efficiency and effectiveness a company manages its entire supply chain to meet its goals. It involves measuring various metrics across the supply chain network, such as delivery times, inventory levels, cost efficiency, and customer satisfaction. (Chopra and Meindl, 2016)

According to Gunasekaran, A. et al (2003), the supply chain performance metrics include four, which order planning metrics, supply link evaluation, production level evaluation, production level metrics, and delivery performance. The order planning metrics includes order lead time, customer query time, and forecasting accuracy. It emphasis that the shorter the cycle time, the better the customer service. For supply link evaluation, it focuses on supplier delivery performance, lead time, and pricing efficiency. This evaluation is essential for companies of long-term supplier partnerships and performance evaluation. Moreover, for production level metrics, the key metrics include defect rates, operation costs, and capacity utilization. It highlights the balance between efficiency, quality and flexibility. Finally, delivery performance, it focuses on the on-time delivery, flexibility, and product quality to meet customer needs and high satisfaction with the low distribution costs.

Measuring supply chain performance brings many benefits to organizations. Firstly, it helps organizations to fulfil customer's expectations by on-time delivery and product quality. This also helps organizations to identify areas to reduce costs and improve efficiency. Secondly, it enables to aligns financial and non-financial goals. Although financial metrics are important, non-financial metrics such as quality and efficiency help balance day-to-day control and long term strategic planning. Furthermore, it enables to achieve continuous improvement. For example, it enables to shorten lead times, improved forecast accuracy, and production efficiency through the collected data. Moreover, it supports decision-making at all-levels. For strategic levels, it helps high-level to making decisions for the corporate planning and long-term strategy by the metrics such as customer perceived value and order delivery period. For the tactical level, it enables to evaluate mid-level management process, such as supplier efficiency and resource allocation. For operational level, it enables to monitors organization daily activities and routine such as production quality and on-time deliveries.Last but not least, it enhances companies competitiveness. Supply chain performance is directly influences the productivity and profitability of an organization. Performance measurement helps align the supply chain with strategic goals such as customer satisfaction, cost efficiency, and market responsiveness. (Gunasekaran, A. et al, 2003)

2.3 Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID), a technology that's becoming more popular, might end up being one of the most widely used computing technologies ever. At its core, RFID works a lot like barcodes, helping to improve data processes and working well with existing tech. It's a tried-and-true technology that's been around since the 1970s. (Roberts, 2006)

In short, RFID uses electromagnetic signals to identify and interact with objects. It involves "RFID tags" attached to items and "RFID readers" that gather information from these tags. Compared to bar codes, RFID offers benefits like being able to read information without direct line of sight, holding more data, and enabling two-way communication. RFID systems use these tags and readers to interact with

objects and databases, providing valuable information and functionality. (Roberts, 2006)

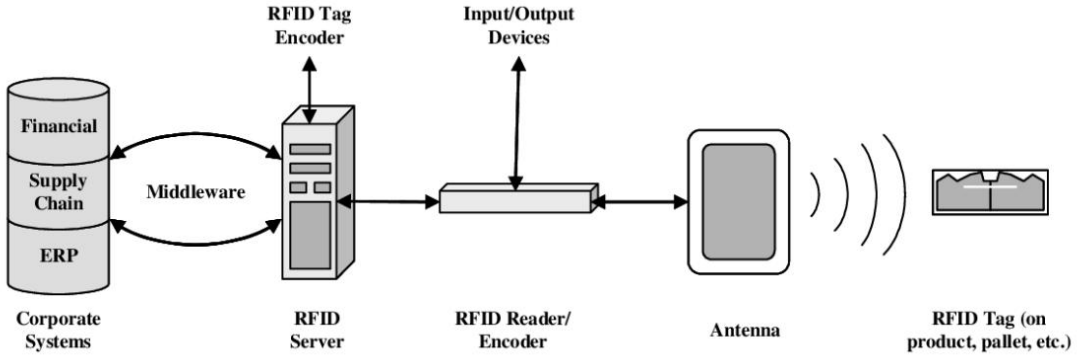

Figure 2.1: Radio Frequency Identification (RFID) Network

(Source: https://www.semanticscholar.org/paper/Understanding-Radio-Frequency-Identification-(RFID)-Maloni/63c402930241562dd4e27f2c52bfd9f9b6455d44)

2.3.1 Core Components of Radio Frequency Identification System

The RFID system typically composed by RFID tags, RFID antenna, middleware, RFID readers, and microcontroller. (Baballe, 2021)

2.3.1.1 RFID Tags

RFID tags also known as transponder. It is a microprocessor chip composed by integrated circuit with memory. (Reyes, 2011) RFID tags have three types, passive tags active tags, and semi-passive tags (i.e. semi-active tags). (Nayak et al., 2007)

RFID tags can be categorized based on their storage capabilities. The classification are divided into read-only, read or write tags, and combination tags. Read-only tags store data that cannot be modified, while read or write tags store data that can be modified. Combination tags include some unchangeable data along with memory capacity, and they are designed to function not merely as pointers to an Electronic Product Code (EPC) system or other databases containing the item's full information. (Reyes, 2011)

The Auto-ID Center established the EPC framework, an RFID industry standard for identifying consumer packaged goods, which defines the data storage capacities of RFID tags for product information. Tags are divided into six classes by the EPC architecture, each with ever more powerful features. However, the EPC framework is only one of several because different businesses have varied needs when it comes to the RFID tags' ability to store data. (Reyes, 2011)

EPC Tag Classes are shown below: -

EPC Tag Class	Tag Class Capabilities
Class 0	The factory-programmed EPC number on these tags is read-only.
Class 1	Users can program these read-once or write-once tags because they are generated without an EPC number.
Class 2	Building on Class 1, these tags feature more memory, encryption, and the ability to read and write data.
Class 3	In addition to Class 2 features, these tags include a power source to extend range and enable more complex capabilities, such as sensing.
Class 4	These tags offer Class 3 functionalities along with an active transmitter and sensing capabilities.
Class 5	Expanding on Class 4, these tags can also interact with passive tags, effectively functioning as a reader.

Table 2.1: EPC Tags Classes

(Source: Adopted from Reyes, P.M. (2011))

2.3.1.1.1 Passive Tags

Passive tags transfer the stored data to the reader using power generated by the reader. The cost of passive tags usually lower than the cost of active tags because there is not built-in power supply. Since there are no batteries, passive tags also enjoy an unlimited lifespan. However, they are affected by noise and require more powerful readers to function as their power comes from these readers. Fewer tags may be scanned at once with passive tags, and their data transfer rates are lower. In addition, passive tags exhibit higher orientation sensitively, meaning their performance can be significantly affected by their positioning angle relative to the reader. (Reyes, 2011)

Typically, passive tags are sent within three primary frequency bands, which are low frequency (LF), high frequency (HF), and ultra-high frequency (UHF). The operates on frequency ranges of passive tags is 120KHz to 915MHz. The three different frequency bands have different operating frequency ranges. The operating frequency ranges are 120KHz - 135KHz, 13.5MHz, and 868MHz - 915MHz for LF, HF, and UHF respectively. (Nora, Felix, Dagmar, Eva, Thomas, 2015)

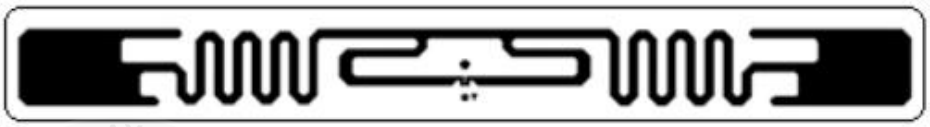

Figure 2.2: RFID Passive Tag

(Source: https://www.seikorfid.com/product/rfid-tags-for-inventory.html)

2.3.1.1.2 Active Tags

Active tags composed by an on-board power supply for sending the saved data to the reader. There are powered by an internal battery. Active tags' cost is expensive compare to passive tags. However, they have better noise immunity and can transmit signals independently due to their internal power supply. This allows them to be useful even with less capable readers. Active tags also support higher data transfer rates and the ability to read more tags simultaneously. Moreover, they are less direction-sensitive, which makes them more reliable in a variety of positions relative to the reader. (Reyes, 2011)

Figure 2.3: RFID Active Tag

(Source: https://www.allied-automation.com/partners/rfid/active-rfid/)

2.3.1.1.3 Semi-passive Tags / Semi-active Tags

Semi-passive tags or semi-active tags combines features of both passive and active tags. It uses an external battery for its power but communicates with the reader just like a passive tag does. (Liu, 2010) Which helps improve its range and reliability. Although it has its own power source, it communicates with the RFID reader similarly to a passive tag, relying on the reader's signal to transmit information. This combination enables semi-passive tags to operate effectively in a variety of environments, providing better performance than purely passive tags while consuming less power than full active tags. (Jankowski-Mihulowicz, Weglarski, Pitera, Kawalec, and Lichon, 2016)

2.3.1.2 RFID Antenna

An RFID antenna is a tool that allows the RFID tag and RFID reader to connect. A cable physically connects the RFID antenna, a special device, to the reader. Usually, a single reader supports up to four antennas with cable lengths from 6 to 25 feet. Furthermore, the RFID antenna can read tags on its front and sides based on its radio wave footprint. The antenna receives the tag's response after sending out the reader's radio frequency signal. The antenna needs to be positioned accurately in relation to the tag in order to guarantee tag reading accuracy. The sensitivity of RFID antenna will influences the supply chain performance. (Reyes, 2011)

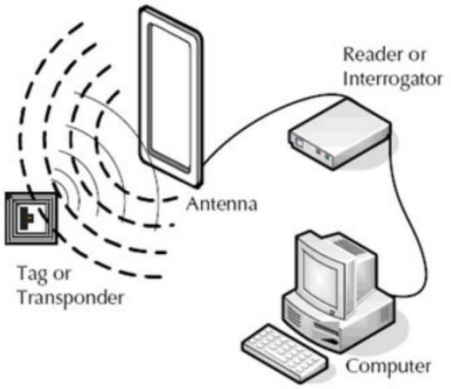

Figure 2.4: RFID Antenna Operation in an RFID System

(Source: https://www.autodesk.com/products/fusion-360/blog/rfid-works-antenna-design/)

2.3.1.3 RFID Readers

RFID reader, also called an interrogator. It is a tool that enables to read and/or write information to an RFID tag. It communicates with RFID tags via an antenna, exchanging information about the tagged object. Readers must match those frequencies to communicate effectively because tags operate on specific frequencies. For successful interaction, the RFID tag and reader must use the same radio frequency and follow the same protocol. In addition, RFID readers come in many forms, including handheld, vehicle-mounted, post-mounted, and hybrid designs. While hybrid readers can alternate between passive and active tags, dedicated readers are designed to read either one. (Reyes, 2011)

Figure 2.5: RFID Reader
(Source: https://www.encstore.com/13-56mhz-wireless-bluetooth-hf-rfid-reader-enc5699)

Figure 2.6: Handheld RFID Reader
(Source: https://www.cipherlab.com/en/product-284078/UHF-RFID-Reader-RK26.html)

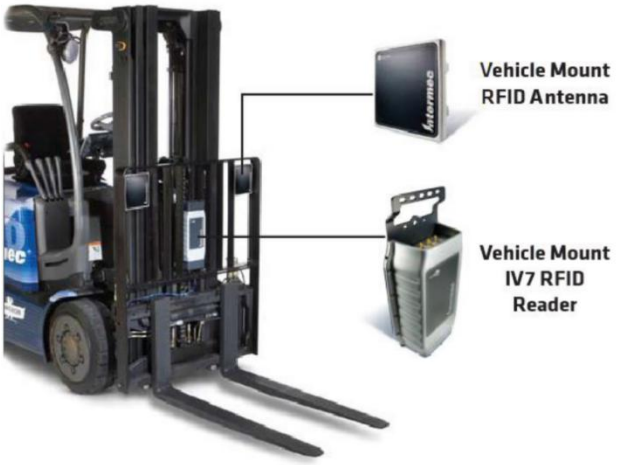

Figure 2.7: Vehicle-mounted RFID Reader and RFID Antenna

(Source: https://www.posdata.com/aidc/products/hardware-and-supplies/rfid-systems)

Figure 2.8: Post-mounted RFID Reader

(Source: https://a3m.eu/en/pedestal-post-for-badge-reader)

2.3.1.4 Middleware

Middleware also known as RFID software. It acts as an intermediary between RFID readers and enterprise business applications. This software has many purposes and it is important for controlling and running RFID systems. It creates links between RFID printers and readers, and business applications, in addition to controlling how these devices operate. Furthermore, it enable to filters, manages, aggregates, and interprets the data received from RFID tags. (Baballe, 2021)

2.3.1.5 Microcontroller

Microcontroller, also known as single-chip microcomputer, is a types of digital chip. It is a highly combined device. A microcontroller consists of a chip and most or all of the parts needed to carry out an application's control functions. An integrated circuit (IC) called a peripheral interface controller (PIC) is used to manage peripheral devices and lessen the strain on the central processing unit (CPU). It is controlled by software, such as a CPU, and does calculations despite having a restricted memory capacity. Microcontroller is a tool used for designs that require local resolution and helps in programming of the entire circuit. (Baballe, 2021)

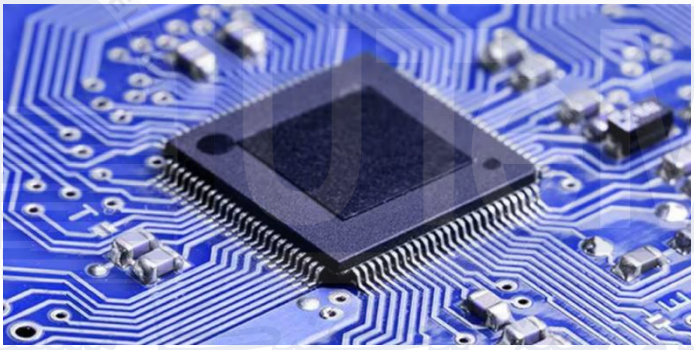

Figure 2.9: Microcontroller

(Source: https://www.arrow.com/en/research-and-events/articles/engineering-basics-what-is-a-microcontroller)

2.4 Relationship between the Impact of Radio Frequency Identification (RFID) Technology and Supply Chain Performance

Visich et al. (2009) states that implementing Radio Frequency Identification (RFID) technology improves on supply chain performance. The impacts of Radio Frequency Identification (RFID) include accuracy of inventory tracking, data visibility and transparency, and operational efficiency.

H1: Implementing Radio Frequency Identification (RFID) will brings a positive impact on supply chain performance.

2.4.1 Relationship between Accuracy of Inventory Tracking and Supply Chain Performance

Visich et al. (2009) claimed that using Radio Frequency Identification (RFID), companies get real-time, precise inventory tracking without needing manual scans. This accuracy reduces stockouts, overstocking, and errors, ensuring products are available when needed. Moreover, implementing Radio Frequency Identification (RFID) enables to tracking goods when companies move a products to another places. Finally, it enables to improve supply chain performance by increasing supply chain efficiency.

Basinger, K.L. (2006) mentioned that the RFID technology has played a crucial role in minimizing discrepancies between recorded and actual inventory counts. By offering real-time tracking and data updates, RFID helps ensure that what's on the shelf matches what's in the system. This accuracy reduces common issues like overstocking or running out of items unexpectedly. With RFID, mistakes due to human error, theft, or delayed data updates are significantly decreased, leading to a more dependable inventory system. Therefore, businesses can keep just the right amount of stock, avoiding both shortages and excess, and making supply chains run more smoothly.

Furthermore, RFID technology provides accurate, real-time updates, making inventory management more efficient. Instead of relying on manual counts that can be slow and prone to errors, RFID tracks inventory automatically, so companies always have the latest information on what's in stock. This up-to-date data helps managers make smarter decisions about when to reorder, avoiding problems like having too much or too little inventory. With RFID, businesses can keep just the right amount of stock, reduce costs, and run their supply chains more smoothly. (Madamidola, OA. et al., 2024)

In summary, the accuracy of inventory tracking provided by RFID technology enables to bring a positive impact to supply chain performance.

H1a: There is a positive relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.

2.4.2 Relationship between Data Visibility and Transparency and Supply Chain Performance

RFID's real-time data transforms supply chains by making them far more transparent and responsive. With this visibility, companies can track product movement, monitor inventory, and respond quickly to changes. This helps reduce stockouts, avoid excess inventory, and shorten lead times, which keeps costs down and service levels high. (Visich et al., 2009)

Hader, M. et al. (2022) also states that RFID technology enables to improving data sharing and transparency among supply chain stakeholders. With RFID, data about product locations, inventory levels, and delivery updates is captured automatically and shared in real-time. The supply chain stakeholders, from suppliers to retailers, has a clear and accurate view in every phrase. It reduces the risks of miscommunication, resulting to better coordination and trust.

In addition, RFID technology help companies to reduce lead time and enhance order fulfillment process. By automating processes like picking items from shelves, organizing them, and tracking their journey, RFID removes many of the manual steps that can slow things down. This means companies know exactly where products are at all times, making it easier to avoid mistakes and delays. The result is faster order processing and shorter delivery times, allowing customers to get what they need more quickly. (Attaran, M., 2012)

In conclusion, the data visibility and transparency provided by RFID technology enables to bring a positive impact to supply chain performance.

H1b: There is a positive relationship between data visibility and transparency provided by RFID technology and supply chain performance.

2.4.3 Relationship between Operational Efficiency and Supply Chain Performance

Visich et al. (2009) states that Radio Frequency Identification (RFID) simplifies operations by automating tasks such as tracking and inventory checks, reducing manual work and errors. This can improve efficiency by speeding up processes, ultimately enhancing supply chain performance through faster, ore reliable service.

Attaran, M. (2012) mentioned that the company reduced errors that are typically caused by manual processes. RFID technology does the data entering and inventory tracking automatically, without relying with human. This means the company increase their data accuracy, reduce errors, and allowing companies to reallocate labor to more critical tasks within the supply chain.

Also, RFID technology has reduced operational costs in the supply chain by cutting down the need for manual labor. This is because the time-consuming and laborious processes such as inventory check and data entry has change to automated. Automated tracking of RFID enables to done quickly and accurately in inventory counts. This process not only reduces human error, it also increase company efficiency and enables the company to reallocate employees to more valuable tasks. (Chen, JC. et al., 2013) In short, the operational efficiency provided by RFID technology enables to bring a positive impact to supply chain performance.

H1c: There is a positive relationship between operational efficiency achieved through RFID technology and supply chain performance.

2.5 Conceptual Framework

In this research, accuracy of inventory tracking, data visibility and transparency, and operational efficiency as the independent variables while the supply chain performance as the dependent variable.

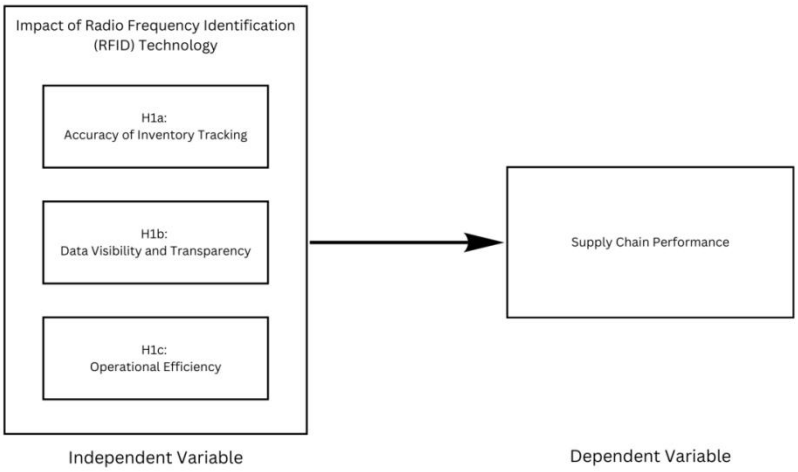

Figure 2.10 : Conceptual Framework of The Impact of Radio Frequency Identification (RFID) Technology on Supply Chain Management

2.6 Research Hypotheses

The following are the hypotheses in this study:

H1: Implementing Radio Frequency Identification (RFID) will brings a positive impact on supply chain performance.

H1a: There is a positive relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.

H1b: There is a positive relationship between data visibility and transparency provided by RFID technology and supply chain performance.

H1c: There is a positive relationship between operational efficiency achieved through RFID technology and supply chain performance.

2.7 Summary

The impact of Radio Frequency Identification (RFID) technology on supply chain performance has been covered by the researchers in this chapter. There are independent and dependent variables in the suggested framework. The the supply chain performance is the dependent variable. The accuracy of inventory tracking, data visibility and transparency, and operational efficiency are the independent factors. Finally, the research methods will be covered in the upcoming chapter.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The researcher will cover about the methodologies used to collect the data and information for this study in this chapter. In the beginning, the explanatory research design is developed to explain the relationship between the variables. In terms of methodological choice, the quantitative approach is chosen. Primary and secondary data were the sources of the information. The research site, research approach, time horizon, validity and reliability, and data analysis method will be covered in the upcoming sections. By following these research technique procedures, the results of this study can be better evaluated and understood.

3.2 Research Design

The general approach describing how the researcher will respond to the study questions is known as the research design. It outlines the data sources and the procedures for gathering and analyzing the data, and it contains specific goals that are formed from these inquiries. Research design also takes into account ethical concerns and limitations including time, budget, location, and data availability. (Saunders, et al.l, 2016)

There are several types of research initiatives, such as exploratory, descriptive, explanatory, evaluative, or a combination of these. Clarifying a knowledge of a problem, issue, or phenomenon is the goal of an exploratory investigation. The goal of descriptive research is to accurately describe situations, people, or events. The goal of explanatory study is to clarify how variables relate to one another. Evaluative research determines the effectiveness of an organizational or business strategy, policy, program, initiative, or process.

For this study, the researcher chose an explanatory approach, as it is well-suited to the nature of the research. Explanatory research focuses on the relationships between variables. The researcher were going to determine the relationship between the accuracy of inventory tracking, data visibility and transparency, and operational efficiency with the supply chain performance.

3.3 Methodological Choices

There are quantitative, qualitative and mixed methods of methodological choice for research design. Quantitative method is usually using questionnaire for collecting data technique, and graphs or statistics for analyzing data procedure that generates or uses numerical data. While qualitative method is uses interview in data collection technique, and categorizing data in data analysis procedure that generates or uses non-numerical data.

In this research, the researcher uses quantitative method to examine the relationship between the variables. This method uses range of statistical and graphical techniques to measure and analyse the independent variable and dependent variable. Quantitative research aims to create knowledge and understand the social world. Like communication researchers, social scientists use it to observe events or behaviors affecting people. They focus on studying groups of people, called sample populations. Through scientific methods, quantitative research relies on observed or measured data to explore questions about these groups. (Ahmad, S. et al, 2019). The researcher is going to reconfirm whether the radical relationship is existed or not as the relationship is already established.

3.4 Primary and Secondary Data Sources

The primary and secondary data were applied in this research. Primary data is information collected directly by the researcher for the specific study. (Sekaran and Bougie, 2010) Usually, primary data is often gathered through observation, interviews, questionnaires, and databases. (Mazhar, Anjun, Anwar, and Khan, 2021) The researcher offer questionnaires to the respondents. The respondents required to

answer the questions based on their attributes (demographic), personality and lifestyle, awareness and knowledge, intentions, motivations, and behaviors.

Secondary data refer to information collected from pre-existing sources. (Sekaran and Bougie, 2010) It's usually more cheaper and save time. Secondary data sources include books, magazines, journals, as well as unpublished autobiographies and biographies (Mazhar, Anjun, Anwar, and Khan, 2021) In addition, the researcher gained the data from books, such as "RFID in the Supply Chain" by Pedro M. Reyes, "Research Methods for Business: A Skill Building Approach" by Uma Sekaran and Roger Bougie, "Research Methods for Business Students" by Mark N.K. Saunders, Philip Lewis, and Adrian Thornhill, and "Management Research Methods" by Phyllis Tharenou, Ross Donohue, and Brian Cooper. Also, the researcher gained the data from internet.

3.5 Research Location

This study will be carried out in all of Malaysia's states by the researcher. This is because the impact of Radio Frequency Identification (RFID) on supply chain performance is going to be everywhere. However, in this research, researcher is only study this impact on Malaysia. The targeted respondents are the companies those involved in supply chain management from Malaysia. The chosen respondents will be drawn at random from these sectors.

3.6 Research Strategy

A research strategy, according to Saunders, is a plan outlining "how the researcher will answer the question". Some common strategies include experiments, surveys, case studies, and archival research, among others. The survey strategy was chosen for this study. Using the questionnaire in the survey strategy, it was easy to compare data from a sizeable population. The researcher also selects archival or documentary research strategy as these sources can be obtained online.

3.6.1 Questionnaire Design

Questionnaires are forms that people fill out on their own, often referred to as self-administered questionnaires. Questionnaires are the first choice of method for collecting data in management research. This is because they are east to use, cost-effective, and great for measuring constructs that we can't see directly, such as personalities, values and preferences, attitudes, and intentions. (Tharenou, Donohue, and Cooper, 2007) The researcher used an online Google Form to administer the questionnaire, regardless of whether respondents answered it on a computer or a mobile device.

There are five sections on the questionnaire. The demographic information of the respondent, including age, gender, education, occupation, awareness of radio frequency identification (RFID), and experience of using RFID, is included in the first section. This portion are containing six questions. The accuracy of inventory tracking, the independent variable, is the main topic of the second part. There are five questions in this section. The independent variable, data visibility and transparency are the main topics of the third section. There are five questions in this section. Operational efficiency, the independent variable, is the subject of the fourth section. There are five questions in this section. The questionnaire's final section asks about supply chain performance, the dependent variable. There are five questions in this section.

The questionnaire uses a Likert scale and multiple-choice questions. A four-point rating system, with 1 denoting "strongly disagree," 2 "disagree," 3 "agree," and 4 "strongly agree," served as the basis for the Likert scale in the second, third, fourth, and fifth sections.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Table 3.1: Four Points Rating Scale by Rensis Likert in 1932

3.6.2 Questionnaire Development and Sources

The following are the items in questionnaire survey and their sources:

No.	Item	Sources
Accuracy of Inventory Tracking		
1	RFID has reduced discrepancies between recorded and actual inventory counts, such as overstocking or stockouts.	Visich et al. (2009) Basinger, K.L. (2006)
2	RFID technology allows us to track the real-time location of inventory with high precision.	Visich et al. (2009) Zhu, XW. et al. (2011)
3	RFID provides accurate and timely updates on inventory levels, which helps in effective inventory management.	Visich et al. (2009) Madamidola, OA. et al. (2024) Ozguven, EE. et al. (2015)
4	Organization has fewer faced inventory data errors after implementing RFID.	Visich et al. (2009) Attaran, M. (2012)
5	RFID technology has improved the accuracy of inventory levels within supply chain.	Visich et al. (2009) Sarac, A. et al. (2010) Fan, T. et al. (2014)
Data Visibility and Transparency		
1	RFID technology provides the transparency of product information such as batch numbers.	Visich et al. (2009) Maity, M. et al. (2021)
2	RFID improves data sharing and transparency among different supply chain stakeholders.	Visich et al. (2009) Hader, M. et al. (2022)
3	Organization enable shorter the lead times to customer since implementing RFID.	Visich et al. (2009) Attaran, M. (2012)
4	RFID improves organization's ability to make timely and informed decisions.	Visich et al. (2009) Unhelkar, B. et al. (2022)
5	RFID data enables to improve organization's forecasting and demand planning.	Visich et al. (2009) Lee, CKM. et al. (2010)
Operational Efficiency		
1	Implementing RFID enables to reduce human error.	Visich et al. (2009) Attaran, M. (2012)

2	The operational cost decrease because the need of manual labors reduce in the supply chain process since implementing RFID.	Visich et al. (2009) Chen, JC. et al. (2013) Attaran, M. (2012)
3	RFID reduces the time required to conduct cycle counts and comprehensive inventory checks.	Visich et al. (2009) Chen, JC. et al. (2013)
4	The automation provided by RFID allows companies to reallocate labor to more critical tasks.	Visich et al. (2009) Attaran, M. (2012)
5	Implementation of RFID increases the productivity in the supply chain.	Visich et al. (2009) Chen, JC. et al. (2013) Shin, S. et al. (2015)
Supply Chain Performance		
1	Company on-time delivery rates has been improved after implementing RFID.	Chopra and Meindl (2016)
2	The supply chain of company is more adaptable to demand fluctuations since implementing RFID.	Chopra and Meindl (2016)
3	The company is more competitive in the industry due to the overall supply chain's efficiency has been improved.	Chopra and Meindl (2016)
4	The implementation of RFID improves customer satisfaction.	Chopra and Meindl (2016)
5	The overall supply chain quality and performance of organization has been improved since implementing RFID.	Chopra and Meindl (2016)

Table 3.2: Questionnaire Development and Sources

3.6.3 Sampling Design (Sampling)

In this study, probability sampling is chosen. It is frequently linked to research methodologies that involve surveys and experiments. According to Sekaran and Bougie (2010), probability sampling can be categorized into unrestricted and restricted. In this research, researcher selects restricted probability as only the related population having the knowledge in this industry. Restricted probability also known as complex probability sampling. Complex probability sampling procedures offer improved efficiency compared to simple random sampling designs by allowing more information to be gathered for a given sample size.

Based on the Department of Statistics Malaysia (DOSM), the current population of employment in 2024 are estimated at 16.69 million. According to Krejcie and Morgan (1970), he calculated that, out of a sample size of 1,000,000 population, there should be 384 respondents. More than 384 respondents who were employed by supply chain, logistics, and warehouse organizations were selected by the researcher.

Table for Determining Sample Size of a Known Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

Table 3.3: Determining sample size of a known population

Source: Krejcie and Morgan (1970)

3.6.4 Pilot Test

Pilot testing involves evaluating the reliability of a questionnaire by testing it on members of the target population before its final distribution. According to Saunders, Lewis, and Thornhill (2016), this small-scale trial allows researchers to refine the questionnaire by identifying and addressing potential issues respondents might encounter and ensuring accurate data recording. 30 respondents will participate in a pilot test of this study. Their feedback and comments will be used to improve the final survey questionnaire. The detailed analysis of the pilot test is shows in part 4.2 (Chapter 4).

3.7 Time Horizons

Cross-sectional studies and longitudinal studies are the two categories of temporal frames. Data collected frequently over an extended period of time is known as longitudinal research. Cross-sectional studies, on the other hand, may take days, weeks, or months to conduct and collect data. Because of time constraints, cross-sectional studies were chosen for this study. Within 10 months, the researcher must finish Chapters 1 through 5. The time frame for finishing the data collecting and analysis is just two months.

3.8 Reliability and Validity

The consistency with which a measuring tool captures the idea it is designed to capture is what determines its reliability. The degree to which an instrument accurately conveys the particular concept it is intended to convey is a gauge of its validity. Simply put, validity is the question of whether we are measuring the right concept, whereas reliability is the stability and consistency of measurement. Internal validity in a survey means that the questions are reliably linked to the specific factor or outcome being studied. However, external validity refers to the extent to which the research's conclusions can be extended to other similar situations or groups. (Sekaran and Bougie, 2010)

Cronbach's Alpha is used by the researcher to evaluate how reliable the variables are. The alpha coefficient ranges from 0 to 1. Schober, Mascha, and Vetter state that a Cronbach's Alpha value of more than 0.7 represents acceptance, more than 0.9 represents good, and equal to or more than 0.9 represents very good. Meanwhile, a Cronbach's Alpha rating below 0.6 is seen as unsatisfactory. When the value turns into a negative number, it indicates that there is a problem with the data.

Cronbach's Alpha Coefficient Range	Strength of Association
$\alpha \geq 0.9$	Very Good Reliability
$0.9 > \alpha \geq 0.8$	Good Reliability
$0.8 > \alpha \geq 0.7$	Acceptable Reliability
$0.7 > \alpha \geq 0.6$	Questionable Reliability
$0.6 > \alpha$	Poor Reliability

Table 3.4: Cronbach's Alpha Coefficient Range and Strength of Association (Source: Schober, Mascha, and Vetter (2021))

3.9 Data Analisis Method

The Statistical Package of Social Sciences (SPSS) is used to analyze the information gathered from the respondents once it has been received through a questionnaire. In this study, descriptive analysis and Pearson's correlation analysis are employed.

3.9.1 Descriptive Analysis

Saunders, Lewis, and Thornhill (2016) explain that descriptive analysis is about using numbers to describe and compare variables, focusing on their average values and how much they spread out. Typically, this involves calculating measures like the mean, median, mode, and standard deviation. In this research, descriptive analysis is used to examines the age, gender, experience of using RFID, occupation, and educational level among the respondents. The raw data was transformed into a more understandable form to better characterize the demographics of the respondents.

3.9.2 Pearson's Correlation Analysis

Pearson correlation analysis is a technique used to measure the linear relationship between three variables, referred to as dependent and independent variables. This analysis typically starts with the creation of a scatter plot, which visually represents the relationship between paired data points. The correlation coefficient, which ranges from -1 to 1, quantifies this relationship: -1 represents a perfectly negative correlation, while 1 represents a perfectly positive correlation. When the correlation coefficient is zero, it shows that the variables do not have a linear relationship. (Saunders, Lewis, and Thornhill, 2016).

Correlation Coefficient Value (r)	Direction and Strength of Correlation
-1	Perfectly negative
-0.8	Strongly negative
-0.5	Moderately negative
-0.2	Weakly negative
0	No association
0.2	Weakly positive
0.5	Moderately positive
0.8	Strongly positive
1	Perfectly positive

Figure 3.1: Value of Correlation Coefficient

(Source: Saunders, Lewis, and Thornhill (2016))

3.9.3 Multiple Regression Analysis

A statistical technique also known as multiple regression analysis allows researchers to evaluate the degree of relationship between three independent variables and one dependent variable. (Saunders et al., 2016). In this research, the focus is on understanding how the independent variables (accuracy of inventory tracking, data visibility and transparency, and operational efficiency) affect the dependent variable (supply chain performance). Multiple regression analysis helps identify which independent variables have the most impact on the dependent variable. The equation for multiple regression analysis is as follows:

Equation of MRA: $Y = a + bX1 + cX2 + dX3$

Where:

Y = Dependent Variable (Supply Chain Performance)

a = Constant value or Intercept

b = Influence of X1 (Accuracy of Inventory Tracking)

c = Influence of X2 (Data Visibility and Transparency)

d = Influence of X3 (Operational Efficiency)

X1, X2 = Independent variables

3.10 Summary

In conclusion, this explanatory study is necessary in order to provide survey questions to the participants. The survey must be completed by 384 respondents from various Malaysian states using a Google form. This study uses cross-sectional time studies, indicating that data is only collected once. Prior to distributing the questionnaire to the respondents, a pilot test will be carried out. Additionally, the researcher cites secondary data sources from books, publications, articles, and online journals. Cronbach's Alpha is a metric used to assess the variables' dependability. The researcher had to use multiple regression analysis, descriptive analysis, and Pearson's correlation analysis to analyze the data after it was collected. Chapter 4 will cover the data analysis and discussion that follows.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

In this chapter, the researcher will discuss and present the result of data analysis collected from the respondents. IBM Statistical for the Social Sciences (SPSS) version 30.0 is used to analyze the data collected. This chapter is using descriptive analysis, Pearson's Correlation Analysis, and Multiple Regression Analysis to determine the relationship between dependent variable and independent variables. The questionnaire is assigned to 100 respondents through an online survey which is Google Forms. The questionnaire consists of five sections, which Section A is the respondents demographic information, Section B is focusing on the independent variable, accuracy of inventory tracking, Section C is focusing on the independent variable, data visibility and transparency, Section D is focusing on the independent variable, operational efficiency, and Section E is focusing in dependent variable, supply chain performance.

4.2 Pilot Test

A pilot test is conducted before the data collection process to reach target respondents. The pilot test is a small-scale trial to make the researcher prevent the problems which conducting to data recording issue (Saunders et al., 2016). 30 respondents are chosen to conduct the pilot test. The researcher is taking one week to complete the pilot test. The objective of the pilot test is to test the reliability of the data and validity of the questionnaire (Bartlett, 2013).

Variable	Cronbach's Alpha	N of Items
Accuracy of Inventory Tracking	0.887	5
Data Visibility and Transparency	0.825	5
Operational Efficiency	0.905	5
Supply Chain Performance	0.867	5

Table 4.1: Reliability Statistic of Variables

(Source: SPSS Output)

Cronbach's Alpha	N of Items
.963	20

Table 4.2: Reliability Statistic of Overall Pilot Test

(Source: SPSS Output)

According to Table 4.1, all variables can be considered to have rather high internal consistency because Cronbach's Alpha is more than 0.7. The Cronbach's Alpha for the Accuracy of Inventory Tracking is 0.887 measured by 5 items. Next, the Cronbach's Alpha for the Data Visibility and Transparency is 0.825 measured by 5 items. And the Cronbach's Alpha for the Operational Efficiency is 0.905 measured by 5 items. Lastly, the Cronbach's Alpha for the Supply Chain Performance is 0.867 measured by 5 items. To conclude, all having good correlation within items of each variable.

According to table 4.2, the Cronbach's Alpha coefficients of overall variables are 0.963, which was excellent with 20 of the number of items. The items' relative internal consistency can therefore be determined.

4.3 Reliability Test

Cronbach's Alpha is used to calculate the internal consistency or average correlation of items for each of independent variables which are cause important, congruence between company's products and cause, cause proximity and length or frequency of support. Although Nunnally (1978) said that a reliability coefficient of 0.7 is acceptable, the literature usually employs lower thresholds.

Variable	Cronbach's Alpha	N of Items
Accuracy of Inventory Tracking	0.856	5
Data Visibility and Transparency	0.829	5
Operational Efficiency	0.904	5
Supply Chain Performance	0.877	5

Table 4.3: Reliability Statistic of All Variables

(Source: SPSS Output)

Cronbach's Alpha	N of Items
.960	20

Table 4.4: Reliability Statistic of Overall Variables

(Source: SPSS Output)

Based on Table 4.3, since the Cronbach's Alpha is greater than 0.7, the items' relative internal consistency can be inferred from all variables. The Cronbach's Alpha for the Accuracy of Inventory Tracking is 0.856 measured by 5 items. Then, the Cronbach's Alpha for the Data Visibility and Transparency is 0.829 calculated by 5 items. Next, the Cronbach's Alpha for the Operational Efficiency is 0.904 determined by 5 items. Lastly, the Cronbach's Alpha for the Supply Chain Performance is 0.877 measured by 5 items.

According to Table 4.4, the Cronbach's Alpha for the overall variables is 0.960 measured by 20 items and which is greater than 0.7. Hence, the items' relative internal consistency can be inferred.

4.4 Validity Test

Validity test has been conducted in this research. There are 26 items are included in the questionnaire. Hence, the internal validity can be observed in this pilot test which determines the relationship between the dependent variable and independent variables.

4.5 Descriptive Data Analysis

A descriptive analysis is used to analyze the demographic background of respondents which includes age, gender, education level, occupation level, awareness of Radio Frequency Identification (RFID), and experience of using Radio Frequency Identification (RFID). It provides a short overview of the sample and the measured output. The SPSS output presents the frequency, percent, valid percent, and cumulative percent.

4.5.1 Age Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 - 23	20	20.0	20.0	20.0
	24 - 29	33	33.0	33.0	53.0
	30 - 35	31	31.0	31.0	84.0
	Above 36	16	16.0	16.0	100.0
	Total	100	100.0	100.0	

Table 4.5: Age Group of Respondents

(Source: SPSS Output)

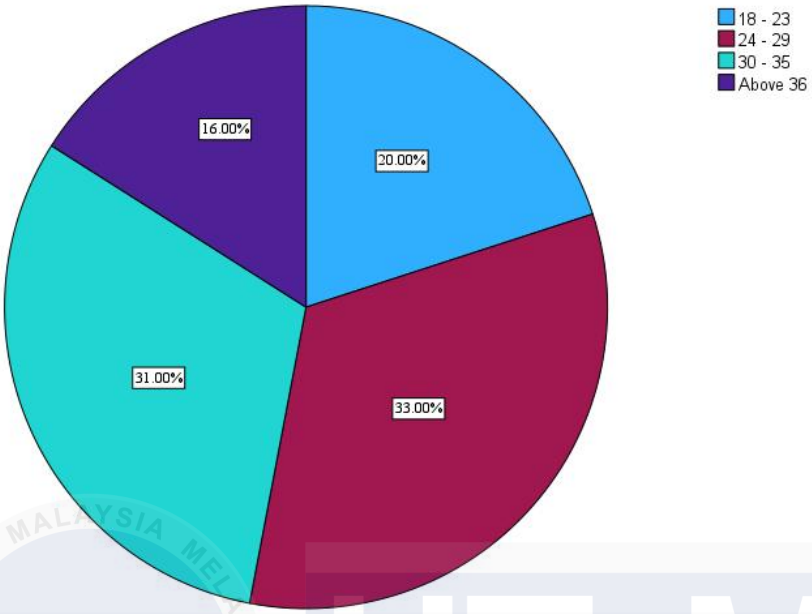

Figure 4.1: Age Group of Respondents
(Source: SPSS Output)

Table 4.5 and Figure 4.1 show the age range of respondents are 18 years old to 36 years old above. It is apparent that majority of respondents were aged 24 to 29 years old (33%). The next followed by 30 to 35 years old which around 31 respondents (31%). They were 20 respondents of 18 to 23 years old (20%), and only 16 respondents were aged above 36, which is 16%.

4.5.2 Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	42	42.0	42.0	42.0
	Male	58	58.0	58.0	100.0
	Total	100	100.0	100.0	

Table 4.6: Gender of Respondents

(Source: SPSS Output)

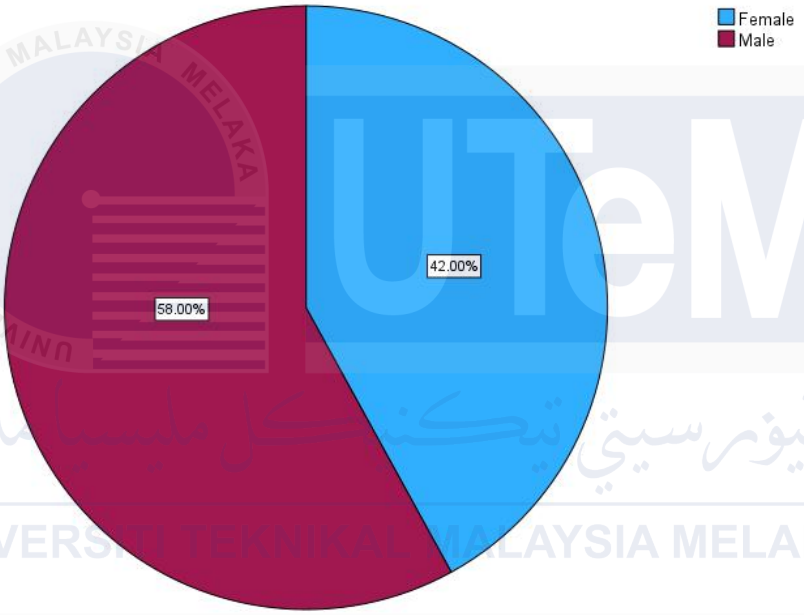

Figure 4.2: Gender of Respondents

(Source: SPSS Output)

Table 4.6 and Figure 4.2 show the gender of 100 respondents involved in this research. There are 42 female respondents which are 42%, and 58 male respondents which are 58%. The majority of respondents are male.

4.5.3 Education Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bachelor Degree	45	45.0	45.0	45.0
	Diploma	14	14.0	14.0	59.0
	Doctoral Degree	4	4.0	4.0	63.0
	High School	22	22.0	22.0	85.0
	Master Degree	15	15.0	15.0	100.0
	Total	100	100.0	100.0	

Table 4.7: Education Level of Respondents

(Source: SPSS Output)

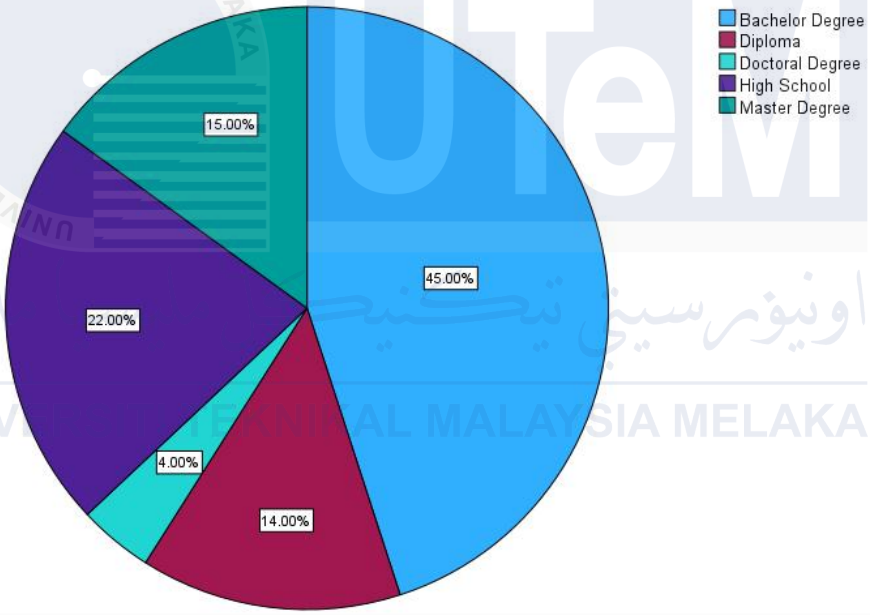

Figure 4.3: Education Level of Respondents

(Source: SPSS Output)

Table 4.7 and Figure 4.3 show the educational level of 100 respondents. The educational level starts from high school level to Doctoral Degree. The majority of respondents have bachelor degree level which is 45 respondents (45%). The next followed by high school level which is 22 respondents (22%), 15 respondents from master degree level (15%), and only 4 respondents are doctoral degree level (4%).

4.5.4 Occupation Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	analyst	1	1.0	1.0	1.0
	Analytics Manager	1	1.0	1.0	2.0
	Assistant Manager	5	5.0	5.0	7.0
	Data Analyst	2	2.0	2.0	9.0
	Executive	28	28.0	28.0	37.0
	Logistics Specialist	3	3.0	3.0	40.0
	Manager	8	8.0	8.0	48.0
	Officer	29	29.0	29.0	77.0
	Operator	20	20.0	20.0	97.0
	Sales Development Representative (SDR)	1	1.0	1.0	98.0
	Supply Chain Analyst	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Table 4.8: Occupation Level of Respondents

(Source: SPSS Output)

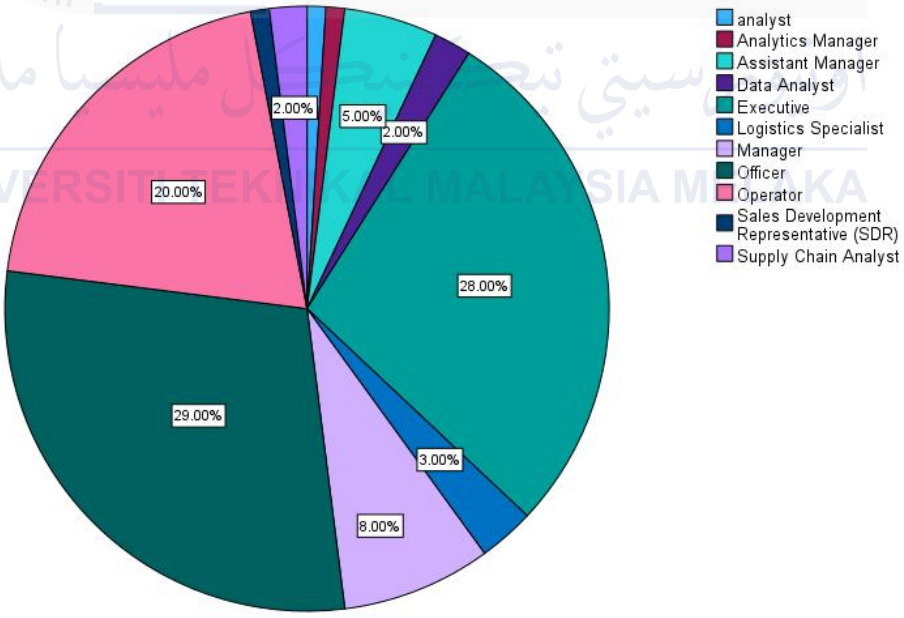

Figure 4.4: Occupation Level of Respondents

(Source: SPSS Output)

Table 4.8 and Figure 4.4 show the occupation level of 100 respondents. The occupation level comprised from Analyst, Analytics Manager, Assistant Manager, Data Analyst, Executive, Logistics Specialist, Manager, Officer, Operator, Sales Development Presentative (SDR), and Supply Chain Analyst. The majority of respondents consists of Officer which is 29 respondents (29%). The next followed by Executive which is 28 respondents (28%), 20 respondents are Operator (20%), 8 respondents are Manager (8%), 5 respondents are Assistant Manager (5%), and 3 respondents are Logistics Specialist (3%). Data Analyst and Supply Chain Analyst have 3 respondents (3%) respectively, and Analyst, Analytics Manager, and Sales Development Representative (SDR) has 1 respondent (1%) respectively.

4.5.5 Awareness of Radio Frequency Identification (RFID)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3	3.0	3.0	3.0
	Yes	97	97.0	97.0	100.0
	Total	100	100.0	100.0	

Table 4.9: Respondents' Awareness of Radio Frequency Identification (RFID)
(Source: SPSS Output)

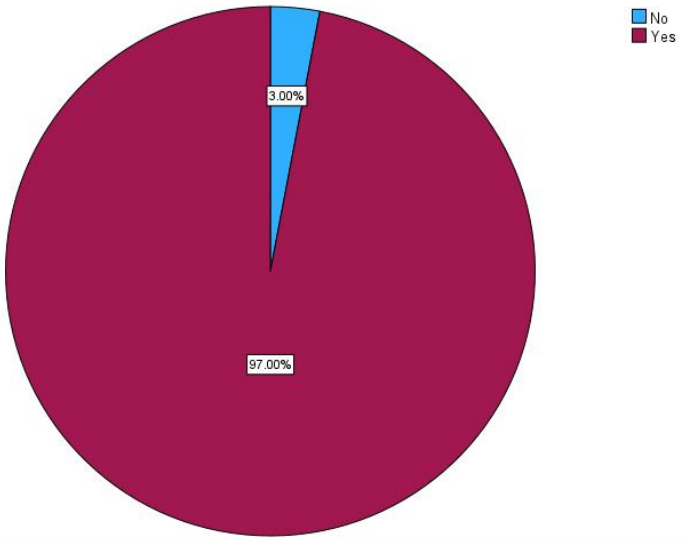

Figure 4.5: Respondents' Awareness of Radio Frequency Identification (RFID)
(Source: SPSS Output)

Table 4.9 and Figure 4.5 show the awareness of Radio Frequency Identification (RFID) in supply chain industries. There are 100 respondents involved in this research. The majority of respondents know the RFID which is 97 respondents (97%), and only 3 respondents (3%) do not know RFID.

4.5.6 Experience of Using Radio Frequency Identification (RFID)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	24	24.0	24.0	24.0
	Yes	76	76.0	76.0	100.0
	Total	100	100.0	100.0	

Table 4.10: Respondents' Experience of Using Radio Frequency Identification (RFID)
(Source: SPSS Output)

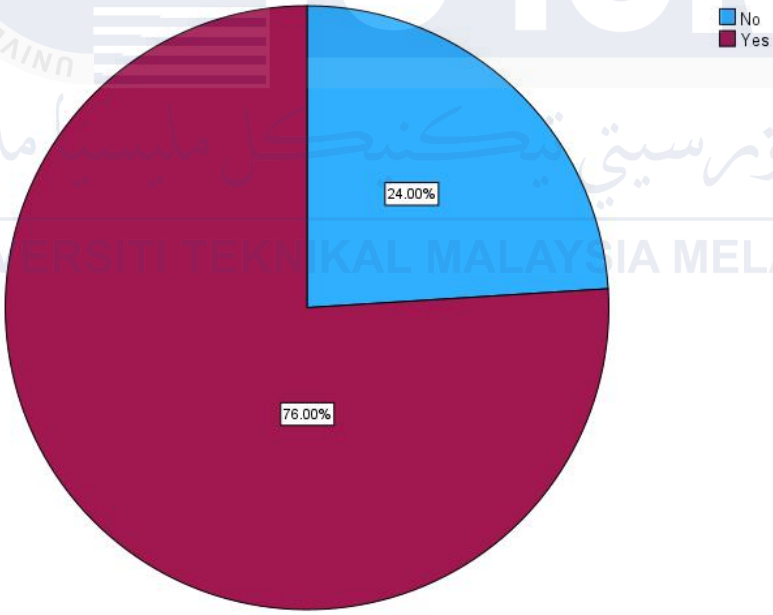

Figure 4.6: Respondents' Experience of Using Radio Frequency Identification (RFID)
(Source: SPSS Output)

Table 4.10 and Figure 4.6 show the experience of using Radio Frequency Identification (RFID) in supply chain industries. There are 76 respondents (76%) are having experience of using RFID and 24 respondents do not have experience of using RFID. The majority of respondents are having experience of using RFID.

4.6 Descriptive Statistics on Independent Variables

The descriptive analysis is used to analyse the independent variables which were Accuracy of Inventory Tracking, Data Visibility and Transparency, and Operational Efficiency in this research. The central tendency measurement was conducted. The mean, medium, and mode of variables is identified by descriptive analysis.

4.6.1 Independent Variable: Accuracy of Inventory Tracking

		IV1.1	IV1.2	IV1.3	IV1.4	IV1.5
N	Valid	100	100	100	100	100
	Missing	0	0	0	0	0
Mean		3.6100	3.6800	3.6900	3.6200	3.7000
Median		4.0000	4.0000	4.0000	4.0000	4.0000
Mode		4.00	4.00	4.00	4.00	4.00
Std. Deviation		.58422	.56640	.52599	.63214	.55958

Table 4.11: Respondents' Perception of the Accuracy of Inventory Tracking

(Source: SPSS Output)

** Mode: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Table 4.11, shows the respondents' perception of the Accuracy of Inventory Tracking. From Table 4.11, the mode showed that the respondents strongly agree with all questions 1 to 5.

4.6.2 Independent Variable: Data Visibility and Transparency

		IV2.1	IV2.2	IV2.3	IV2.4	IV2.5
N	Valid	100	100	100	100	100
	Missing	0	0	0	0	0
Mean		3.7000	3.6700	3.6700	3.6500	3.6400
Median		4.0000	4.0000	4.0000	4.0000	4.0000
Mode		4.00	4.00	4.00	4.00	4.00
Std. Deviation		.54123	.60394	.55149	.59246	.57770

Table 4.12: Respondents' Perception of the Data Visibility and Transparency

(Source: SPSS Output)

** Mode: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Table 4.12, shows the respondents' perception of the Data Visibility and Transparency. From Table 4.12, the respondents strongly agree in data visibility and transparency section. They strongly agree with all questions 1 to 5.

4.6.3 Independent Variable: Operational Efficiency

		IV3.1	IV3.2	IV3.3	IV3.4	IV3.5
N	Valid	100	100	100	100	100
	Missing	0	0	0	0	0
Mean		3.6400	3.6300	3.6700	3.6300	3.7100
Median		4.0000	4.0000	4.0000	4.0000	4.0000
Mode		4.00	4.00	4.00	4.00	4.00
Std. Deviation		.61167	.63014	.58698	.61390	.55587

Table 4.13: Respondents' Perception of the Operational Efficiency

(Source: SPSS Output)

** Mode: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Table 4.13, shows the respondents' perception of the Operational Efficiency. From Table 4.13, the mode showed that the respondents strongly agree with all questions 1 to 5.

4.7 Descriptive Statistics on Dependent Variable

4.7.1 Dependent Variable: Supply Chain Performance

		DV1	DV2	DV3	DV4	DV5
N	Valid	100	100	100	100	100
	Missing	0	0	0	0	0
Mean		3.6600	3.6900	3.7000	3.6700	3.7000
Median		4.0000	4.0000	4.0000	4.0000	4.0000
Mode		4.00	4.00	4.00	4.00	4.00
Std. Deviation		.60670	.59789	.59459	.60394	.57735

Table 4.14: Respondents' Perception of the Supply Chain Performance

(Source: SPSS Output)

** Mode: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Based on Table 4.14 above indicated the perception of the supply chain performance among 100 respondents. The respondents strongly agreed with all of the questions in this section with a mode strongly agree.

4.8 Pearson Correlation Coefficient Analysis

In Chapter 3, the researcher stated that Pearson's Correlation is used for data analysis. Pearson's Correlation Coefficient (r) is a statistical tool for assessing the degree of the linear relationship between a dependent variable and independent variables. It is employed to evaluate how strongly the variables in the data are related to one another (Saunders et al., 2016). Figure 4.7 showed the guidelines of Pearson's Correlation Coefficients.

Correlation Coefficient Value (r)	Direction and Strength of Correlation
-1	Perfectly negative
-0.8	Strongly negative
-0.5	Moderately negative
-0.2	Weakly negative
0	No association
0.2	Weakly positive
0.5	Moderately positive
0.8	Strongly positive
1	Perfectly positive

Figure 4.7: Value of Correlation Coefficient

(Source: Saunders, Lewis, and Thornhill (2016))

Correlations

		Accuracy_of_Inventory_Tracking	Data_Visibility_and_Transparency	Operational_Efficiency	Supply_Chain_Performance
Accuracy_of_Inventory_Tracking	Pearson Correlation	1	.870**	.757**	.803**
	Sig. (2-tailed)		<.001	<.001	<.001
	N	100	100	100	100
Data_Visibility_and_Transparency	Pearson Correlation	.870**	1	.782**	.833**
	Sig. (2-tailed)	<.001		<.001	<.001
	N	100	100	100	100
Operational_Efficiency	Pearson Correlation	.757**	.782**	1	.865**
	Sig. (2-tailed)	<.001	<.001		<.001
	N	100	100	100	100
Supply_Chain_Performance	Pearson Correlation	.803**	.833**	.865**	1
	Sig. (2-tailed)	<.001	<.001	<.001	
	N	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.15: Pearson Correlation Coefficient Analysis of All Variables

(Source: SPSS Output)

From Table 4.15, the independent variables in this research are accuracy of inventory tracking, data visibility and transparency, operational efficiency while the dependent variable is supply chain performance. The correlation value for the accuracy of inventory tracking was 0.803 with a significant level 0.001 ($p>0.01$). This showed that there was a strong relationship between accuracy of inventory tracking and supply chain performance and the correlation between these two variables is not statistically significant. Next, the correlation value for the data visibility and transparency was 0.833 with a significant level 0.001 ($p<0.01$). It was also a strong relationship between data visibility and transparency and supply chain performance. Third, the correlation value for the operational efficiency was 0.865 with significant level 0.001 ($p<0.01$). There was a strong relationship between the operational efficiency and supply chain performance.

4.9 Multiple Regression Analysis

Multiple regression analysis is used to measure the significant relationship between independent variables (accuracy of inventory tracking, data visibility and transparency, operational efficiency) and dependent variable (supply chain performance). It is a statistical tool to measure the relationship of strength of a cause and effect between independent variables and dependent variable.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.904[a]	.816	.811	.21246

a. Predictors: (Constant), Operational_Efficiency, Accuracy_of_Inventory_Tracking, Data_Visibility_and_Transparency

Table 4.16: Model Summary of Multiple Regression Analysis

(Source: SPSS Output)

Table 4.16 showed the model summary that illustrates the relationship between the independent variables and dependent variable. The correlation coefficient value (R) is 0.904. This showed that there was a very strong correlation between the variables. Next, the coefficient of determinant, R square showed value of 0.816 which means that the supply chain performance were affected by independent variables with 81.6%. The other 18.4% was the other factors which are not involved in this research. The adjusted R square showed 81.1%.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.079	.182		.435	.665
	Accuracy_of_Inventory_Tracking	.170	.098	.160	1.745	.084
	Data_Visibility_and_Transparency	.318	.106	.288	3.002	.003
	Operational_Efficiency	.496	.069	.518	7.156	<.001

a. Dependent Variable: Supply_Chain_Performance

Table 4.17: Coefficient of Multiple Regression Analysis

(Source: SPSS Output)

Table 4.17 showed the beta value of independent variables which was accuracy of inventory tracking (AIT) 0.170, 0.318 for data visibility and transparency (DVT) and 0.496 for operational efficiency (OE). Based on ascending order, the least significant of beta value was accuracy of inventory tracking, then came with data visibility and operational efficiency have the most significant beta value. The linear equation of Multiple Regression Analysis (MRA) was Y = a + bX1 + cX2, thus Supply Chain Performance = 0.079 + 0.496OE + 0.318DVT + 0.170AIT.

4.10 Hypothesis Testing

H1: Implementing Radio Frequency Identification (RFID) will brings a positive impact on supply chain performance.
H1a: There is a positive relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.
H1b: There is a positive relationship between data visibility and transparency provided by RFID technology and supply chain performance.
H1c: There is a positive relationship between operational efficiency achieved through RFID technology and supply chain performance.

Accept H1a

Table 4.17 showed the result of coefficient of multiple regression analysis. The significant value of the accuracy of inventory tracking towards the supply chain performance is 0.084. Although the significant value is more than 0.05, it is not significantly in statistic, the positive coefficient indicates that accuracy of inventory tracking has a weaker but still positive impact on supply chain performance compared to other factors.

Accept H1b

Table 4.17 showed the result of coefficient of multiple regression analysis. The significant value of the data visibility and transparency towards the supply chain performance is 0.003. Therefore, there is a positive relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance as the value is less than 0.05.

Accept H1c

Table 4.17 showed the result of coefficient of multiple regression analysis. The significant value of the operational efficiency towards the supply chain performance is 0.01. Therefore, there is a positive relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance as the value is not more than 0.05.

4.11 Summary

In Chapter 4, the researcher has analyzed the data collected from the respondents. All of the data was analyzed by SPSS software version 30.0. The researcher imported the data into SPSS and used reliability analysis for pilot test, descriptive analysis, Pearson's Correlation Coefficient analysis, and Multiple Regression analysis. The data outputs showed the relationship between independent variables and dependent variable. The result showed that the accuracy of inventory tracking, data visibility and transparency, and operational efficiency have a positive relationship with the supply chain performance. In next chapter, the researcher will discuss about the results outcome, limitation and recommendation of the overall research.

CHAPTER 5

DISCUSSION, RECOMMENDATION AND CONCLUSION

5.1 Introduction

In this chapter, the researcher discussed about the conclusion of the overall result. The summary of the findings will be explained. The summary of the findings is elaborated in the first section of this chapter while the justification of the research objectives is explained in the second section. The third section is discussed about the limitation of the study and last, the fourth section is described about the recommendations for the future study.

5.2 Summary of the Findings

The researcher finished the data analysis of the demographic variables. The total number of respondents was 100 and the demographic background provided by them included age, gender, education level, occupation level, awareness of Radio Frequency Identification (RFID), and experience of using Radio Frequency Identification (RFID). From the data output, the majority of respondents were male. The major age range of respondents was 24 to 29 years old. For educational level and occupation level, most of the respondents had bachelor's degrees and are of officer level. The major of respondents had the awareness and experience in using Radio Frequency Identification (RFID). In Pearson's Correlation Coefficients analysis, the correlation analysis and the relationship between three independent variables and one dependent variable had been tested. The independent variables were the accuracy of inventory tracking, data visibility and transparency, and operational efficiency while the dependent variable was the supply chain performance. There have positive relationship between accuracy of inventory tracking, data visibility and transparency, and operational efficiency with supply chain performance.

In the Multiple Regression analysis, the relationship between independent variables and dependent variables had been determined. The correlation coefficient value (R) showed that there was a strong correlation between the variables. Based on

the Multiple Regression analysis, the researcher can conclude that there is a significant relationship between independent variables as the significant level of the regression model is below 0.05. Data visibility and transparency, and operational efficiency had significant positive impacts on supply chain performance with significant values not more than 0.05. Although the overall model showed a significant relationship between the variables, the significance value for accuracy of inventory tracking was more than 0.05. This shows that the accuracy of inventory tracking does not have a statistically significant direct impact on supply chain performance, even though it still plays a positive role. Thus, for the hypothesis testing, the accuracy of inventory tracking, data visibility and transparency, and operational efficiency have positive relationship with the supply chain performance.

5.3 Discussion of Findings

The data analysis results showed there is a positively impact between the accuracy of inventory tracking, data visibility and transparency, and operational efficiency with the supply chain performance.

RO1: To explore the relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.

Fan, M. et al. (2023) stated that one of the causes that inventory inaccuracy in Radio Frequency Identification (RFID) is missing RFID tags. This is a big challenge for the companies that implement RFID technology. Missing RFID tags will make companies harder to keep track of stock accurately. This issue can lead to situations where items are either overstocked or out of stock. It will disrupt the supply chain and cause financial losses for businesses.

Jacobsen, R. et al. (2009) mentioned that another cause that inventory inaccuracy in RFID on supply chain is communication errors. The communication errors such as the obstacles in the radio path. It will result in incomplete or inaccurate inventory data, leading to inventory inaccuracies problem. It proved the data shows on Table 4.17 that the accuracy of inventory tracking relatively weaker beta value (0.170)

and higher significance level (p = 0.084) indicate that even though it is beneficial, but it only has a weak impact on overall supply chain performance.

RO2: To identify the relationship between data visibility and transparency provided by RFID technology and supply chain performance.

Unhelkar et al. (2022) mentioned that one of the advantages of RFID technology is it can create transparency across the supply chain. Companies can monitor the movement of goods from suppliers to customers with real-time data. This transparency enables to building of trust among stakeholders. Also, RFID technology enhances visibility and enables to discovery of issues such as delays. Thus, companies can identify problems early and make a quicker resolution.

According to Zelbst, P.J. et al. (2019), implementing RFID technology on supply chain enables to enhance its transparency by information processing and analytics. It proved that data visibility and transparency provided by RFID has a positive relationship with supply chain performance. As Table 4.17 showed that the significance level of data visibility and transparency is 0.003, which is lower than 0.05. Real-time tracking of goods enables businesses to respond quickly to issues such as delays or miscommunications, improving coordination and trust among supply chain partners. These findings also support the arguments by Hader, M. et al. (2022) in section 2.4.2.

RO3: To examine the relationship between operational efficiency achieved through RFID technology and supply chain performance.

RFID technology has changed the landscape of streamlined operations. Automating tasks like inventory checks and tracking shipments reduces the need for manual work and speeds up processes. For example, what used to take weeks to manage can now be done in just a few days. This can make the entire supply chain run more smoothly. Moreover, RFID technology enables to reduction of human errors. This is because the supply chain process becomes automated, and inventory data is collected by scanning barcodes. (Unhelkar et al., 2022)

Table 4.17 showed that operational efficiency is the most significant impact of RFID technology on supply chain performance. It shows the highest beta value which is 0.496 and significant level of 0.01. It shows its ability to automate tasks, reduce human errors, and streamline processes such as inventory checks and shipment tracking. It also proved the argument of Attaran (2012), automation leads to cost reductions, faster processing times, and the reallocation of labor to more value-added tasks, making the supply chain more efficient and responsive to market demands.

5.4 Limitation of the Study

The researcher planned to complete the research at home due to the lack of research costs and geographical constraints. The questionnaire was occasionally ignored by the respondents after the researcher distributed it via social media or email. Based on the sample size and demographic data, the researcher was expected to find 384 responses. Unfortunately, only 100 respondents took part in this research. The accuracy and consistency of the data may be less accurate. The researcher's last limitation was the data accuracy. As Radio Frequency Identification (RFID) in the supply chain industry is still not fully implemented in Malaysia, people who working in this industries still unable to fully identity the strengths and weaknesses of using RFID technologies. Hence, this will reduce the accuracy of data analysis and have an impact on the data output.

5.5 Recommendation for the Future Study

This research is about the impact of Radio Frequency Identification (RFID) on supply chain performance. There are some suggestions and recommendations from the researcher to people who conduct a similar study. All of the suggestions are to improve future research.

A large sample size and population are required in this research. People today are constantly exposed to technologies. As a consequence, 384 respondents and above are necessary to improve the accuracy and precision of future data results. Furthermore, the researcher in the future research should expand the geographical

scope. The research can including multiple countries respondents because the implementation of Radio Frequency Identification (RFID) is started from aboard.

Following that, the researcher in the future study can use the qualitative method to carry out the research. The qualitative methods include interviews or experiments. This method allows the researcher to gather specific information and direct responses from the respondents. It can enhanced the data reliability and accuracy. Also, sometimes the researcher can get feedback out of the questionnaire. This results in the researcher will be able to provide additional explanation and discussion in the research.

5.6 Conclusion

In conclusion, implementation of Radio Frequency Identification (RFID) has brings positive impacts to the supply chain performance, primarily though operational efficiency, and data visibility and transparency. Although inventory tracking accuracy had a positive impact, but its impact not significant. For the hypothesis testing, H1a (There is a positive relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.), H1b (There is a positive relationship between data visibility and transparency provided by RFID technology and supply chain performance.), and H1c (There is a positive relationship between operational efficiency achieved through RFID technology and supply chain performance.) had accepted.

At the end of this chapter, the researcher explained the summary of the findings, limitations, and recommendations of the study. In the summary of the findings, the researcher concluded the result based on data analysis and discussion in Chapter 4. For the limitation, the researcher listed out the problem facing in this research such as sample size and population, time limitation, and accuracy of data collection. For the recommendation, the researcher was giving suggestions to make the future study more perfect. The recommendation included a large sample size, expand geographical scope, and using qualitative methods.

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APPENDIX 1

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Questionnaire Research Project Survey

Dear participant,

I am a final year student at Universiti Teknikal Malaysia Melaka (UTeM) studying Bachelor of Technology Management (Supply Chain Management and Logistics) with Honours.

I am conducting a study on "IMPACT OF RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY ON SUPPLY CHAIN PERFORMANCE". The purpose of this study is to identify whether RFID technology affects supply chain performance.

The objectives of this survey are to:

1. To explore the relationship between the accuracy of inventory tracking enabled by RFID technology and supply chain performance.
2. To identify the relationship between data visibility and transparency provided by RFID technology and supply chain performance.
3. To examine the relationship between operational efficiency achieved through RFID technology and supply chain performance.

The questionnaire contains five sections, section A, B, C, D, and E. The survey should take five (5) minutes to complete. The researcher would be grateful if the researcher would be grateful if the respondents are able to complete the questionnaire below. Any information obtained for this study that can be identified as yours will be kept confidential and will be used for academic purposes only. Thank you.

Any queries please address to:

TAN YEAN LENG

Faculty of Technology Management and Technopreneurship (FPTT)

E-mail:

Contact Number:

SECTION A: DEMOGRAPHIC AND GENERAL INFORMATION

The questions in this section list some related information about your profiling. Please choose the appropriate answer for your response.

1. Age Group

18 - 23 ( )
24 - 29 ( )
30 - 35 ( )
Above 36 ( )

2. Gender

Male ( )
Female ( )

3. What is your highest education level?

High School ( )
Diploma ( )
Bachelor Degree ( )
Master Degree ( )
Doctoral Degree ( )
Other: _____

4. What is your highest position in supply chain or logistics department?

Manager ( )
Executive ( )
Officer ( )
Operator ( )
Other: _____

5. **Do you know what is Radio Frequency Identification (RFID)?**

   Yes ( )

   No ( )

6. **Do you have experience of using Radio Frequency Identification (RFID)?**

   Yes ( )

   No ( )

SECTION B: ACCURACY OF INVENTORY TRACKING

This section is the statements that reflect your perception of the Accuracy of Inventory Tracking. Please select your answer in the appropriate space to demonstrate the extent of your agreement with each statement by using the Likert scale as below.

1 - strongly disagree

2 - disagree

3 - agree

4 - strongly agree

No.	Items	1	2	3	4
1	RFID has reduced discrepancies between recorded and actual inventory counts, such as overstocking or stockouts.				
2	RFID technology allows us to track the real-time location of inventory with high precision.				
3	RFID provides accurate and timely updates on inventory levels, which helps in effective inventory management.				
4	Organization has fewer faced inventory data errors after implementing RFID.				
5	RFID technology has improved the accuracy of inventory levels within supply chain.				

SECTION C: DATA VISIBILITY AND TRANSPARENCY

This section is the statements that reflect your perception of the Data Visibility and Transparency. Please select your answer in the appropriate space to demonstrate the extent of your agreement with each statement by using the Likert scale as below.

1 - strongly disagree

2 - disagree

3 - agree

4 - strongly agree

No.	Items	1	2	3	4
1	RFID technology provides the transparency of product information such as batch numbers.				
2	RFID improves data sharing and transparency among different supply chain stakeholders.				
3	Organization enable shorter the lead times to customer since implementing RFID.				
4	RFID improves organization's ability to make timely and informed decisions.				
5	RFID data enables to improve organization's forecasting and demand planning.				

SECTION D: OPERATIONAL EFFICIENCY

This section is the statements that reflect your perception of the Operational Efficiency. Please select your answer in the appropriate space to demonstrate the extent of your agreement with each statement by using the Likert scale as below.

1 - strongly disagree

2 - disagree

3 - agree

4 - strongly agree

No.	Items	1	2	3	4
1	Implementing RFID enables to reduce human error.				
2	The operational cost decrease because the need of manual labors reduce in the supply chain process since implementing RFID.				
3	RFID reduces the time required to conduct cycle counts and comprehensive inventory checks.				
4	The automation provided by RFID allows companies to reallocate labor to more critical tasks.				
5	Implementation of RFID increases the productivity in the supply chain.				

SECTION D: SUPPLY CHAIN PERFORMANCE

This section is the statements that reflect your perception of the Supply Chain Performance. Please select your answer in the appropriate space to demonstrate the extent of your agreement with each statement by using the Likert scale as below.

1 - strongly disagree

2 - disagree

3 - agree

4 - strongly agree

No.	Items	1	2	3	4
1	Company on-time delivery rates has been improved after implementing RFID.				
2	The supply chain of company is more adaptable to demand fluctuations since implementing RFID.				
3	The company is more competitive in the industry due to the overall supply chain's efficiency has been improved.				
4	The implementation of RFID improves customer satisfaction.				
5	The overall supply chain quality and performance of organization has been improved since implementing RFID.				

APPENDIX 2

Gantt Chart of Final Year Project (FYP) I

WEEK / ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FYP Talk																
Search for FYP Topic																
Topic Discussion																
Topic Confirmation																
RO & RQ Construction																
Development of Chapter 1																
Submission of Chapter 1																
Development of Chapter 2																
Submission of Chapter 2																
Development of Chapter 3																
Submission of Chapter 3																
First Draft of FYP I																
Submission of FYP I																
Presentation I																
Revised of FYP I																

APPENDIX 3

Gantt Chart of Final Year Project (FYP) II

WEEK / ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Create Questionnaire														
Distribute Questionnaire														
Collect Data														
Data Analysis														
Submission Chapter 4														
Submission Chapter 5														
Proposal Correction														
Submission of FYP II														
Presentation II														
Submission of FYP II (final version)														