THE UTILIZATION OF RADIO FREQUENCY IDENTIFICATION (RFID) ON OPERATIONAL PERFORMANCE THROUGH SUPPLY CHAIN MANAGEMENT AND LOGISTICS PERFORMANCE OF AUTOMOTIVE INDUSTRY

SIRICHAI KINGSIDA

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF
PHILOSOPHY PROGRAM IN BUSINESS ADMINISTRATION
FACULTY OF BUSINESS ADMINISREATION
RAJAMANGALA UNIVERSITY OF TECHNOLOGY THANYABURI
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Dissertation Title	The Utilization of Radio Frequency Identification (RFID) on Operational Performance through Supply Chain Management and Logistics Performance of Automotive Industry
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ABSTRACT

Radio Frequency Identification (RFID) is a technology currently playing an important role in the industrial sector and there is some speculation that it may replace barcode technology. RFID can be used to identify products, trace raw materials, work-in-process, finished goods, supply chain management and logistics performance. This enhances work efficiency by reducing working steps and increasing accuracy. The technology has been widely used in the automotive industry to increase work potential and efficiency. Therefore, this research is intended to investigate the application of RFID and its relationship to supply chain management and logistics performance in the automotive industry. The study will focus on the issue of operational performance.

The sampling frame consisted of 1,975 companies in the automotive parts manufacturing industry in Thailand. The companies were identified through the Office of Business Development, Ministry of Commerce of Thailand. Next, a questionnaire was distributed to IT leaders of those automotive parts manufacturing companies. Through a data cleaning procedure, feedback from IT leaders of 144 companies were analyzed using Structural Equation Modeling (SEM). Finally, IT leaders from five automotive parts manufacturing companies were selected for an in-depth interview.

The results show the model supported the regression hypotheses, were accepted at a p-value of < 0.05. RFID utilization had not only a direct effect on operational performance, but also an indirect impact on supply chain management and logistics performance.

Keywords: RFID utilization, supply chain management, logistics performance, operational performance

Acknowledgement

The author would like to express his deepest and sincere gratitude to Assistant Professor Dr. Natnarong Jaturat, his advisor and Associate Professor Dr. Chanongkorn Kuntonbutr, his Co – Advisor for their consultancy, suggestions and assistance in various ways until this dissertation was well accomplished.

Also, the author would like to thank Associate Professor Dr. Kanibhatti Nitirojntanad, chairman of the dissertation test as well as Associate Professor Dr. Arunee Intrapairoth and Associate Professor Dr. Somchai Prakancharoen, the dissertation committees who provided advisory and consulting for the dissertation revision. Next thanks go to all professors and experts from the companies who kindly verified the research tools and participated in the in depth interview as well as all the beneficial recommendations provided for this research

He would like to thank all the Ph.D. colleagues who supported and assisted each other throughout the courses. Last but not least, the author would like to express his special thanks to his beloved family that always supported him with love and care and looked forward to the author's success.

Sirichai Kingsida

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CHAPTER 1
INTRODUCTION

1.1 Background and Statement of Problem

In the global industrial sector, there are the dominating and interesting industries such as the automotive industry. According to the Organization International des

Constructers d' Automobiles (OICA), it was found that in 2015, the regions in the world had 90,683,072 total amount of automobile productions. The world's most automobile productions region was Asia with the amount of 47,786,156. For the group of ASEAN which consists of 10 member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Philippine, Singapore, Vietnam and Thailand, there are three countries in the group that have the potential for automobile productions which are; Thailand (1,915,420), Indonesia (1,098,780) and Malaysia (614,671).

From the progress of the productivity ratios that continually increase both on the production quantity and cars distribution of Thailand, it would lead to a positive effect

on the relevant industry which is the automobile components manufacturing (Sivabrovonvattana, 2009). The automobile components manufacturing is an important industry that can generate income, employment, trade value, and the growing ratio of national economy. Since many internal factors of the country enhance growth either in the domestic and international requirements such as tax ratio, raw materials, manufacturing location, transportation, and wages as well as supports from public and private sectors. Management of automobile structural parts can be divided in two groups as follows: Group 1 Main group can be divided into 5 groups which are suspension system, transmission system, the electrical system, the chassis and other groups. Group2, Component group.

Value : MUSD

Code	Items	2012	2013	2014	2014 Jan-Jun	2015 Jan-Jun	% of Growth rate 2014	2015 Jan-Jun
32 10400000	(3.1) Spark-ignition reciprocating internal combustion piston engines and parts thereof	3,204.94	3,347.60	3,386.63	1,775.66	1,615.59	1.17	-9.01
3431000000	(3.2) Transmission shafts and cranks	324.40	321.05	328.56	162.87	157.24	2.34	-3.46
32 10500000	(3.3) Electrical equipment for spark-ignition internal combustion engines and parts thereof	378.90	400.95	400.26	201.54	172.84	-0.17	-14.24
321010404	(3.4) Ignition wiring sets used in vehicles	471.56	434.29	435.70	205.14	243.62	0.32	18.18
3031600000	(3.5) Electric accumulators and parts thereof	709.83	782.63	913.65	460.31	380.48	16.74	-23.86
3170100000	(3.6) Pneumatic tyres and innertubes of rubber	3,482.98	3,625.36	3,697.75	1,842.98	1,839.67	2.00	-0.18
3360300000	(3.7) Safety glass and glass mirrors	174.70	188.40	191.80	92.98	82.70	1.64	-11.00
321010405	(3.8) Other parts and accessories for motor vehicles	6,207.18	6,726.12	7,203.20	3,530.56	3,634.77	7.17	2.95
321020202	(3.9) Other parts and accessories for motorcycles	597.63	644.39	599.48	302.82	273.50	-6.97	-9.68
	(3) Total Number of Export Auto Parts	**15,552.11**	**16,470.80**	**17,161.73**	**8,575.81**	**8,370.43**	**4.19**	**-2.39**

Figure 1.1 Total Export Value of Thailand Automotive and Auto Part as of 2012 – 2015 Overview of Thailand Automotive industry as of 2015 (Jan – Jun)

It was found that the total number of Export Auto Parts of 2015 (January – June) had an export values of 8,370.43 US Dollars. This was a reduction by 2.39 percent compared to the previous year. By separating into the automobile parts manufacturing such as piston inside the engine, transmission shaft and crank, electrical equipment for ignition, wire set, battery and components, vehicle tires, glass and auto glass, and other components, the export value was 8,096 million US Dollars. The automobile components with the top three export ranks are other components with the export values up to 3,634.77 million US Dollars. Second by the vehicle tires with the export value of 1,839.67 million US Dollars and the electrical equipment for ignition with the export value of 1,615.59 million US Dollars. Besides, there were export of parts of motorcycles and accessories for motorcycles with the export value of 273.50 million US Dollars. It can be seen that the automotive parts industry is strongly important to Thailand. It can generate high income for the country. Besides, automotive parts industry also linked with various parts in the supply chain from the origin stream, middle and downstream.

However, according to the free trade policy under the rule of the World Trade Organization (WTO) and Asian Free Trade Agreement (AFTA), these effect on the automotive parts industry as it has to face the severe competition overseas such as in Taiwan, China, and India. This leads to high competition of product price and quality therefor, the automobile components manufacturers in the industry have to develop themselves to add more competitive opportunities for the organization and create confidence for the car manufacturers. The problems as found in the operation of the

automotive parts industry are the loss of parts and components as well as work efficiency problem. The operation efficiency problem of time consumed to disburse and give the automobile parts and components, errors in products counting and transportation, speed and information update efficiency restrict the management in receiving the Real-time information.

Thus, RFID (Radio Frequency identification) was used with the hope of increasing the potential and work effectiveness in the automotive parts industry as well as the need to control product movement and the connection with partners' supply chain. From a previous research study, it was found in the research of Zelbst, Green, Sower, and Reyes (2012) that RFID technology is used to increase the efficiency and effectiveness for better performance of work and reduce production cost. Leung, Cheung, and Chu (2014) stated that using RFID can benefit in three aspects: 1. Revenue 2. Operating margin 3. Capital efficiency.

Cao, Folan, Mascolo, and Browne (2009)used RFID in the management of lifecycle within the automotive parts industry. From the characteristic of RFID technology, there is the ability to enter into Real-time information which of interest to the cars manufacturers such as BMW. By there is the use of RFID to check for the container movements between the manufacturer and suppliers. By installing RFID Tag and Real-time location system (RTLS) throughout the plant areas, RTLS can reduce the problem of stock levels and time to read RFID Tag. Moreover, the processing time in the system is 2 seconds which is quite quick to send and receive the stock information (Wessel, 2012).

Besides, Mercedes Benz uses RFID technology to check for safety in the equipment setting the car to ensure that all equipment components have proper configuration according to the steps and condition set by the company, for instance, airbag setting etc. ("INDIA: Mercedes-Benz starts production of M-Class in Chakan," 2012).

Thus, RFID technology is not only used in work but it also helps on the aspect of security such as installing RFID Tag in the airbag. Or posting RFID tag on the tires to

check for the air pressure and tire temperature to add more safety and prevent accident from flat tires or tire explosion. Besides, RFID technology also has the ability to follow the sources such as recall 1.4 millions cars globally by Toyota after the testing officer found some abnormality in the airbag. If there is RFID tag in the airbag, the office could know the source and production date.

RFID technology helps in the automotive parts industry operation by adding more compatibility for competition and efficiency on the aspect of transparency in supply chains, production control, logistics, products distribution, products submission, and equipment installation safety. Besides Jeske, Grüner, and Weiß (2013) used the database in the holistic analysis of the problems in supply chain. As mentioned, it can be seen that RFID technology used in the automotive parts industry to add more potential in the operation and form competitive advantage.

Mostly, RFID technology is used in the sensor system but with its qualification, RFID technology can record and store information into the database and bring those information for information technology analysis. It can be applied in the supply chain management and logistics performance and what should be done by the management for the success within automotive parts industry.

1.2 Purpose of Study

Presently, the automotive parts industry in Thailand has up to 1,975 industrial plants throughout the country. Using RFID technology within the automotive parts industry in Thailand could boost operational performance in the organizations. Since RFID technology can check inventory information, sources of product, save times in products count, save cost in employees hiring, and save cost in products sorting.

Besides, the information from sensors was also stored in the database to use for need analysis of future customers. This leads to the competitive advantages and more work effectiveness. However, the automotive parts industry operations in Thailand have some complexities and diversities in each organization performance in supply chain management, and logistics performance. Thailand’s automotive parts industry needs to be successful in operation under RFID technology. Increasing the effectiveness on the aspect supply chain management and logistics performance could result in successful

operational performance in Thailand's automotive parts industry. It is an interesting knowledge and guideline for organizational decision making. The following were objectives of the study.

1.2.1 To study the supporting factors for the use of RFID and how they affect operational performance in Thailand's automotive parts industry.

1.2.2 To study the relationship between RFID benefits and supply chain management and how it influences the success of operational performance in Thailand's automotive parts industry.

1.2.3 To study the relationship between RFID and logistics performance and its influences on the success of operational performance in Thailand's automotive parts industry.

1.2.4 To study how the benefits of RFID impact the current operational performance in Thailand's automotive parts industry.

1.2.5 To develop and test the model benefits of RFID for operational performance.

1.3 Research Question and Hypothesis

1.3.1 Research Question

In the operation of the automobile and automobile parts industry in Thailand, the use of RFID technology is benefit in various aspects. The research allows us to recognize the impacts of using RFID and the factors in Thailand's automotive parts industry. For supply chain management and logistics performance effecting the operational performance, below are the research questions:

1.3.1.1 How does RFID utilization affect operational performance in the automotive parts industry?

1.3.1.2 How does RFID utilization affect operational performance through supply chain management and logistics performance in the automotive parts industry?

1.3.1.3 How does supply chain management affect logistics performance in the automotive parts industry?

1.3.2 Hypothesis

Presently, Thailand's automotive parts industry has used the RFID technology to add more efficiency and effectiveness in its organizational operation such as using RFID technology for operational profit generation, reducing the inventory product costs and related costs to help the firm improve on its return on investment. Jaska, Reyes, Zelbst, Green Jr, and Sower (2010) studied the impact of the use of RFID technology in the operational management. The research result revealed that the implementation of RFID technology can help improve on the aspect of work efficiency at the inventory level, operating expense and inventory expense. Therefore, using the benefits of RFID to add more efficiency and effectiveness of supply chain management can lead to higher profits. This is presented in H1 below.

H1: Using RFID can have a positive impact on the supply chain management.

The transportation efficiency such as speedy transportation, credibility, flexibility, and confidence in transportation has reflected the ability of the organization and customer satisfaction. Zelbst, Sower, Green Jr, and Abshire (2011) studied the benefits of RFID technology and organizational agility. The results of then study showed in general, the use of RFID technology has an effect on operational performance and logistics performance. Therefore, using RFID technology brings more effectiveness in operation and it's good for the organization as suggested in H2 and H6 below.

H2: Using RFID has a positive impact on logistics performance.

H6: Using RFID has a positive impact on operational performance.

Using only RFID cannot improve effectiveness and efficiency in the organizational logistics performance. Chalotra (2016) said that products sale can have an impact cost on the price of product because the costs from packaging, supply chain management and logistics performance. It is fundamentally important to work within the supply chain. Therefore, improving the efficiency may lead to more transportation effectiveness in the supply chain management to reduce the cost of logistics performance. Thus, H3 is proposed below.

H3: Supply chain management has a positive impact on logistics performance

In a good supply chain management, it allows the organization to know the goods status as well as the quantity. The essential component in a good supply chain management is to know the amount of products. This will allow us to know when to buy the product and how much to order to support the needs of customers and to prevent the lack of products which result in strategic planning for organizational production plan. Lenny Koh, Demirbag, Bayraktar, Tatoglu, and Zaim (2007) studied the impact of supply chain management of SMEs. The research result on SCM had a direct impact on operational performance of SMEs. Therefore, good supply chain management could lead to operational performance. H4 is proposed as follow.

H4: Supply chain management has a positive impact on operational performance.

The processes in the automotive parts industry involve either export or import where there are key factors that affect operational performance in transportation strategic planning. For creating competitive advantage while products transportation is the capital cost. Fugate, Mentzer, and Stank (2010) studied to logistics performance and the contribution of logistics. Then results indicate that logistics performance positively impacts organizational performance. Thus, H5 is proposed as follow.

H5: Logistic performance has a positive impact on the operational performance

1.4 Research Framework

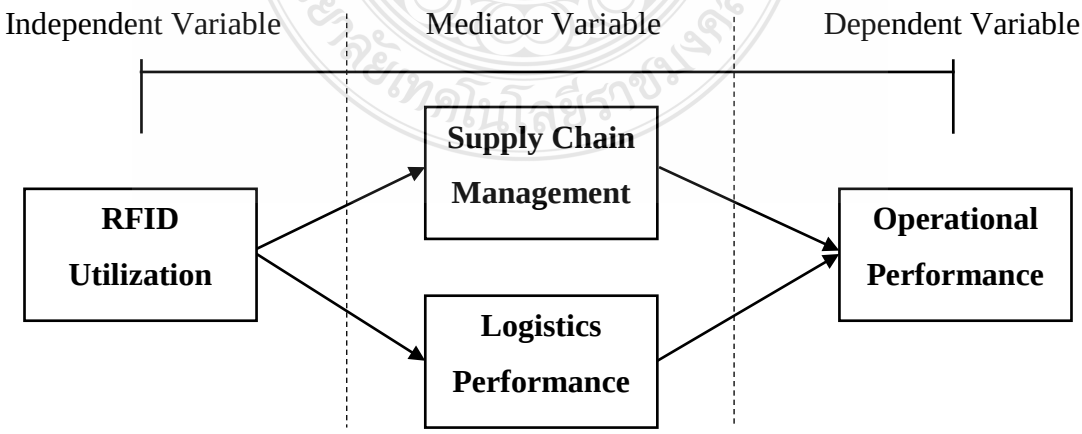

Figure 1.2 Research Framework

1.5 Definition of Terms

The following definitions will help create understanding about the terms used in this research.

RFID **(**Radio Frequency identification**)** refers to the technology that used in Thailand's automobile and automotive parts industry. It has the characteristic of electronics tag (RFID Tag) for testing, follow up and record the information by RFID Tag posted on devices such as products, product box, etc.

Passive Tags refers to tags without internal battery. It uses the electric power generated by induction from the electromagnetic waves of the reader. Passive Tags have a moderate price (Mehta, 2011). The disadvantage of Passive Tags is the distance of close information sending and receiving; the longest distance is 1.5 meters which is a short reading distance. Passive Tags are the small memory unit that is about 32 to 128 bits in general and the reader device must be quick and have high power. Passive Tag is produced in various forms in different shapes. It can be in the form of a tiny bar or plate that is almost hardly seen.

Semi-passive RFID Tags refers to the communication in the same way as Passive RFID Tags, but Semi-passive RFID tags have an internal power supply thus, semi-passive RFID tags can be used for running the logic within the chip and stimulate sensors to work. Semi-passive RFID tags have a better wave length compared to passive RFID tags, and better reading length. Semi-passive RFID tags posted on high value products and with the need for longer reading distance (Mehta, 2011).

Active RFID Tags refers to the tags that use battery all the time during communication. In general, it is used to read write the information within the device different from passive RFID tags. In communication, active RFID tags use microchip to give a signal but passive RFID tags use radio signal from the reader to send a signal (Chiewnawin, 2009). Active RFID tags work well for long distance follow up (Mehta, 2011). Besides, it has the ability to confirm the identity or Real-time location but the size of Active RFID Tags is larger than Passive RFID Tags (Cisco System, 2008).

Semi - active RFID Tags have a similar characteristic with active RFID tags; they have battery for communication but semi – active RFID tags remain still until they sense a signal from the reader, and then they begin to work (Mehta, 2011). Semi – active

RFID has a limitation from the environmental aspect such moisture of the area and years of use (Song, Kang, Yoon, & Jeong, 2009). Since battery in the semi – active RFID cannot be charged, thus the life span of semi – active RFID is around 2-7 years (Chu, Wu, Chen, & Zhao, 2011).

Inventory Management refers to the current or future resource management for the smoothness of the operation through planning for proper quantity of product inventory. They were divided into 4 types: raw material, work-in-process, maintenance materials and finished goods (Asasongtham, 2011); they are considered as part of the business assets for sales. The establishing of proper form of inventory is crucial for the industrial sector (Ziukov, 2015).

Transportation refers product and service movement from the suppliers to the distributors. There are various forms of transportation such as truck, train, air, water and pipe transportation. Each form of transportation is different in terms of economic structure, transportation technique and transportation quality (Coyle, Gibson, Langley, & Novack, 2013).

Operation Performance refers to the performance result that suite the operational process in the organization or activities that meet the organization is objective. Operational performance also refers to the operational quality, flexibility, transportation and efficiency in other aspects of management (Zhao, Yu, Li, & Tian, 2014).

1.6 Limitation of the study

Some limitations of the study were shown in the following.

It is necessary to address certain limitation of this study to help advance future research. The limitations of this study come from companies that responded to the questions but had no knowledge about RFID technology or companies with knowledge about RFID but led not adopted technology. In addition, the automotive parts industry had differences in their operation thus; bringing RFID technology to use was up to their strategic operation. Moreover the success of applying RFID technology need more time in management of complex tasks or the differences in product value. Finally, limitations in the items applied with each observed variables, despite the thorough relevant

literatures review, there could be opportunities for the items to be chosen as the tool for data collection while the model may not well represent the observed variables and could give bias outcomes.

1.7 Scope of study

This research studies on the relationship context of RFID technology applying with the Operational Performance with the sample group from automobile and automobile components industry in Thailand. The informants are the RFID technology keeper and the statistical analysis on the information as collected from the questionnaire and interview.

1.8 Organization of the study

This study consisted of five chapters. Chapter one covers the content related to background and statement of problem of study, research question and hypotheses, research framework, limitation of study and significant of study. Chapter two is the literature reviews related to RFID utilization and operation performance. The studying variables were drawn to design a framework of the research. Chapter three discussed the research methodology consisting of quantitative research and qualitative methods to analyze and test the hypotheses, including qualitative research. Chapter four presented and discussed the research findings. Chapter five was composed of the conclusion, discussion, research implication, and future research.

CHAPTER 2
REVIEW OF LITERATURE

Introduction

This chapter reviews the relevant literature consisting of three parts; first the explanation about the related literatures on RFID technology, supply chain management, logistic performance and operational performance. The second part explains the theoretical framework of the research model. The third part explains RFID concept in the context of automobile parts manufacturing.

2.1 RFID technology

Technology is used in establishing the strategy to enhance the management and internal organization operation to solve the emerging problems (BurgeSmani & Wheelwright, 2004). Therefore, RFID technology helps with the internal organizational operation.

RFID is a technology that was developed to promote or replace Barcode technology for identification or automatic follow up (Asif, 2005). Besides, RFID technology can re-check the inventory such as checking for the raw material, work-in-process, and finished goods (Pelton et al., 2010).

Thus there is the wide use of RFID technology in the military, navigation, transportation, logistic, production, automobile industry, retail business, pharmacy, animals management, food management, garment industry, books and Anti-counterfeiting (Weihua, Yuwei & Tingting, 2012). Besides, RFID is the technology that is efficiently used in supply chain management, it is fast and can control products movement, details and types of products. This allows for more work efficiency, reducing the process of counting and record the receiving as well as increase the accuracy in products arrangement including sale information and fast supply chain management (Sivabrovonvattana, 2009).

Researchers defined the three compositions in RFID consisting of RFID tag or transponder, RFID reader, and host computer (Attaran, 2007; Robert, 2006) while some

bathers RFID as consisting of three parts which were reader, tags and antennas. Thus, The basic components of RFID can be explain as follows:

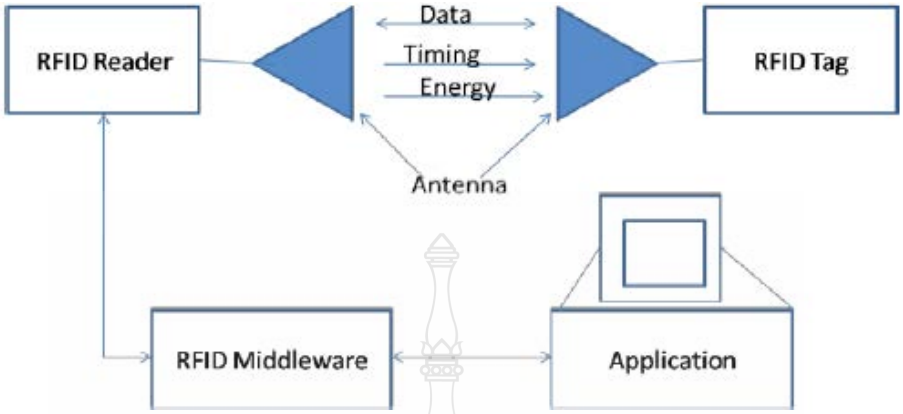

Figure 2.1 Presents the basic components of RFID system (Raghuwanshi, 2010).

Tag (**Transponder)**

RFID Tags is a small tag with the front chip to keep the object data such as product code, antenna send and receive the signals from radio frequencies and form energy for the chip part. RFID tags can make a conversation by using radio frequencies as the medium to talk with RFID reader to send, process, and store the information. (Wu, Nystrom, Lin & Yu, 2006).

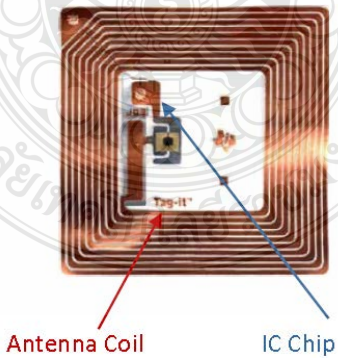

Figure 2.2 Structure of RFID tags (Rahming, 2012).

Thus, RFID Tags that are selling in the market can be defined into four types. The type used for the conversation between tag and reader are passive, semi-passive, active and semi-active tag (Mehta, 2011).

Reader

Reader is the device that is used to read the ID Code from RFID tag. (Chiewnawin, 2009). The function of RFID reader is to read and write tags and at the same time it functions to connect with the computer to collect the information and process the information from the reader. Inside the reader, the antenna functions to send and receive signal from tags while the selection of antenna is up to the application to use (Raghuwanshi, 2010). Besides, the good reader should be capable of protecting the repeated reading, for instance, in case the tags are left in the magnetic field area formed by the reader or in the distance of sending and receiving that can make the reader never stop read the data from tags repeatedly.

The advantage of RFID reader is that it has no limitation in case of obstruction, so tag can be hidden in the objects and it can also read several tags at the same time.

Antenna

Antenna is part of the communication system, it uses the frequencies and tags. Antenna is part of the operation by using the paring between frequencies in the system operation and application (Gaukler & Seifert, 2007). Therefore, antenna functions to send or receive information by using reader and tags by antenna has different sizes from the square centimeter till square meter (Chiewnawin, 2009).

Middleware

Middleware is the part that is used for the necessary communication between RFID reader and Computer Database of the firm and information management software (Raghuwanshi, 2010).

2.1.1 Frequencies used by RFID system

Frequencies used in RFID system can be divided into 4 frequency band as follows:

2.1.1.1 Low Frequency : LF

125 - 134 KHz of frequency is the low frequency for the checking of RFID tags at short distance with the length for reading around 0.5 meters with the ratio

of data transfer at 1 kbit per second. This frequency can read through water but cannot read through metal. This frequency band is used for livestock (Domdouzis, Kumar & Anumba, 2007; Ward; Van Kranenburg & Backhouse, 2006).

2.1.1.2 High Frequency: HF

13.55 MHz is the frequency used to check on RFID Tags with the reading distance about 1.5 meters and the data transferring ratio at 25 kbit per second. This frequency can read through water but not through metal. It is used for accessing and security (Domdouzis et al., 2007; Ward et al., 2006).

2.1.1.3 Ultra High Frequency: UHF

Frequency from 433 MHz – 956 MHz is the high frequency with the reading distance of about 100 meters while the length of frequency from 865-956 has the reading distance of 0.5 to 5 meters with the data transferring ratio about 100 kbit per second. This frequency can read through water and metal by this frequency band will be applied in logistics (Domdouzis et al., 2007; Ward et al., 2006).

2.1.1.4 Microwave Frequency

It has 2.4 GHz frequency. This length allows for Tags reading in far more than 10 meters since it uses a specific frequency of microwave with the data transferring ratio of more than 100 kbit per second. This frequency cannot be read through water or metal. It is used for the applications related to mobile vehicle toll (Domdouzis et al., 2007; Ward et al., 2006).

2.1.2 RFID technology usage

At present, RFID technology is use to help increase the efficiency and effectiveness in operation or any service provided. Besides, RFID technology can also reduce the damages that can occur and prevent the errors from the operation. RFID technology is widely used such as the retail business sector, education sector, warehouse management and production process etc.

2.1.2.1 RFID technology usage in business trading sector

Recently in the retail business sector, RFID technology is used to enhance supply chain by the research of Attaran (2007) on the subject of “RFID: an enabler of supply chain operations”. It has the objective to reduce the cost of supply chain by using RFID technology. According to the research, it is found that RFID

Technology helps in making a effectively successful company by reducing cost, and information will assist the firm to foresee and respond to customers' requirement. RFID is the solution that increases the return on investment (ROI) of the organization while improving the communication between retail and supply chain. Proper RFID technology management can also lead to a mixed change with the former system. Besides, the research also gives the example of RFID technology used on the retail aspect such as Krivda (2004) has given the example of RFID technology usage of firms such as Wal-Mart, Target Corp needs the suppliers to begin using the RFID Technology in supply chain operation.

2.1.2.2 Using RFID technology in warehouse

The application of RFID technology on the aspect of warehouse management can be seen in the research by Reechaipichitkul and Archint (2009) on the subject of "Genius warehouse management system via RFID technology: the case study of Pimaifoot co,. ltd." It presents the technology application in the warehouse system since barcode technology shows the problem on efficiency in the management; the precise speed of bringing the products in and out of the warehouse. Thus, RFID technology is used to fix the problem of receiving products and disbursing of products from the warehouse; moreover to check for the amount and position of products storing.

It was found from the study results that bringing RFID to use can support the effective warehouse management and reduce the errors in information technology. Besides, it can reduce the capital cost of inventory and lead to the customer's confidence toward organization. (Reechaipichitkul and Archint 2009). There is a research by Liu, Yu, and Liu (2006) on the application of RFID technology in the warehouse to help keeping the operation information in real-time. The results reflect more benefit in reducing work errors and saving operational costs when compared to the old system.

2.1.2.3 Using of RFID technology in production process

In bringing the RFID technology in the production sector for the benefits that focus more on operational effectiveness and increase the speed in the production process RFID technology is capable in the form of real-time. From the diverse ability in RFID, Evdokimov, Fabian, and Gunther (2011) designed the use of RFID in 7 forms which are accelerating scan processes, extending scan processes for quality and

efficiency, extending scan processes for narrowing recalls, reducing paper-based data management, automating asset tracking, reducing back-end interactions, and unifying labels. Thus, the characteristics of technology application in the production system are summarized in table 2.1 The information shows the differences of the operations such as in production of airbags, production of sliding clutches, production of engine-cooling modules, tracking of cast parts, and production of packaging materials.

Table 2.1 Identified application scenarios for RFID in manufacturing (Evdokimov et al., 2011)

Case study	**The seven RFID-application Scenarios**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Case 1: Airbags	✓	✓				✓	✓
Case 2: Sliding clutches	✓	✓	✓				
Case 3: Engine cooling module						✓	
Case 4: Cast parts		✓			✓		
Case 5: Connectors	✓	✓		✓			✓
Case 6: Packaging materials		✓	✓	✓	✓	✓	

The key motivation of bringing RFID technology to use in the production process is the automatic operation and speedy operation, and the ability to trace back. Thus, it is installed within the parts in the automobile such as airbags etc.

Heng (2006) brought RFID technology to use in airbag installation to control the pressure in the airbag. Besides, Daimlerchrysle is the production company for child chair and airbag for kids. Tag RFID is installed to prevent dangers for kids as well. And the automobile manufacturer like Mercedes Benz uses RFID technology for security check within the car equipment configuration to ensure that all the parts have been appropriately configured according to the steps and condition as required by the company. For example, airbag configuration up to the air pressure of the tires to prevent accident that may be caused by flat tire or explosion, including the re-check on what

date the parts were produced and who were the producer in case that the equipment or other parts had problems in production, the re-check can be done fast.

2.1.3 Adoption and Diffusion of RFID Technology

Technology acceptance such as RFID technology which is the technology that allows for transparency improvement in the process and increases the efficiency within supply chain. In the past there is apparently the adoption and diffusion of RFID technology, especially in the automobile industry (Schmitt, Thiesse & Fleisch, 2007). There are four aspects in the key elements of diffusion rationale: 1. Innovation 2. Communication channels 3. Time and 4. Social system (Roger, 2002). Theoretical characteristics of innovation diffusion is important for the adoption and diffusion of RFID technology in the automobile industry (Schmitt et al., 2007). Fleisch, Ringbeck, Stroh, Plenge, and Strassner (2004) studied the potential of RFID for the automobile industry and found the factors of RFID diffusion from the interview with the experts on costs, perceived benefits, cooperation, performance, compatibility, top management support, and centralized plants and control. Besides, Weigert (2007) explored the potential of RFID in the automobile production industry in the aspect of information system. The goal was to study the influencing factors on the diffusion of RFID technology such as costs, complexity, top management support, compatibility, coercive influence, privacy, and strategy. Additional research by Wessel (2006), Coronado Mondragon, Lyons, Michaelides, and Kehoe (2006) mentioned about the factors of RFID diffusion such as costs, performance, complexity, and coercive influence.

Many researchers studied by bringing RFID technology to use in the supply chain process in the automobile industry Matta and Moberg (2006) describe the adoption and resulting benefits of RFID as a new information technology such as improved speed, accuracy, and visibility of information exchange within supply chains. According to those benefits, they lead toward cost reducing of inventory and better customer services. The study aimed at the factors of RFID diffusion on the aspect of standard factors (i.e. compatibility), top management support, both operational and strategic information exchange (cooperation), commitment to supply chain principles and the size of an organization. Besides, it also conforms to Sharma, Citurs, and Konsynski (2007) who analyzed the adoption and diffusion as well as factors that are the

perceived benefit of the technology, costs, the existence of a dominant supply chain partner (coercive influence), intellectual property and ownership standards adoption, data and software standards (compatibility), diffusion champion presence, and top management support. Also, Sewdberg (2007) explained the future development of the use of RFID in the production industry from many firms in which the influential factors on the future RFID diffusion are performance, standards and costs. There are additional research from Fleisch and Tellkamp (2003), Gerst, Bunduchi, and Graham (2005) which add more crucial factors of innovation diffusion for instance, costs, performance of the technology, compatibility, and the relative advantage. The crucial factors of RFID adoption can be concluded in Table 2.2.

Table 2.2 Extracted RFID adoption factors sorted by category and reviewed publications (Schmitt et al., 2007)

		Supply chain						**Auto motive**		
		Matta and Moberg (2006)	Sharma et al. (2007)	Sewdberg (2007)	Fleisch and Tellkamp (2003)	Gerst et al. (2005)	Fleisch et al. (2004)	Weigert (2007)	Wessel (2006)	Coronado Mondragon et al. (2006)
Technology	Compatibility	X	X	X	X	X	X	X	X	X
	Complexity					X	X	X		X
	Rel. Advantage				X					
	Costs		X	X	X	X	X	X		X
	Performance			X	X		X			
	Perceived Benefits		X		X	X	X			

Table 2.2 Extracted RFID adoption factors sorted by category and reviewed publications (Schmitt et al., 2007)

		Supply chain					Auto motive			
		Matta and Moberg (2006)	Sharma et al. (2007)	Sewdberg (2007)	Fleisch and Tellkamp (2003)	Gerst et al. (2005)	Fleisch et al. (2004)	Weigert (2007)	Wessel (2006)	Coronado Mondragon et al. (2006)
Organizational	Top Mgmt Sup.	X	X				X	X		
	Strategy							X		
	Commitment to SC principles	X								
	Cooperation	X					X			
	Centralized planning						X			
Environment	Coercive infl.	X	X					X		
	Diff champion		X							
	Ownership standard adopt.		X							

2.2 Supply chain management

Supply Chain has a major role in the firms and aim at the competitive business advantage by the firms add values for their overall products by using the resources throughout the firm (Hall, 1992). The operation system of Supply Chain covers all the relevant department either direct or indirect way to respond to the needs of customers in the Supply Chain. This includes the producer, supplier, transportation, warehouse until the parts required by customers as well as the new product development, marketing,

distribution, financial, and customer service (Chopra & Meindl, 2007). To increase the potential in efficient competition, the types of activities done in Supply Chain should be clearly divided as follows

Logistics Management

Logistics system is the flow procedure of the whole system products in the system of Supply Chain from the transportation on entry products, products movement in the inventory and shipping which is a crucial part in the supply chain. It consists of many operational strategies. Logistics arranged for effective transportation routes via computer program that is purchased to plan for the routes and reduce the cost of fuel, transportation, and inventory management to be able to see the overall picture of management in a more efficient way. This is via connecting the information for the work on the part of inventory and transportation to go in the same way. Lastly, the transportation strategy via the distribution points to reduce the areas and steps of product storing, if there is an efficient administration of the logistics system; it would result in a speedy management. Moreover, this would reduce the cost of Supply Chain Management and add to the competitive potential of the organization.

Inventory Management

Inventory management can increase the efficiency of products and services in business operation. This will increase the profits, increase the competitive ability, the service efficiency and investing distribution into other markets (Chalotra, 2013). The popular strategies widely used are Just in Time (JIT) and Vendor Management Inventory (VMI).

Just in Time (JIT) begun to be used by Toyota Motor co., ltd. for the punctual product delivery as needed and to reduce the stocks inventory of the firm. It is also the method for inventory management and manufacturing (Soin, 2004).

Vendor Management Inventory (VMI) begun to be use at Apple Computer co., ltd., it is used for processing the purchasing for inventory instead of customers.

Retailers will receive the daily sales information of customers to use in the analysis and calculation of the amount of products to supply for the inventory as required by customers (Soin, 2004).

Both forms have the same work characteristic that is to submit the required products on time as needed. Effective inventory management would help in production planning and for efficient production process; product inventory has been divided in four types which are raw material, work-in-process, maintenance materials, and finished goods (Asasongtham, 2011).

Raw Material Inventory

Raw material inventory is the product that is used in the production process until it becomes the finished products such as bean, door locker, flour, sugar (Muller, 2011).

Work-in-Process Inventory

Work in process inventory or WIP refers to the products supplied into the production process but not complete yet such as sub-component equipment (Muller, 2011).

Maintenance/Repair/Operating (MROS)

Maintenance/Repair/Operating refer to the parts or components of the machine that to support changes if the old parts are broken or expired (Asasongtham, 2011).

Finished Goods Inventory

Finished goods inventory refers to the finished products waiting to be sold such as bar stools, bread, cookies (Muller, 2011).

2.2.1 Inventory Control System

Inventory control system is so important to the organization; the management shall the record each type of product list. For the information that reflects the amount of products that match with the real counting (Asasongtham, 2011). There are two methods of inventory amount calculation as follows:

2.2.1.1 Perpetual Inventory System

Perpetual inventory system is to follow up changes continually in the inventory account and record the changes in inventory products information both the amount and values of residual inventory in detail all the time. Moreover, the total buys and sales products will be directly recorded in the inventory account while the perpetual inventory system will work as follows:

1) Products bought for sale or for production will be debited in the product account

2) Transportation cost; the amount of return and discount will be recorded in the account instead of separating into another account.

3) Every sale should record the cost by debit the cost of sale of product and credit the residual products.

4) Residual product account will be the rate control account but there will be the sub account to record each product items and the separated sub account will show the amount and cost of each product type at hand. (Kieso, Weygandt & Warfield, 2013)

Currently, technology is used in the office and accounting task such as computer, using of Bar Code and RFID (Asasongtham, 2011). The study by Hardgrave, Goyal, and Aloysius (2011) used RFID technology to enhance the effectiveness in products counting for inventory management in retail shops.

2.2.1.2 Periodic Inventory System

Periodic inventory system is an inventory information record at the periodic end in each accounting round. The amount of product at hand will be counted in tranches and record all the product in purchasing account and record only the rate when all are sold (Sentlowitz, 2014). For example, when there is a product count at the periodic end for instance, at every friday at the end of the month (Asasongtham, 2011). Periodic inventory system counting has the minor form of data recording compared to perpetual inventory system with the less cost of inventory control but the organization will be unable to know the inventory information at all time as needed. Disadvantages of periodic inventory system is that the organization will not receive the information about robbery or waste of products as well as the cost of products sold in a period of time (Sentlowitz, 2014).

2.2.2 Benefits from Inventory Management

Inventory management are beneficial for the business to prepare the products in response to customers in each time period both in season and non-season. It affects the preserving of production process to keep operating at a constant rate and to help

preserve the level of employment, preventing out of stock and the most crucial impact on the business is to generate the profit (Asasongtham, 2011).

According to the literature review above, it can be concluded that the inventory management procedure can result in the better response to the customers of the organization and can reduce the costs of supply chain which will increase the competitive potential.

2.2.3 Production Management

It can be said that production management is to transform the condition of raw material importing factor to become the products with higher values than the importing factor. The current organization has the strategy to support the supply chain management and it is the main responsibility for success and survival of the organization. Therefore, for the highest efficiency in the production operation, it requires to have the education and to select the proper methods of production management implementation including changes to support the market change by including the up to date methods and technology in the operation.

2.2.4 Information Technology Management

Presently, information technology system is much advanced and popularly used. As the organization brings information technology system to apply in the supply chain management, it would have many benefits in the organization. Since information technology system can increase the ability and potential of the organization in customers management such as transferring the product and service information to the customers, suggesting new products, receiving orders as well as payment that can also done via information technology system. Supply chain activities then can be processed everywhere without limitation and this will increase the channels and opportunities for customer service.

2.3 Logistics Performance

Any products and raw material transportation between the producers and consumers is another key step in the production process. The emerging cost is much crucial in the pricing and unavoidable. The efficient products transportation and distribution can partly help reduce the costs of production and pricing which has a direct

impact on consumers (Chalotra, 2016). Presently, automobile parts manufacturing in Thailand tends to expand with the high competition both in exporting and importing of raw material. From the literature review on logistics according to John J. Coyle, Langley, Novack, and Gibson (2012), logistic is the products and services movement from the producer to distributors of the products with the forms of transportation through trucks, trains, air, ship, and pipe. While at the same time logistics is the operation planning procedure to effectively control the flow and storing at raw materials and products as well as the information from the production origin to the consumers at the lowest cost. The aim is to improve the customer service toward highest satisfaction.

Bringing logistics to apply in products distribution is to manage on products movement and administration from the production until consumption. Distributing business can also be divided into many types from the distribution for purchasing, distribution for production and for sales. In general, distribution of products is related to three main tasks which are the inventory management, packaging, shipment. The scope that logistics come into play in the products transportation process is from the raw materials transportation until the production and pass to the distributors and sale till reaching to the customers. It can be seen that there is value added to the products from the movement, from one process to another process.

From the higher advancement and development, the business entrepreneurs have the choices of transportation and can select the transportation method that suite to their own business. For the convenience in study and understanding, the transportation forms can be set as follows:

Road Transportation

Road transportation had been in used since WWII but there is a high level of growth in the transportation service industry (Bowersox, Closs & Cooper, 2002). Transportation to day is operated with more needs and the attempt to develop better main roads (Dobie, 2005). Road transportation widely used in every country's supply chain is in the form truck, while truck sizes are from small truck to large. For the truck transportation, it can be divided into 3 types (John Joseph Coyle, Gibson, Langley & Novack, 2013).

Truckload (TL)

Truckload (TL) is the large transportation that weigh more than 15,000 Pounds or in form of connecting truck (John Joseph Coyle et al., 2013). In the Truckload (TL) mode, there are six types of transportations which are general freight, automobile transport, refrigerated, bulk commodity, tank truck, and other specialized. In general Truckload (TL) is the large product transportation, thus in the cost calculation for Truckload (TL), it is in form of ton-miles (Forkenbrock, 2001). In Truckload (TL) transportation, there is no need to stop from the beginning to the end.

However, the large transportation companies such as Schneider National and J. B. Hunt provide outstanding nationwide service in large transportation, small transportation, can also have an the advantage on price as well. (Bowersox et al., 2002)

Less-than-Truckload (LTL)

Less-than-Truckload (LTL) is a large product transportation that weighs from 150 Pounds to 15,000 Pounds. The Less-than-Truckload (LTL) form in any country is in the form of hub-and-spoke network and uses any geographical areas of the country to ship to other areas (John Joseph Coyle et al., 2013). Less-than-Truckload (LTL) transportation has quite high market cost and the transportation cost from the point of origin to the destination is more than Truckload (TL). Besides, the Less-than-Truckload (LTL) transportation leads to the wide cooperation in the industry (Bowersox et al., 2002).

Small Package Carriers

Small package carriers are the transportation at weight of 150 Pounds with diverse products in transportation; it is be done via van or truck. It uses the characteristic of transportation network like Less-than-Truckload (LTL) to effectively move the product in the local, for example, Transportation Company in form of Small package parriers include UPS and FedEx (John Joseph Coyle et al., 2013).

Train Transportation

Train transportation is important in transporting the products with safety especially dangerous products. The form of train transportation aims at dangerous products and the products that require high security (Barkan, 2008; Kawprasert, 2011).

From the ability and effectiveness of train transportation, on the safety aspect, train transportation still has the ability to carry large products to long distances. It is the main reason for using train transportation between cities. However, train transportation has high fixed cost because of the high price of relevant equipment, but it still has low variable cost (Bowersox et al., 2002). Train transportation can be in two forms; line haul freight carriers are the service for the group of main customers and general customers in the form of transportation that uses container.

Short line carriers are the local and regional service to connect between each customer; it is the service to the group of small market and local service. (John Joseph Coyle et al., 2013)

Air Transportation

In general, air transportation can also be called as hub and spoke network, products transporting by plane come from various areas to the same destination called hub. Hub is the place that gathers the products or all of what is required to transport to other hub; normally it is a large amount transportation (Bartodziej, Derigs, Malcherek & Vogel, 2009). Examples of airlines that provide air transportation are Federal Express, United Parcel Air, DHL, and Airborne Express.

However, in air transportation, the fixed cost is lower compared to rail, water or pipe transportation. Fixed cost of air transportation is related to plane purchasing and the special needs for containers management. For the part of flight route and airport development, it is the responsility of the government. For air transportation, there is a high variable cost from the cost of maintenance, staff employment wage both ground and flight attendant (Bowersoz et al., 2002).

Water Transportation

Water transportation can be seen from decades through the rivers, lakes and oceans or even through the natural sources. Water transportation has been developed and improved via the advancement of transportation to add potential in competition. Products with water transportation are those basic products or raw materials. The characteristic of water transportation is quite similar to train transportation. In water transportation, in each time it is in large amount and large product sizes such as, grains, coal, mineral and chemical (John J Coyle, 2011).

For water transportation, the fixed cost level is between the train and road transportation. The fixed cost of water transportation comes from the development of the transporting station that lead to higher cost compared to train transportation. In contrast, water transportation has the lower variable cost, so it is a good option for future logistic system (Bowersox et al., 2002).

Pipe Transportation

Pipe transportation was important in the industries in WWII era since it was used in feed the animals. Next, there was an ongoing development of pipe transportation until the 19th century but there was the pier transportation system for oil supplying in Pennsylvania, USA and extended to oil production. Today, people still lack understanding about the pipe transportation operation, only few people know about the role and significance of pipe transportation (John J Coyle, 2011). Pipe transportation has the highest fixed cost and the least variable cost. The high capital of fixed cost comes from the right-of-way pipe transportation that is required in the control stations construction. It also has a low wage cost therefore, the variable cost is low. In pipe transportation, there is the limitation from the flexibility of products movement since most of the products are gas, liquid or substance (Bowersox et al., 2002).

2.3.1 Transportation Management

The current transportation in globalization era with the free market for trade makes transportation becomes the crucial things in market activities processing. Currently, products sale can have an impact on cost and the price of product because the costs from packaging, inventory and transportation (Chalotra, 2016).

Therefore, transportation is a critical basis in supply chain for proper products delivery, punctuality, with the proper amount and cost, with quality and reaching to the destination properly. Besides, transportation management is also crucial on the aspect of organizational strategic plan the business competition such as Just-in-Time inventory, lean logistics and manufacturing, and scheduled deliveries (John J. Coyle et al., 2012). Effective transportation consists of four major components as follows:

2.3.1.1 Planning and decision making to manage for the best effectiveness in transportation system, it relates to low cost of transportation, confidence in purchasing quality and time of transportation.

2.3.1.2 Transportation execution in the transportation system planning, it should consider the rate of service, readiness of operation and products delivery.

2.3.1.3 Transport follow-up in the transportation management, it would begin the monitoring to the product transporting time from point A to point B etc.

2.3.1.4 Measurement under the transportation management system, the KPI (Key Performance Indicator) is set for the operation, of transportation report both in currency and cost such as productivity in monetary terms and productivity in operational terms (Chalotra, 2016).

2.3.2 Transportation Risk Management

Risk refers to the gathering of possibility and dangers as established and can be measured from danger and loss. In everyday, risks can occur to assets, environment, staff and citizens in the risky areas (Dobbins & Abkowitz, 2002). Therefore, risk management emphasizes two issues which are the main reasons for risk. First, on the natural disaster such as flooding, earthquake, storm, etc. And second, on the disaster causes by human (Abkowitz, 2002). Risk management is the guideline to effectively manage risks and uncertainty that may occur (Giunipero & Aly Eltantawy, 2004).

For risk in transportation, it could cause the stop of transportation and delay shipment. It could also affect to the overall image of the organization. Therefore, transportation risk management is the management of product movements with assurance during the transportation, this affects the supply chain efficiency (John J. Coyle, 2011).

2.3.3 Transportation Performance

The efficiency of transportation consists of three bases :

2.3.3.1 Cost

Transportation cost is the cost for products transportation in two geographic positions with the relevant cost of maintenance in products transportation.

Logistics system shall select the transportation system that helps reduce the overall cost of the whole system that means the least cost of transportation will not affect the overall picture of logistics system.

2.3.3.2 Speed

Speed in transportation is the most important thing, and it related to the cost in two ways :

1) Transportation company has the ability to transport the products quickly but at the high cost accordingly.

2) Speed in transportation sometimes may an not be realized as planned. Therefore, to choose the most proper transportation method can keep the balance of speed in transportation as well as the cost of service.

2.3.4 Consistency

The consistency of transportation in uncertain time for specific amount of products movement can reflect the reliability of the transportation. In transportation management, it is stated that consistency is very important for quality transportation. Therefore, speed and consistence in transportation can lead to quality transportation (Bowersox et al., 2002).

2.4 Operational performance

The operational performance of the organization can be divided into two forms which are work efficiency of the organization and organizational performance. This part will explain the organization's performance. And many more researchers give diverse meaning of operational performance for instance, Li, Ragu-Nathan, Ragu-Nathan, & Rao (2006) stated that operational performance refers to the method by which the organization accomplishes the setting of goal such as financial goal etc.

Chi Anh and Matsui (2011) stated that operational performance relates to the cost per unit, conformance of product, efficiency of time in transportation, speed of transportation and Inventory turnover. Besides, Feng, Terziovski, and Samson (2007) stated that organizational performance has two dimensions which are;

Operational performance related to the internal organization operation such as productivity, products quality, customer satisfaction.

Business performance is the operational performance related to the financial and market such as the growth rate, profit margin and profits generating.

Operational performance can be measured in several aspects such as quality performance, delivery performance, cost and flexibility performance, (Zhao, Yu, Li & Tian, 2014) throughput, inventory expense, operating expense, and lead time is the key variance in operational performance evaluation (Jaska, Reyes, Zelbst, Green Jr & Sower, 2010). This conforms to Mabin and Balderstone (2003) who stated that success of operational performance can be measured from throughput, inventory, and operating expense. From the views of the researchers who gave opinions about the measurement of the success in the operational performance, it relates to inventory expense, operating expense and lead time.

2.4.1 Inventory expense

Inventory expenses are the cost from inventory itself, the costs can be divided into three characteristics:

2.4.1.1 Purchasing expenses

The purchasing expenses are the price paid to get the required products. It may depend on the numbers of times for ordering and the amount of inventory. For all purchasing in each time, the payment must be done at all times for the transportation. But if the purchasing is more often, the cost of purchasing could increase accordingly. Therefore, purchasing cost does not only include the transportation cost, but also the staff purchases, checking cost, etc.

2.4.1.2 Cost of preservation

Cost of preservation is the cost in case there is a residual inventory and it requires preserving the product in the usable condition such as to preserve the products that can deteriorate so easily at the proper temperature etc. Besides, the cost of preservation may depend on the amount of inventory and time to keep the product inventory.

Therefore, the cost of preservation is the capital cost that sinks for the inventory. It could be the interests if the capital comes from loan or the loss of opportunity if the capital comes from the owner, electric cost if it has to be preserved under low temperature and the deterioration cost in case the products are kept too long.

2.4.1.3 Cost from the lack of product

The cost from lack of products occurrs when there is an insufficient inventory for the needs of productions or sales. The lack of products could make the firm unable to submit the product on time leading to bad effects or the termination of purchase from customers. But having too less in inventory it could lead to the chance of product shortage. On the other hand, too much inventory could lead to the problem from costs.

Therefore, product shortage if occurrs, it can make the company spend more rather than normal for example, in case of urgency, it must consider air transportation or there may be some fine if unable to deliver the products on time.

2.4.2 Operating expenses

Operating expenses are the cost of operation including wage either in direct and indirect way as well as the expenses from work processing. These expenses are the cost that cannot be avoided in business conducting (Spector, 2006).

Besides, Jackson (2011) gave an additional definition for the term operating expenses as the cost of operation related to the initial expense to run the business, tax, deterioration cost, and management cost, (Preston, 2013) salary and other benefits for staff, office expenses, maintenance cost and infrastructure cost.

Operating expenses can be measured from the financial results such as net profit and Return on Investment (ROI) (Spector, 2006). Therefore, it can be concluded that the operating costs can be divided in 2 types, which are :

2.4.1.1 Selling expense: the cost related to products sale such as advertising cost, transportation cost, commission, etc.

2.4.1.2 General and administrative expense: the cost from the management part such as staff wage, space rental, infrastructure cost, etc.

2.5 Theoretical Framework

With the strong advanced technology development, all sectors pay attention to bringing advanced technologies in organizations to improve work effectiveness and reduce overlapping in operation such as to reduce the overlapping in product check or work time, etc.

The industrial sector make use RFID (Radio Frequency Identification) which is a technology that has the ability to reduce the loss of product as well as check information in Real-Time for reducing working time. Thus, using RFID in the industrial sector affects improves efficiency management and the operational performance. This is the key supporting reason for this research.

Jaska et al. (2010) conducted a study on the impact from the use of RFID technology in operating efficienctly. by surveying the information from 122 manufacturers. The dimensions of RFID Technology was divided into three aspects as inventory management, tracking capability, and supply chain requirement. Moreover, the dimensions of operational performance were divided into five aspects as throughput, expense, time, inventory, and cash flow.

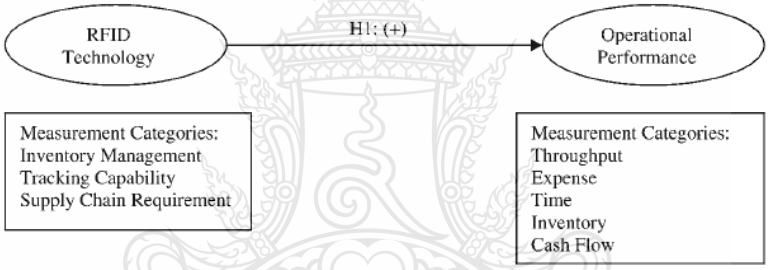

Figure 2.3 RFID Technology Performance Model with Hypothesis and Measurement Categories (Jaska et al., 2010)

The study result showed that the implementation of RFID technology can help improve on the aspect of work efficiency such as Inventory Level, Operating Expense, Inventory Expense and Effectiveness like Throughput.

Zelbst, Sower, Green Jr, and Abshire (2011) studied the benefits of RFID technology and Radio Frequency Identification Technology and organizational agility by collecting the information from 328 manufacturers within the dimensions of organizational agility, operational performance and logistics performance.

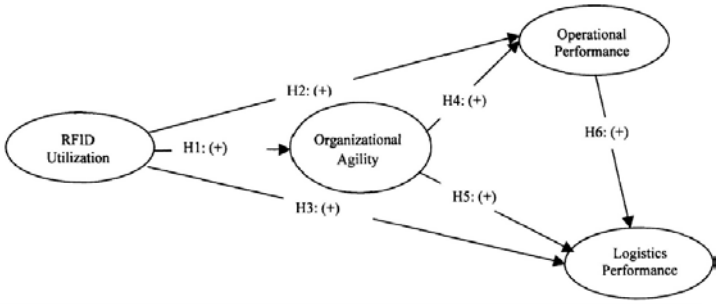

Figure 2.4 RFID Technology Utilization and Organizational Agility Performance Model with Hypotheses (Zelbst et al., 2011)

The result revealed that in general, the use of the benefit from RFID technology is positively affected by the organizational agility. Similarly, organizational agility has the positive effect on operational performance and logistics performance. The benefits of RFID technology can positive affect on the operational performance and operational performance has the positive effect on logistics performance. But using RFID technology can have the negative effect on logistics performance. This can be summed that organizational agility is the operational driver for better logistics performance.

In relation to the research objectives, the efficacy of RFID technology is used in the automotive parts industry to add more potential in the operation and competitive advantage and bring those information for information technology analysis. The research framework was used to develop the research model for the hypothesis testing, RFID utilization represents independent variable. While big data, inventory management, and transportation represent mediator variable and the operational performance represents the dependent variable. The statistic of this model conforms to the structural Equation Model Analysis.

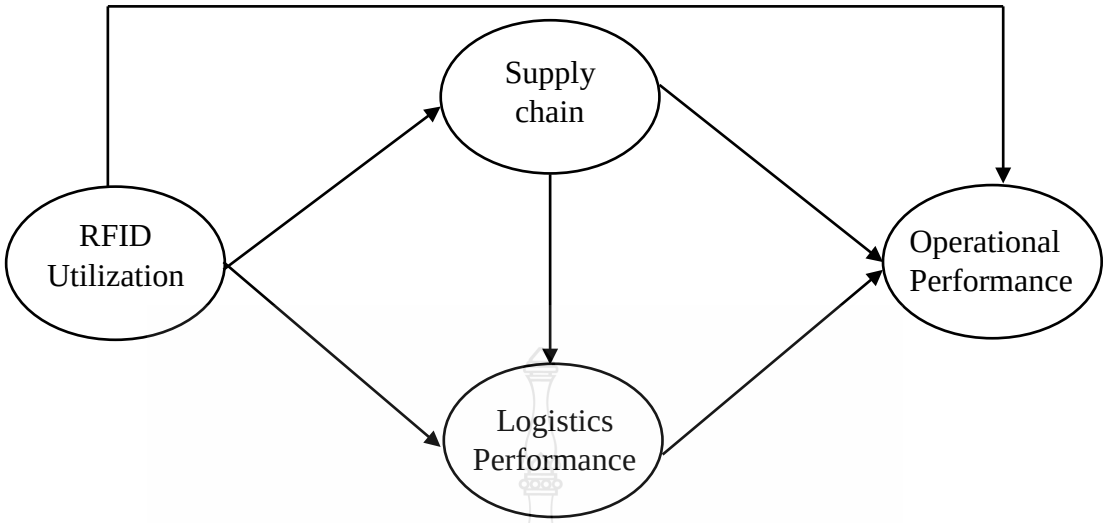

Figure 2.5 Theoretical Framework

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology used for the study of influence of RFID utilization in inventory and transportation on operational performance. The chapter comprises of four parts including Research Design, Quantitative Methodology, Qualitative Methodology and Sequence of Analysis.

3.2 Research Sample Appropriate with Model

Based on the research framework and hypothesis provided in chapter one, this study used Structural Equation Model (SEM) analysis. Thus, the statistic research model was created for hypothesis testing as follows:

The model was used to test that RFID utilization has an effect on supply chain management and logistic performance. Moreover supply chain management has an effect on logistic performance and supply chain management while logistic performances has an effect on operational performance as shown in figure 3-1.

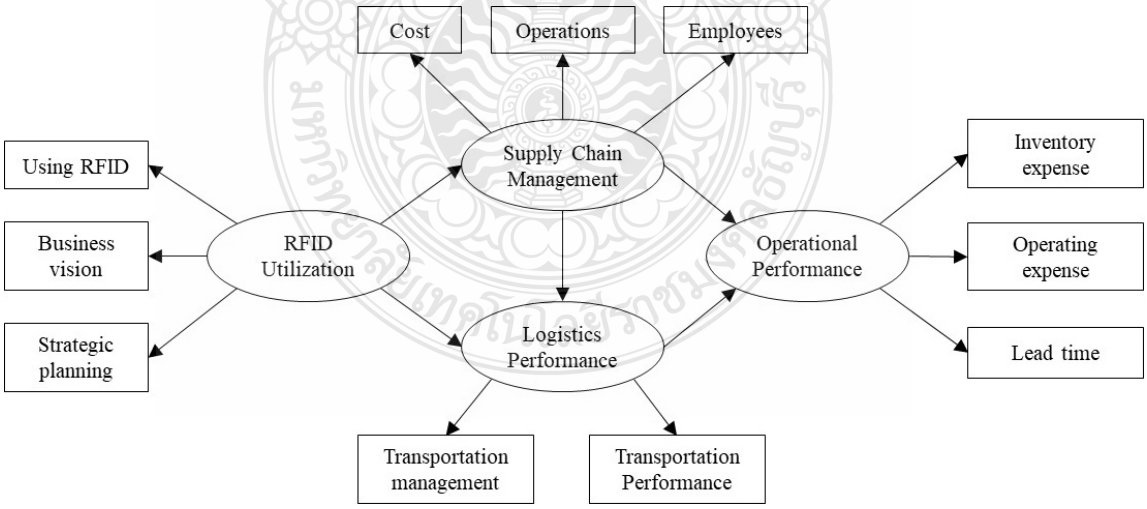

Figure 3.1 Purposed Statistic Research Model for Operational Performance

3.3 Research Design

This research is a cross-sectional study that observes the population or research sample at one specific point in time. The methodology is divided into quantitative research and qualitative research. Quantitative research uses questionnaire as an instrument for data survey. The qualitative research uses deep interview with the IT leaders while the author uses the interview data to confirm the results of the quantitative research.

3.3.1 Quantitative Methodology

3.3.1.1 Population and Sampling

In regard of the population and sampling, this research aims to study the IT leaders with the RFID use in their operation in an automotive parts industry of Thailand. A total of 1,975 business firms listed in the Department of Business Development, Ministry of Commerce of Thailand was the research population. The sample size was computer by Yamane formula at 95% confidence levels.

$$n = N/(1+N*(e)^2)$$

Where n is the sample size, N is the population, and e is error value. Using the Yamane formula, 335 firms were chosen out of 1,975. There were 10 groups of population, so the sample size was chosen from group with good proportion as presented in table 3.1

Table 3.1 The Proportion and Distribution of Sample Size.

Division of Manufacturing	Population (N)	Sample (n)
Automobile body manufacturing	89	15
Automobile engine manufacturing	19	4
Radiator manufacturing for cooling and heat ventilation from the central part	16	3
Tires and wheels manufacturing	89	15
Pumps and other compressor manufacturing	40	7

Table 3.1 The Proportion and Distribution of Sample Size. (Cont.)

Division of Manufacturing	Population (N)	Sample (n)
Pumps and other compressor manufacturing	40	7
bearings and gears for drive manufacturing	21	4
Electrical equipment manufacturing for automobile	23	4
Other parts and accessories manufacturing without category	1,458	246
Car seats manufacturing	74	13
Motorcycle engine, parts and accessories manufacturing	146	24
Total	1,975	335

3.3.1.2 Data Collection

Data was collected from two sources. Secondary data came from the listed firms in the database of the Department of Business Development, Ministry of Commerce of Thailand. The selected field as used in this research was the company's name, year of establishment, and total fixed asset in 2014.

Primary data was collection from the questionnaire survey with the IT leaders. The respondents here represented the attitude of the IT leaders on the important of RFID utilization in inventory and transportation to effect in operational performance. Questionnaires were sent to the IT leader by mail with the letter of introduction and request for survey issued by the university.

3.3.1.3 Research Instrumentation

Questionnaire

The questionnaire was used as a tool for gathering data from the research respondents, and it was constructed from the literature review and resigned to meet the research objectives and research questions. The questionnaire consisted of five parts.

The first part of the questionnaire investigates the perception of the IT leaders on the level of importance of the adoption of RFID technology. Question 1 to 3 were on the level of attention given to RFID technology usage in response to the

speediness in business operation, reducing the errors in business operation, and checking for the sources of the auto-mobile parts origin.

Question 4 to 6 were on the level of business vision including, RFID technology adoption into the management of raw materials quantity in inventory, RFID technology adoption into the inventory management, and RFID technology adoption in the management of the amount of ready-product.

Question 7 to 10 were on the level of strategy planning including, establishment of strategic plan for the use of RFID technology, supporting of management by RFID technology, RFID technology adoption into decisions for the operation, and maintenance and data backup from the operation by RFID technology. These 10 question were 7-point Likert 7 scale (1 = least important, 2 = less important, 3 = rather less important, 4 = neutral, 5 = rather much important, 6= much important, 7= most important)

The second part was on RFID technology adoption into logistics performance. Question 11 to 13 were on the level of transportation management, including RFID technology adoption and the follow up of transportation process, RFID technology adoption to check for the routes of auto-mobile parts, and RFID technology adoption to recall for damaged or under standard automotive parts.

Question 14 to 19 were on the level of effectiveness of transportation including, RFID technology adoption on the aspect of customer satisfaction toward competitiveness in transportation, RFID technology adoption on the aspect of speed toward competitiveness in transportation, RFID technology adoption on the aspect of reliability toward competitiveness in transportation, RFID technology adoption on the aspect of responsiveness toward competitiveness in transportation, RFID technology adoption on the aspect of flexibility toward competitiveness in transportation, and RFID technology adoption on the aspect of ability toward competitiveness in transportation. These 9 question were 7-point Likert 7 scale (1 = least important, 2 = less important, 3 = rather less important, 4 = neutral, 5 = rather much important, 6= much important, 7= most important)

The third part was on the adoption of RFID technology in supply chain management. Question 20 to 22 were on the level of expenditure management including

lower cost of wage, lower cost of inventory management, and lower cost of products purchasing.

Question 23 to 27 were on the level of administrative management including, transparency in the level of products stock, information into real-time with better reliability and accuracy, reducing the problems of out of stock event, helping in better follow up of products movement, and counting of inventory. Question 28 to 29 were on the level of personnel management including, reducing employees' product stolen, and reducing employees' error in operation. These 10 question were 7-point Likert 7 scale (1 = least important, 2 = less important, 3 = rather less important, 4 = neutral, 5 = rather much important, 6 = much important, 7 = most important).

The fourth part were on the operational performance. Question 30 to 34 were on the level of using RFID technology to increase organizational effectiveness including, helping to increase the effectiveness in the operation, helping to reduce the cost of inventory, helping to reduce the cost of operation, helping to generate more preciseness and punctuality in the operation, and helping recognize the levels of inventories in the operation. These 5 question were 7-point Likert 7 scale (1 = least important, 2 = less important, 3 = rather less important, 4 = neutral, 5 = rather much important, 6 = much important, 7= most important). The last part of the questionnaire was on the demography consisted of gender, age, experience, education and job position.

3.3.1.4 Measurement

The measurement on the importance given to the use of RFID in the operation can be done by the third variables, including using RFID technology, business vision, and strategic. The detail and definition of each variable is shown in table 3.2.

Table 3.2 Definition and Measurement of Independent Variables.

Variable	Element	Measurement
Using RFID technology	Speediness, error, check for the sources.	- Interval variable - 7 Likert scale
Business vision	Raw materials quantity, inventory management, finished goods.	- Interval variable - 7 Likert scale
Strategic	Establishment of strategic plan, supporting of management, decision for the operation, maintenance data backup	- Interval variable - 7 Likert scale

Logistics performance measure from two variables, transportation management and transportation performance. The detail and definition of each variable is presented in table 3.3.

Table 3.3 Definition and Measurement of Mediator Variables (Logistics performance)

Variable	Element	Measurement
Transportation management	Follow up of transportation process, check for the routes, recall for the damage or under standard.	- Interval variable - Likert 7 scale
Transportation performance	Customer satisfaction, speed, reliability, responsiveness, flexibility, ability toward competitiveness.	- Interval variable - Likert 7 scale

The measurement gives importance to supply chain management in operational measurement of the three variables, including cost, operation and operating employees. The detail and definition of each variable are presented in table 3.4.

Table 3.4 Definition and Measurement of Mediator Variables (Supply chain management)

Variable	Element	Measurement
Cost	Decrease cost of wage, decrease cost of inventory, decrease cost of products purchasing.	- Interval variable - 7 Likert scale
Operation	More transparent level of products stock, real-time, problems of out of stock event, products movement, counting of inventory.	- Interval variable - 7 Likert scale
Employees	Product stolen, reducing the employee error in operation.	- Interval variable - 7 Likert scale

Operational performance can be measured by the benefit of RFID to increase the performance in operational management as presented in table 3.5

Table 3.5 Definition and Measurement of Dependent Variables

Variable	Element	Measurement
Operational performance	Inventory expense, operating expense, lead time, Inventory level, throughput	- Interval variable - 7 Likert scale

3.3.1.5 Validity and Reliability

Content validity testing. The content validity is used to assess the questionnaire whether it covers the theory. The questionnaire was assessed by the five experts consisting of three scholars and two businessmen from business sector based on IOC (Index of Item Objective Congruence) method. The result from the assessment was used to adjust and improve the questionnaire's accuracy.

1) Pre-Testing

The questionnaire was tested for content validity and reliability before using for the survey the data from research sample.

(1) Content validity

The content validity was assessed by five expert consisting of three scholars, including Assistant Professor Dr.Amnat Sawatnatee, Assistant Professor Dr.Adirek Yaowong, and Assistant Professor Dr. Rungtiva Saosing, and two businessmen from business sector, including Mr.Parinya Punaprasart who is the IT manager of Thai Beverage Public Company Limited, and Mr.Passawee Sanguanrat who is IT manager of Proficient Tech Company Limited. The assessment used IOC (Index of Item Objective Congruence) method to score each question in accordance with theory, research objective, and accurate meaning. The testing results of Index of Item Objective Congruence is presented in Table 3.6.

Table 3.6 Index of Item-Objective Congruence (IOC)

Variable	**Latent**	**Expert's responses**					**Total**	**Ave rage**
		1	**2**	**3**	**4**	**5**		
Attention to RFID technology usage	RFID_1	1	1	1	1	1	1	0.93
	RFID_2	1	1	1	1	1	1	
	RFID_3	0	1	1	1	1	0.8	
Business vision	RFID_4	1	1	1	1	1	1	0.93
	RFID_5	1	0	1	1	1	0.8	
	RFID_6	1	1	1	1	1	1	

Table 3.6 Index of Item-Objective Congruence (IOC) (Cont.)

Variable	Latent	Expert's responses					Total	Ave rage
		1	2	3	4	5		
Strategy planning	RFID_7	1	1	1	1	1	1	0.95
	RFID_8	1	0	1	1	1	0.8	
	RFID_9	1	1	1	1	1	1	
	RFID_10	1	1	1	1	1	1	
Transportation management	LOG_1	1	0	1	1	1	0.8	0.80
	LOG_2	1	0	1	0	1	0.6	
	LOG_3	1	1	1	1	1	1	
Effectiveness of transportation	LOG_4	1	1	1	1	1	1	0.83
	LOG_5	0	1	1	0	1	0.6	
	LOG_6	1	1	1	1	1	1	
	LOG_7	1	0	1	1	1	0.8	
	LOG_8	1	1	0	1	1	0.8	
	LOG_9	1	0	1	1	1	0.8	
Expenditure management	SCM_1	0	1	1	1	1	0.8	0.86
	SCM_2	1	1	0	1	1	0.8	
	SCM_3	1	1	1	1	1	1	
Administrative management	SCM_4	1	0	1	1	1	0.8	0.84
	SCM_5	1	1	1	1	1	1	
	SCM_6	0	1	1	1	0	0.6	
	SCM_7	1	1	1	1	1	1	
	SCM_8	1	1	0	1	1	0.8	
Personnel management	SCM_9	1	0	0	1	1	0.6	0.70
	SCM_10	1	1	1	0	1	0.8	
Strategy planning	OP_1	1	0	1	1	0	0.6	0.88
	OP_2	1	1	1	1	1	1	
	OP_3	1	1	0	1	1	0.8	
	OP_4	1	1	1	1	1	1	
	OP_5	1	1	1	1	1	1	
Total IOC average								0.85

After testing was done, the score was 0.85 indicating acceptable content validity.

(2) Reliability Testing (Trying out)

The reliability was measurement of consistency of the responses given by respondents. The questionnaires were sent to 30 firms, and after they were completed and returned, data were analyzed using Cronbach's alpha to assess reliability. The reliability coefficients for the four latent variables are presented in table 3.7

Table 3.7 Reliability Statistic (Trying out)

Question	Cronbach's Alpha
Part 1 : RFID utilization	
Attention to RFID technology usage	.852
Business vision	.874
Strategy planning	.867
Part 2 : Supply chain management	
Expenditure management	.873
Administrative management	.867
Personnel management	.727
Part 3 : Logistics performance	
Transportation management	.887
Effectiveness of transportation	.894
Part 4 : Operational performance	
Increase of effectiveness in the operation	.775
Reduce the cost of inventory	.844
Reducing the cost of operation	.958
Generating more preciseness and punctuality in the operation	.923
Recognizing the levels of inventory in the operation	.914

In table 3.7, the Cronbach's alpha coefficients of reducing the cost of operation, generate more preciseness and punctuality in the operation, and recognizing the levels of inventory in the operation showed scores above 0.9. Meanwhile, the results of the Cronbach's alpha testing on attention to RFID technology usage, business vision, strategy planning, expenditure management, administrative management, transportation management, effectiveness of transportation, reducing the cost of inventory showed scores above 0.8 while those of personnel management and increasing the effectiveness in the operation had scores above 0.7. These results indicated that the questionnaires had reliability.

3.3.1.6 Data Preparation

The direct concern of this stage was on data arrangement including data screening and editing. The researcher distributed the questionnaire to 1500 firms in the automotive industry as well as online questionnaire. After three months, the researcher received letters from 245 firms in automotive industry and another 35 firms from online answering; all were 280 firms. After that data cleaning was made to generate the proper data for the analysis and accountability and number checking of questionnaires to avoid issues like repeating missing values, and abnormal values. The data used was generalized and checked by using RFID technology. After data cleaning, there were only 144 companies left with complete information.

3.3.1.7 Data Analysis

In conducting of data analysis, the researcher presented the use of Bootstrap. The basic idea of the bootstrap is to reconstruct the relationship between the population and the sample and to use the computer to generate many Bootstrap samples from this reconstructed relationship (Zhang, 2006). Then, the value from making Bootstrap will be used in standardized estimates.

Next was the analysis on respondents demographic data that used means, frequency, percentage, and standard deviation. The analysis of descriptive statistics studied supply chain management performance in the context of logistics and cold chain by comparing the organizational success factors with the following scale.

The levels of scale that the firms give as important were calculated from (7-1) /7 = 0.86. These consisted of 1.00 - 1.86 = least important, 1.87 – 2.70 = less

important, 2.71 – 3.55 = rather less important, 3.56 – 4.41 = neutral, 4.42 – 5.27 = rather much important, 5.28 – 6.13 = much important, 6.14 – 7.00 = most important.

The levels of scale that the firms are satisfied were calculated from (7-1)/7 = 0.86. These comprised 1.00 - 1.86 = least satisfied, 1.87 – 2.70 = less satisfied, 2.71 – 3.55 = rather less satisfied, 3.56 – 4.41 = neutral satisfied, 4.42 – 5.27 = rather much satisfied, 5.28 – 6.13 = much satisfied, 6.14 – 7.00 = most satisfied. The Structural Equation Model was analyzed as follows:

1) Investigating the variable with reliability, convergent validity, discriminant validity

2) Assess the model-data fit by considering the following indices

(1) Chi-Square should not be significant, p-value < .05

(2) Chi-Square/ Degree of Freedom should be less than 2.00

(3) RMR (Root Mean Square Residual) should be less than 0.05

(4) Good of fit index is close to 1

(5) Root Mean Square Error of Approximation should be less than 0.05

(6) NFI (Normed Fit Index) and CFI (Comparative Fit Index) are close to 1

(7) The Hoelter value examined should be more than 200

3.3.2 Qualitative Methodology

Qualitative methodology is a method which provides detailed explanation and descriptions of the procedures, situation, communications, experiences and knowledge related to the questions raised in the study. All of these could provoke deep level of responses in an open-ended environment in the data collection process which allows richness of information. This study used an in-depth interview with the IT leaders.

3.3.2.1 Population and Sample

The qualitative research population was same as the quantitative research population. This step did not define the amount of research sample. The interview

question were designed for the IT leaders who were responsible in the business firms. There were ten question as follows:

1) How does your business give importance on RFID technology usage?

2) What is the main objective of using RFID ?

3) Why does your business using RFID technology ?

4) What are your business products that apply RFID technology?

5) How is RFID technology crucial for your SCM and Logistics processes?

6) What part of your business has RFID taken the main role in SCM and Logistics management?

7) How can RFID increase the competitive potential for automobile parts manufacturing industry on SCM and Logistics?

8) Does your business gather existing information technology to connect with RFID?

9) What are the benefits of RFID technology in enhancing efficiency forming for SCM and Logistics in your business?

10) How can RFID technology usage affect operational performance in SCM and Logistics processes?

3.3.2.2 Research Instrument

The in-depth interview was basically the face-to-face interview with IT leaders. The questions asked were open-ended question which elicited answers to explain without any control.

The questions of the in-depth interview were divided into 8 parts as follows:

1) Consent to participate

2) Confidentiality policy

3) Open question

4) Utilization of RFID in business question

5) Supply chain management and logistics performance question

6) Operational performance question

7) Ended question

8) Gratefulness

CHAPTER 4
RESEARCH RESULT

4.1 Introduction

Chapter 4 presents the results from the research statistic analysis of the data collected through the questionnaire distributed to the groups of automotive parts industry in Thailand. The researcher received 208 completed questionnaires from the respondent companies. The results are presented in two parts. Part 1 is the results presentation on the quantitative research such as pre-testing, demographic data, and the Structural Equation Model (SEM) analysis. Part 2 is the qualitative research results presentation on the depth interview with the IT leaders or those related. To make the work casier, the anthor made use of some abbveriations this chapter such as M for Mean, SD for standard deviation, Min for minimum, and Max for maximum.

4.2 Quantitative Result

4.2.1 Response Rate

To prevent less response, questionnaires were sent to 1,500 companies in the automotive parts industry of Thailand, instead of the 335 calculated sample.

The top three firm types which were the respondents of the study were as follows: 95 firms from other parts and accessories manufacturing without category, 19 firms from tires and wheels manufacturing, 16 firms from motorcycle engine, parts and accessories manufacturing.

Table 4.1 Firm Respondent

Type of Firm	Size	Sent	Return
Automobile body manufacturing.	15	141	3
Automobile engine manufacturing.	4	36	0
Radiator manufacturing for cooling and heat ventilation from the central part.	3	19	1
Tires and wheels manufacturing.	15	98	19
Pumps and other compressor manufacturing.	7	32	2

Table 4.1 Firm Respondent (Cont.)

Type of Firm	Size	Sent	Return
Bearings and gears for drive manufacturing.	4	23	1
Electrical equipment manufacturing for automobile.	4	34	2
Other parts and accessories manufacturing without category.	246	926	95
Car seats manufacturing.	13	59	5
Motorcycle engine, parts and accessories manufacturing.	24	132	16
Total	335	1,500	144

4.2.2 Demographic Data

Demographic data was obtained from the questionnaires returned from the research sample in the automotive parts industry of Thailand. The respondents were the companies' IT leaders. The questions used to obtain the demographic data were in 4 parts. They were business size, registered capital, nature of investment and RFID application in operation. Details are shown in table 4.2.

Table 4.2 Demographic Summary

	Frequency	Percentage
Business Size		
Small-sized.	70	48.6
Medium-sized.	25	17.3
Large-sized.	49	34.0
Registered Capital (Million Baht)		
Less than 10 million.	53	36.8
10-50 million.	27	18.7
51-100 million.	14	9.7
More than 100 million.	50	34.7

Table 4.2 Demographic Summary (Cont.)

	Frequency	Percentage
Nature of Investment		
Local company.	69	47.9
Joint Venture.	39	27.0
Foreign Direct Investment.	36	25.0
RFID Application in Operation		
1-5 years.	116	80.5
6-10 years.	22	15.2
11-15 years.	6	4.1

From to table 4.2, the results of demographic data of the respondents are discussed in four parts below.

4.2.2.1 Business Size

From the demographic data, for the business size of the respondents, the results revealed that 70 respondents (48.6%) had a business size of small-sized, followed by 49 respondents (34.0%) with large-sized, and 25 respondents (17.3%) with the medium-sized. Thus, it showed that the majority of the business sizes were small-sized.

4.2.2.2 Registered Capital (Million Baht)

Regarding the registered capital of the respondents, the results revealed that 53 respondents (36.8%) had a registered capital of less than 10 million, followed by 50 respondents (34.7%) with a registered capital of more than 100 million, 27 respondents (18.7%) with the registered capital of 10-50 million, and 14 respondents (9.7%) with a registered capital of 51-100 million. Thus, it showed that the majority of the registered capital were less than 10 million.

4.2.2.3 Nature of Investment

Regarding the nature of investment, it revealed that 69 respondents (47.9%) were local companies, followed by 39 respondents (27.0%) with joint venture,

and 36 respondents (25.0%) having foreign direct investment. Therefore, it showed that the majority of the companies were local companies.

4.2.2.4 RFID Application in Operation

Regarding the RFID application in operation response, the results revealed that 116 respondents (80.5%) had RFID application in operation for 1-5 years, followed by 22 respondents (15.2%) with RFID application in operation for 6-10 years, and 6 respondents (4.1%) with RFID application in operation for 11-15 years. Therefore, it showed that the majority of the companies had used RFID for 1-5 years.

4.2.3 Descriptive Statistics

4.2.3.1 RFID Utilization

RFID utilization was the independent variable of the study. It was divided into three variables including the attention to RFID technology usage, business vision, and strategic planning. The statistical results of the minimum, maximum, mean, and standard deviation are presented in table 4.3.

Table 4.3 Descriptive Statistics of Independent Variables

Variable	Min	Max	M	SD
Attention to RFID technology usage				
Response to the speediness in the business operation.	1	7	4.076	1.640
Reducing the errors in the business operation.	1	7	4.052	1.612
Checking for the sources of the auto-mobile parts origin.	1	7	3.913	1.686
Business vision				
RFID technology adoption into the management of raw materials quantity in inventory.	1	7	3.985	1.692
RFID technology adoption into the inventory management.	1	7	3.966	1.666
RFID technology adoption in the management of the amount of ready-product.	1	7	3.995	1.669

Table 4.3 Descriptive Statistics of Independent Variables (Cont.)

Variable	Min	Max	M	SD
Strategy planning				
Establishment of strategic plan for the use of RFID technology.	1	7	3.976	1.564
Supporting of management by RFID technology.	1	7	4.081	1.590
RFID technology adoption into operational decisions.	1	7	3.985	1.637
Maintenance and data backup from the operation by RFID technology.	1	7	3.860	1.657

Where: Min = Minimum, Max = Maximum, M = Mean, SD = Standard Deviation.

The results of the statistical analysis of the RFID utilization in table 4.3 are expatiated in the following.

Regarding the level of importance in giving attention to RFID technology usage, the result revealed that response to speediness in the business operation was the most important. It had an M of 4.076 and SD of 1.640. This was followed by reducing the errors in business operation with an M of 4.052 and the SD of 1.612 and checking for the sources of the auto-mobile parts origin with an level M of 3.913 and SD of 1.686.

As for business vision, the result revealed that RFID technology adoption into the management of raw materials quantity in inventory was the most important with an level M of 3.985 and SD of 1.692. This was followed by RFID technology adoption into the inventory management with an M of 3.966 and the SD of 1.666, and RFID technology adoption in the management of the amount of ready-product with an M of 3.995 and SD of 1.669.

Due to the importance of strategy planning, it appeared that establishment of strategic plan for the use of RFID technology was the most important an M of 3.976 and SD of 1.564. It was followed by supporting management by RFID technology with an M of 4.081 and SD of 1.590. This was followed by RFID

technology adoption into operational decision with M of 3.985 and SD of 1.637 and maintenance and data backup from the operation by RFID technology with an M of 3.860 and SD of 1.657.

4.2.3.2 Logistics Performance

The logistics performance was the mediator variable. It was divided into two variables, transportation management and effectiveness of transportation. The statistical results of the minimum, maximum, mean, and standard deviation are presented in table 4.4.

Table 4.4 Descriptive Statistics of Mediating Variables

Variable	Min	Max	M	SD
Transportation management				
RFID technology adoption into the follow up of transportation process.	1	7	3.798	1.707
RFID technology adoption to check for the routes of auto-mobile parts.	1	7	3.668	1.711
RFID technology adoption to recall for the damage or under standard automotive parts.	1	7	3.649	1.707
Effectiveness of transportation				
RFID technology adoption on the aspect of customer satisfaction toward the competitiveness in transportation.	1	7	3.682	1.660
RFID technology adoption on the aspect of speed toward the competitiveness in transportation.	1	7	3.726	1.687
RFID technology adoption on the aspect of reliability toward competitiveness in transportation.	1	7	3.851	1.742

Table 4.4 Descriptive Statistics of Mediating Variables (Cont.)

Variable	Min	Max	M	SD
RFID technology adoption on the aspect of responsiveness toward competitiveness in transportation.	1	7	3.855	1.785
Effectiveness of transportation (cont.)				
RFID technology adoption on the aspect of flexibility toward competitiveness in transportation.	1	7	3.726	1.690
RFID technology adoption on the aspect of ability toward competitiveness in transportation.	1	7	3.783	1.729

Where: Min = Minimum, Max = Maximum, M = Mean, SD = Standard Deviation.

Expatiating table 4.4, the statistical results of logistic performance are presented below:

For transportation management, the RFID technology adoption into the follow up of transportation process was the most important. It had an M of 3.798 and SD of 1.707. This was followed by RFID technology adoption to check for the routes of auto-mobile parts with an M of 3.668 and SD of 1.711, and RFID technology adoption to recall for the damage or under standard automobile parts with an M of 3.649 and SD of 1.707.

Regarding effectiveness of transportation, it showed that RFID technology adoption on the aspect of responsiveness toward competitiveness in transportation was the most important. It had an M of 3.855 and SD of 1.785. This was followed by RFID technology adoption on the aspect of reliability toward competitiveness in transportation with an M of 3.851 and SD of 1.742, RFID technology adoption on the aspect of ability toward competitiveness in transportation with an M of 3.783 and SD of 1.729, RFID technology adoption on the aspect of flexibility toward competitiveness in transportation with an M of 3.726 and SD of 1.690, RFID technology adoption on the aspect of speed toward competitiveness in

transportation with an M of 3.726 and the SD of 1.687, and RFID technology adoption on the aspect of customer satisfaction toward the competitiveness in transportation with the importance level M of 3.682 and the SD of 1.660.

4.2.3.3 Supply Chain Management

The supply chain management was the mediator variable. It was divided into three variables expenditure management, administrative management and personnel management. The statistical results of the minimum, maximum, mean, and standard deviation are presented in table 4.5.

Table 4.5 Descriptive Statistics of Mediating Variables

Variable	Min	Max	M	SD
Expenditure Management				
Lower cost of wage.	1	7	3.937	1.711
Lower cost of inventory management.	1	7	3.932	1.709
Lower cost of products purchasing.	1	7	3.971	1.749
Administrative Management				
Transparent level of products stock.	1	7	4.091	1.765
Information into Real-time with better reliability and accuracy.	1	7	4.216	1.790
Reducing the problems of out of stock event.	1	7	4.028	1.713
Helping in better follow up on products movement.	1	7	4.105	1.716
Counting of inventory.	1	7	4.009	1.758
Personnel Management.				
Reducing employees' product stolen.	1	7	3.966	1.589
Reducing the employees' error in operation.	1	7	4.081	1.752

Where: Min = Minimum, Max = Maximum, M = Mean, SD = Standard Deviation.

According to table 4.5 the statistical results of supply chain management are shown as follows:

For expenditure management, lower cost of products purchasing was the most important It had an M of 3.971 and SD of 1.749. This was followed by lower cost of wage with an M of 3.937 and SD of 1.711, and lower cost of inventory management with an M of 3.932 and the SD of 1.709.

Regarding administrative management, it showed that Information into Real-time with better reliability and accuracy was the most important. It had an M of 4.216 and SD of 1.790. This was followed by helping in better follow up on products movement with an M of 4.105 and SD of 1.716, transparent in level of products stock with an M of 4.091 and SD of 1.765, reducing the problems of out of stock event with an M of 4.028 and SD of 1.713, and counting of inventory with an M of 4.009 and SD of 1.758.

Regarding personnel management, it showed that reducing the employees' error in operation was the most important. It had an M of 4.081 and SD of 1.752. This was followed by reducing employees' product stolen with an M of 3.966 and SD of 1.589.

4.2.3.4 Operational Performance

The operational performance was the dependent variable of the study. It was divided into five variables including increasing the effectiveness of operation, reducing the cost of inventory, reducing the cost of operation, generating more preciseness and punctuality in operation, and recognizing the levels of inventory in operation. The statistical results of the minimum, maximum, mean, and standard deviation are presented in table 4.6.

Table 4.6 Descriptive Statistics of Dependent Variables

Variable	Min	Max	M	SD
Using RFID technology to increase the organizational effectiveness				
Can help increase the effectiveness in the operation.	1	7	4.115	1.637
Can help reduce the cost of inventory.	1	7	4.038	1.727
Can help reducing the cost of operation.	1	7	4.120	1.755
Can help generate more preciseness and punctuality in operation.	1	7	4.216	1.760
Can help recognize the levels of inventories in the operation.	1	7	4.192	1.756

Where: Min = Minimum, Max = Maximum, M = Mean, SD = Standard Deviation.

According to table 4.6, the statistic results of operational performance were generated more preciseness and punctuality in the operation and was of greatest. It had benefit an M of 4.216 and SD of 1.760. This was followed by recognizing the levels of inventory in the operation with a M of 4.192 and SD of 1.756, reducing the cost of operation with an M of 4.120 and SD of 1.755, increasing the effectiveness in the operation with an M of 4.115 and SD of 1.637 and reducing the cost of inventory with an M of 4.038 and SD of 1.637.

4.2.4 Structural Equation Model

4.2.4.1 Reliability Testing

One of the structural equation model analysis requirement, the observed variables should have the reliability. The Cronbach's alpha above .7 is a criterion for acceptance. After testing the reliability, the results of the group of variables are shown in table 4.7.

Table 4.7 Reliability Statistics

Variable	Cronbach's Alpha	Mean	Std
RFID utilization			
RFID_2	.962	4.052	1.612
RFID_3	.962	3.913	1.686
RFID_5	.960	3.966	1.666
RFID_6	.960	3.995	1.669
RFID_7	.964	3.976	1.564
RFID_8	.964	4.081	1.590
RFID_4	.961	3.985	1.692
Supply chain management			
SCM_9	.951	3.966	1.589
SCM_7	.914	4.105	1.716
SCM_5	.919	4.216	1.790
SCM_2	.926	3.932	1.709
Logistics performance			
LOG_3	.966	3.649	1.707
LOG_4	.963	3.682	1.660
LOG_5	.962	3.726	1.687
LOG_9	.965	3.783	1.729
LOG_2	.967	3.668	1.711
LOG_6	.964	3.851	1.742
Operational performance			
OP_5	.957	4.192	1.756
OP_4	.956	4.216	1.760
OP_3	.955	4.120	1.755
OP_2	.958	4.038	1.727

Where: Std = Standard Deviation.

Table 4.7 indicated the results of the reliability testing. It is expatiated as follows.

RFID utilization

The final Cronbach's alpha was 0.967. RFID_1 had Cronbach's alpha of 0.962 (M = 4.052) with SD of 1.612, while RFID_2 had Cronbach's alpha of 0.962 (M = 3.913) with SD of 1.686. This was followed by RFID_3 with Cronbach's alpha of 0.960 (M = 3.966) and SD of 1.666, RFID_4 had Cronbach's alpha of 0.960 (M = 3.995) with the SD of 1.669, RFID_5 had Cronbach's alpha of 0.964 (M = 3.976) with SD of 1.564, RFID_6 had Cronbach's alpha of 0.964 (M = 4.081) with SD of 1.590, and RFID_7 had Cronbach's alpha of 0.961 (M = 3.985) with SD of 1.692. Thus, it could be concluded that the RFID utilization instrument of the study is reliable for the measurement of RFID utilization.

Supply chain management

The final Cronbach's alpha was 0.945. SCM_1 had Cronbach's alpha of 0.951 (M = 3.966) with SD of 1.589, while SCM_2 had Cronbach's alpha of 0.914 (M = 4.105) with SD of 1.716. This was followed by SCM_3 with Cronbach's alpha of 0.919 (M = 4.216) and SD of 1.790, and SCM_4 with Cronbach's alpha of 0.926 (M = 3.932) and SD of 1.709. Thus, it could be concluded that the supply chain management instrument of the study is reliable for the measurement of supply chain management.

Logistics performance

The final Cronbach's alpha was 0.970. LOG_1 had Cronbach's alpha of 0.966 (M = 3.649) with SD of 1.707, while LOG_2 had Cronbach's alpha of 0.963 (M = 3.682) with the SD of 1.660. This was followed by LOG_3 with Cronbach's alpha of 0.962 (M = 3.726) and SD of 1.687, LOG_4 had Cronbach's alpha of 0.965 (M = 3.783) with SD of 1.729, LOG_5 had Cronbach's alpha of 0.967(M = 3.668) with SD of 1.711, and LOG_6 with Cronbach's alpha of 0.964 (M = 3.851) and SD of 1.742. Thus, it could be concluded that the logistics performance instrument of the study is reliable for the measurement of logistics performance.

Operational performance

The final Cronbach's alpha was 0.967. OP_1 had Cronbach's alpha of 0.957(M = 4.192) with SD of 1.756, while OP_2 had Cronbach's alpha of 0.956 (M =

4.216) with SD of 1.760. This was followed by OP_3with Cronbach's alpha of 0.955 (M = 4.120) and SD of 1.755, and OP_4 with Cronbach's alpha of 0.958 (M = 4.038) and SD of 1.727. Thus, it could be concluded that the operational performance instrument of the study is reliable for the measurement of operational performance. According to all variables, Cronbach's alpha scores were greater than .7 indicating that they had reliability.

4.2.4.2 Construct Validity

The next testing before creating a model for the structural equation model analysis included convergent validity testing and discriminant validity testing**.** The convergent validity testing was performed to verify that the indicators could represent latent variable whereas discriminant validity testing was performed to show that the observed variable represented the same latent variable and was not associated with the observe variable of the other latent variables**.**

Convergent validity

Convergent validity assesses the extent to which the indicators can be represented in latent variable. In other words, convergent validity examines the degree to which the measurement is similar to other measurements theoretically. In this study, convergent validity was assessed by factor loadings. The factor loading of all items should exceed 0.6, and the factor loading from 0.3 to 0.4 were considered to meet the minimal level for interpretation of the structure.

The convergent validity used in structural equation model analysis for assessing variables that were correct with latent variables. The CFA (Confirm Factor Analysis) was the method for testing. After CFA analysis was done, if they were grouped in the same group, this indicated that they were good represention of latent variables (Hair, Black, Babin, & Anderson, 2009; J. F. Hair, Black, Babin, Anderson, & Tatham, 2009). If this value is satisfactory, the CFA would be considered as the data-fit model (Arbuckle, 2011) . Convergent validity was evaluated with an average variance extracted (AVE). It was accepted when AVE was more than or equal to 0.5.(Fornell & Larcker, 1981; Hair Jr, 2005) AVE was calculated based on the calculation formula as follows:

$$AVE = \frac{\sum_{i=0}^{n} Li^2}{n} > 0.5$$

The researcher measured convergent validity with confirm factor analysis (CFA)**.** If the observed variable is the best represention of latent variable, factor loading should be above **.**6**.** In addition, all average variance extracted **(**AVE**)** of all variables were not above **.**5, and composite reliability **(**CR**)** of all variables were not also above **.**6**.**

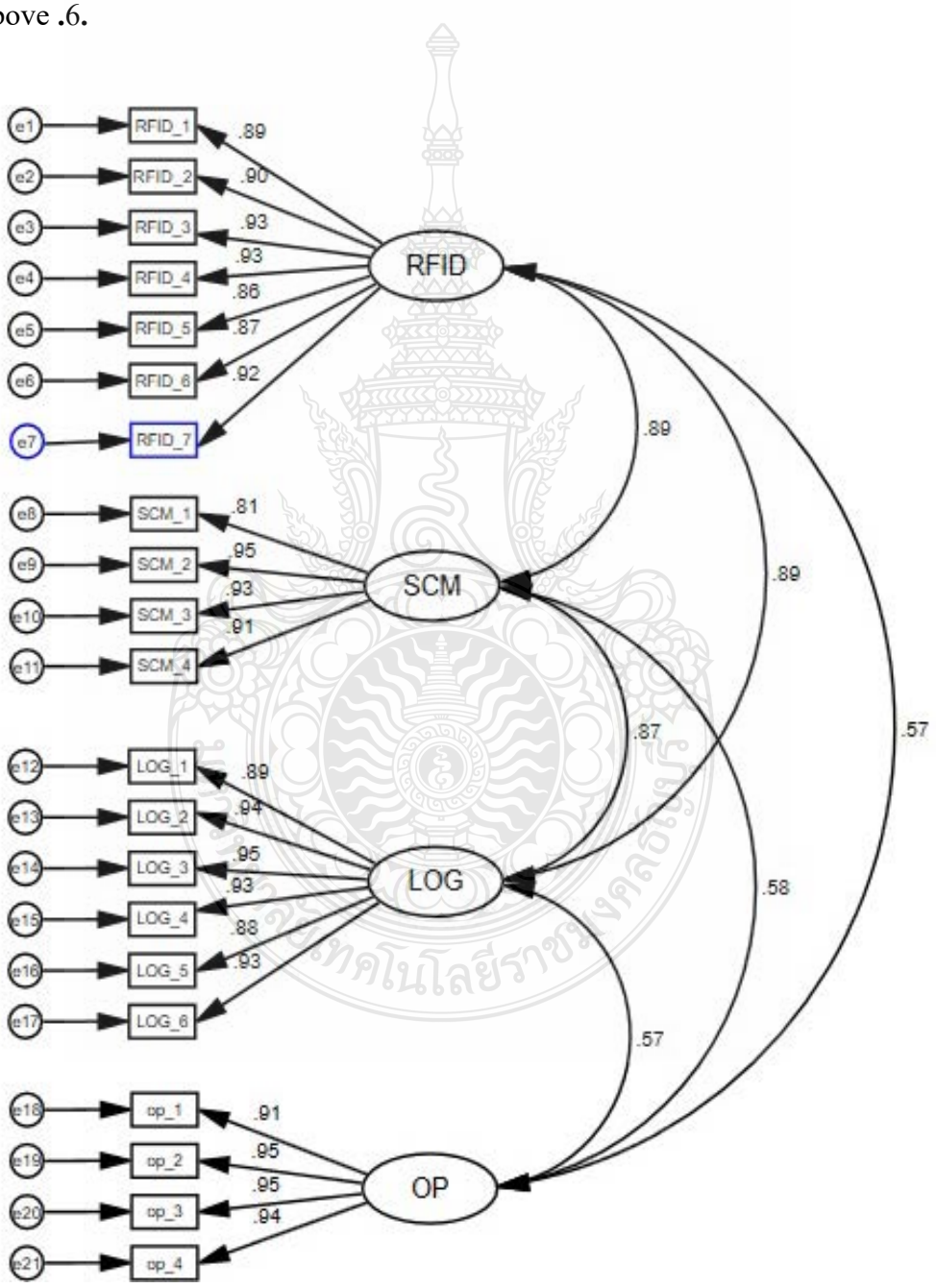

Figure 4.1 Measurement Model

Table 4.8 Factor Loading, Critical Ratio, R^2, Composite Reliability, Average Variance Extracted of Independent Variable 1 (RFID utilization)

Variable	**Factor Loading**	***t***	R^2	**Composite Reliability**	**AVE**
RFID utilization				0.967	0.900
RFID_2	0.89	36.2	0.80		
RFID_3	0.90	33.4	0.80		
RFID_5	0.93	34.3	0.86		
RFID_6	0.93	34.51	0.86		
RFID_7	0.86	36.6	0.73		
RFID_8	0.87	37.0	0.76		
RFID_4	0.92	33.9	0.85		

Table 4.9 Factor Loading, Critical Ratio, R^2, Composite Reliability, Average Variance Extracted of Mediating Variable (Supply chain management)

Variable	**Factor Loading**	***t***	R^2	**Composite Reliability**	**AVE**
Supply chain management				0.945	0.901
SCM_9	0.81	35.9	0.66		
SCM_7	0.95	34.5	0.90		
SCM_5	0.93	33.9	0.87		
SCM_2	0.91	33.1	0.83		

Table 4.10 Factor Loading, Critical Ratio, R^2, Composite Reliability, Average Variance Extracted of Mediating Variable (Logistic performance)

Variable	Factor Loading	*t*	R^2	Composite Reliability	AVE
Logistic performance				0.970	0.920
LOG_3	0.89	30.8	0.80		
LOG_4	0.94	31.9	0.88		
LOG_5	0.95	31.8	0.89		
LOG_9	0.93	31.5	0.86		
LOG_2	0.88	30.9	0.87		
LOG_6	0.93	31.8	0.86		

Table 4.11 Factor Loading, Critical Ratio, R^2, Composite Reliability, Average Variance Extracted of Dependent Variable (Operational performance)

Variable	Factor Loading	*t*	R^2	Composite Reliability	AVE
Operational performance				0.967	0.937
OP_5	0.91	34.4	0.83		
OP_4	0.95	34.5	0.90		
OP_3	0.95	33.8	0.91		
OP_2	0.94	33.7	0.88		

According to the testing results from table 4.8, 4.9, 4.10 and 4.11, in the test of the model measurement, the researcher has assessed two types of validity: convergent validity and discriminant validity.

The values from the convergent validity test on factor loading were above 0.6 where the loading ranged from 0.86 to 0.95, and each was more than 0.6 indicating that the result was accepted. The value of *t*-test from the test ranged from

30.8 to 37.0 which were an acceptable value. The value of R^2 from the test ranged from 0.80 to 0.91 which were an acceptable value. Composite reliability ranged from 0.94 to 0.96, which suggested the acceptability of the construct reliability. Regarding the AVE, it was more than 0.5 and was also an acceptable value(Fornel & Larcker, 1981). The AVEs according to the test ranged from 0.90 to 0.93, which indicated acceptability.

4.2.4.3 Discriminant Validity

The squared correlation values ranged from 0.57 to 0.89 which were equal or more than 0.2 but not over 1.00. The testing result of the squared correlation was then accepted. This kind of discriminant validity could be checked from the comparison between AVE value and the squared correlation (J. F. Hair, 2010). Finally, the researcher proved on the discriminant validity of the instrument by examining the AVE which should be more than the squared correlation as recommended by Fornell and Larcker (1981).

Discriminant validity testing was performed to show observed variable representing the same latent variable and was not associated with other observed variable of the other latent variables. It provided evidence that the construct was unique and captured some phenomena that were not similar to other constructs. This study has verified the discriminant validity of the instrument by examining based on the following criteria. (Fornell & Larcker, 1981) $\sqrt{AVE} > r^2\,(correlation)$

The testing results showed that the values obtained supported the discriminant validity as shown in table 4.12. The value of AVE for each construct was greater than the level of correction involving the construct.

Table 4.12 Discriminant validity

	RFID	**SCM**	**LOG**	**OP**
RFID	0.90			
SCM	0.89	0.90		
LOG	0.89	0.87	0.92	
OP	0.57	0.58	0.57	0.93

Where : RFID = RFID utilization, SCM = Supply chain management

LOG = Logistics performance, OP = Operational performance

4.2.5 Research Model

4.2.5.1 Model One: The effects of RFID utilization on operational performance are shown in figure 4.2.

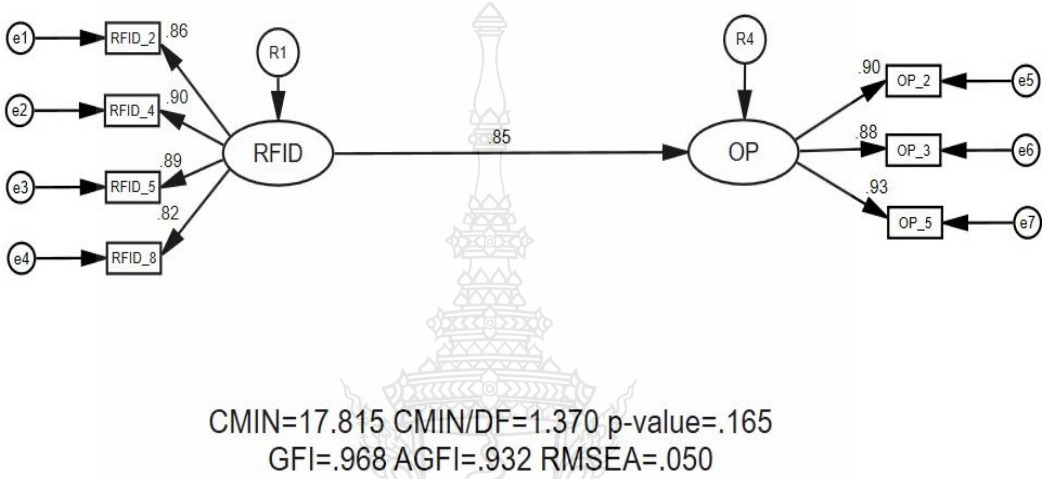

Figure 4.2 Construct Model One.

The objective of creating model one was to investigate the effects of RFID utilization on operational performance. The model fit testing was conducted following the methodology stated as the analysis of structure equation model in chapter three.

The results of the model fit testing was as follows: Chi-Square = 17.815, Degree of freedom = 13, Chi-Square/Degree of freedom = 1.370 , p-value = .165, GFI = 0.968, AGFI = 0.932, RMR = 0.053, RMSEA = 0.050 (PCLOSE = 0.457), NFI = 0.982, CFI = 0.995, and Hoelter = 235 (0.01) as shown in table 4.13.

Table 4.13 Measuring of Model Fit of Model One.

Model Fit Criteria	Value	Acceptable Level value
Chi-Square	17.815	-
Degree of freedom	13	-
Chi-Square/Degree of freedom	1.370	Less than 2
p-value	0.165	*P* > .05
GFI	0.968	>= 0.90
AGFI	0.932	>=0.80
RMR	0.053	Close to zero
RMSEA	0.050	< 0.10
NFI	0.982	> 0.90
CFI	0.995	> 0.90
Holelter	235	> 200

After analyzing model one, it showed that RFID utilization (RFID) had a positive direct effect on operational performance (OP) ($\beta = 0.85$).

The results of significance for the final model one are presented in table 4.14. The model one demonstrated is statistically significant at the significance level of 0.001.

Table 4.14 Hypothesis Testing of Model One

			Estimate	S.E.	C.R.	*p*-value
H6: RFID	→	OP	0.884	0.069	12.740	***

****p*-value < 0.001 (*p*-value less than 0.001 was at the significance level of 0.001)

4.2.5.2 Model Two: The effects of RFID utilization on operational performance through supply chain management and logistics performance are shown in figure 4.3.

The objective of creating model was to investigate the RFID utilization on operational performance through supply chain management and logistics

performance. After creating the model, the model fit testing was conducted following the methodology stated in the analysis of structure equation model in chapter three.

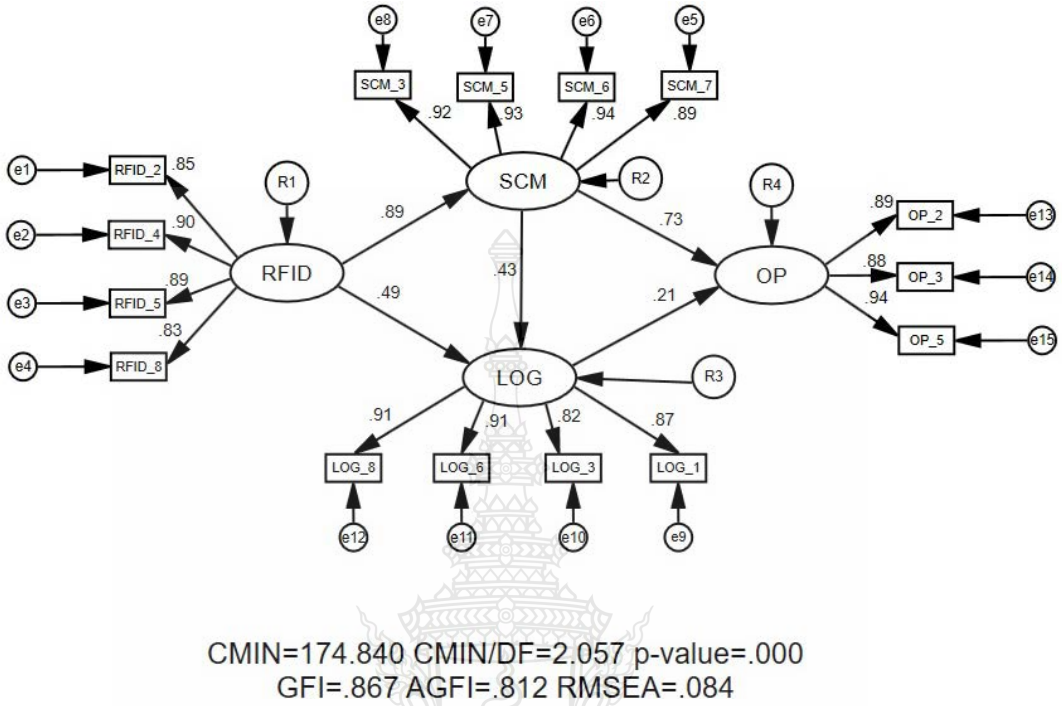

Figure 4.3 Construct Model Two.

The results of the model fit testing are as follows: Chi-Square = 174.84, Degree of freedom = 85, Chi-Square/Degree of freedom = 2.057, p-value = .000, GFI = 0.867, AGFI = 0.812, RMR = 0.077, RMSEA = 0.084 (PCLOSE = 0.001), NFI = 0.936, CFI = 0.966, and Hoelter = 103 (0.01) as shown in table 4.15.

Table 4.15 Measuring of Model Fit of Model Two

Model Fit Criteria	Value	Acceptable Level value
Chi-Square	174.84	-
Degree of freedom	85	-
Chi-Square/Degree of freedom	2.057	Less than 2
p-value	.000	*P* > .05
GFI	0.867	>= 0.90

Table 4.15 Measuring of Model Fit of Model Two (Cont.)

Model Fit Criteria	Value	Acceptable Level value
AGFI	0.812	>=0.80
RMR	0.077	Close to zero
RMSEA	0.084	< 0.10
NFI	0.936	> 0.90
CFI	0.966	> 0.90
Holelter	103	> 200

According to table 4.15, the modification indices were adjusted to the model by adding covariance between residual error as follow: e3 and e6, e12 and e14. After the model was modified, the results of model fit were as follows: Chi-Square = 62.456, Degree of freedom = 47, Chi-Square/Degree of freedom = 1.329, p-value = .065, GFI = 0.931, AGFI = 0.885, RMR = 0.051, RMSEA = 0.048 (PCLOSE = 0.521), NFI = 0.969, CFI = 0.992, and Hoelter = 168 (0.01) as shown in table 4.16.

Table 4.16 Measuring of Model Fit of Model Two After Modification Indices

Model Fit Criteria	Value	Acceptable Level value
Chi-Square	62.456	-
Degree of freedom	47	-
Chi-Square/Degree of freedom	1.329	Less than 2
p-value	0.065	*P* > .05
GFI	0.931	>= 0.90
AGFI	0.885	>=0.80
RMR	0.051	Close to zero
RMSEA	0.048	< 0.10
NFI	0.969	> 0.90
CFI	0.992	> 0.90
Holelter	168	> 200

According to table 4.16, the results of the model fit testing were consistent with data. The diagram of model two is depicted in figure 4.4.

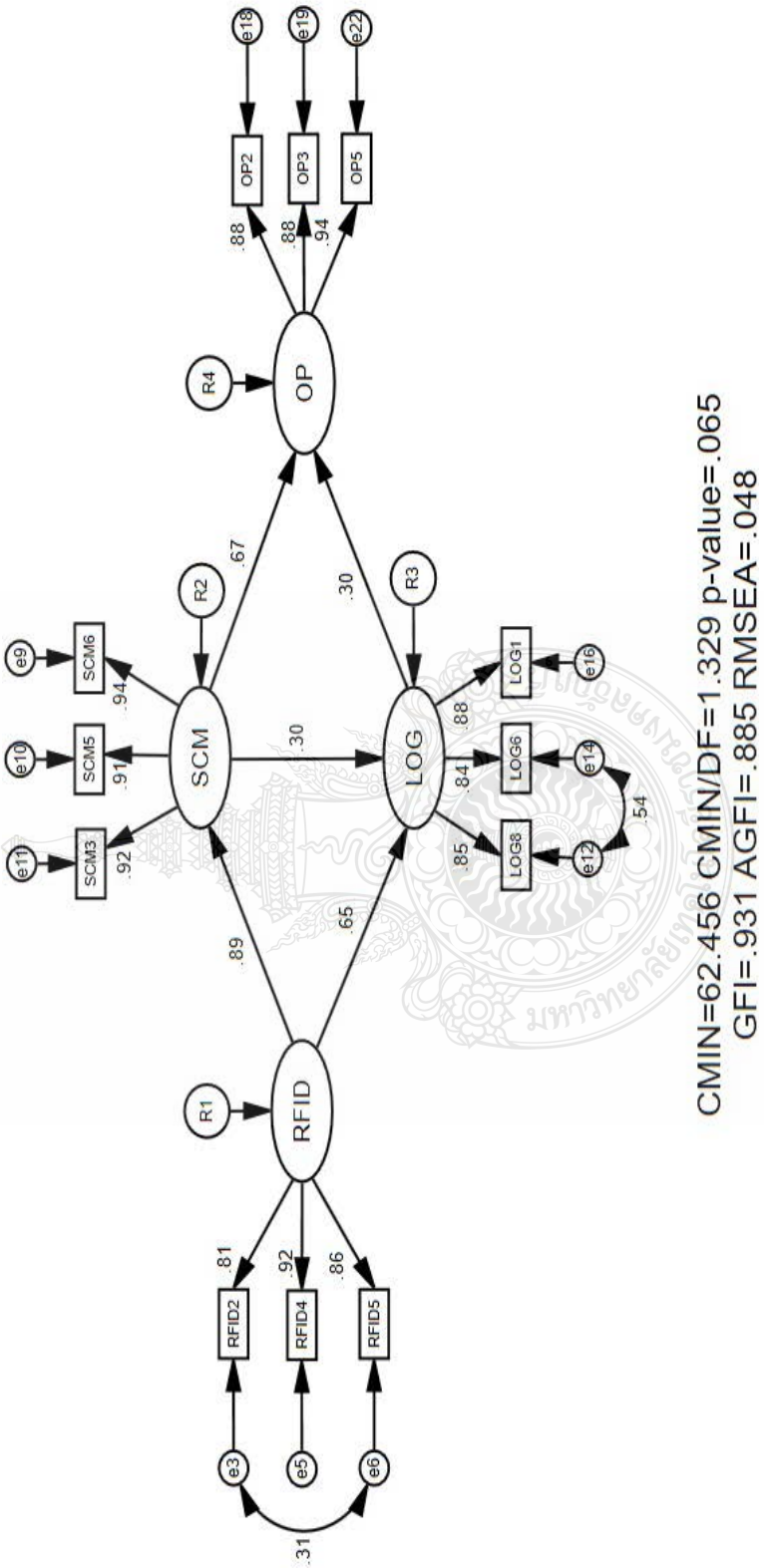

Figure 4.4 Standardized Estimates Effects of RFID Utilization on Operational Performance through Supply Chain Management and Logistics Performance

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After analyzing the model, it indicated that RFID utilization (RFID) had a positive direct effect on supply chain management (SCM) (β = 0.89), and RFID utilization (RFID) also had a positive direct effect on logistics performance (LOG) (β = 0.65). In addition, supply chain management (SCM) had a positive in direct effect on logistics performance (LOG) (β = 0.30), and supply chain management (SCM) had a positive direct effect on operational performance (OP) (β = 0.67) while logistics performance (LOG) had a positive direct effect on operational performance (OP) (β = 0.30). Finally, RFID utilization (RFID) had a positive indirect effect on logistics performance (LOG) (β = 0.28), and RFID utilization (RFID) had a positive indirect effect on operational performance (OP) (β = 0.86), while supply chain management (SCM) had a positive indirect effect on operational performance (OP) (β = 0.08). These indicated that both RFID utilization had positive effects on operational performance through supply chain management and logistics performance.

The results of significance for the model two are presented in table 4.17 and 4.18.

Table 4.17 Hypothesis Testing of Model Two

			Estimate	**S.E.**	**C.R.**	***p*-value**
H1: RFID	→	SCM	0.949	0.076	12.498	***
H2: RFID	→	LOG	0.656	0.156	4.198	***
H3: SCM	→	LOG	0.284	0.140	2.029	0.042
H4: SCM	→	OP	0.676	0.119	5.702	***
H5: LOG	→	OP	0.317	0.126	2.518	0.012

****p*-value < 0.001 (*p*-value less than 0.001 was at the significance level of 0.001)

Table 4.18 Standardized Direct, Indirect, and Total Effects among Variables

Dependent Variable	R^2	Direct Effect				Indirect Effect				Total Direct Effect			
		RFID	SCM	LOG	OP	RFID	SCM	LOG	OP	RFID	SCM	LOG	OP
SCM	0.79	0.89	-	-	-	-	-	-	-	0.89	-	-	-
LOG	0.82	0.65	0.30	-	-	0.26	-	-	-	0.92	0.30	-	-
OP	0.86	-	0.66	0.30	-	0.86	0.08	-	-	0.86	0.75	0.30	-

According to table 4.18, it can be expressed by equation as below:

SCM = 0.89*RFID ; R2 = 0.79

LOG = 0.92*RFID + 0.30*SCM ; R2 = 0.82

OP = 0.86*RFID + 0.75*SCM + 0.30*LOG ; R2 = 0.86

Where :

RFID = RFID utilization

SCM = Supply chain management

LOG = Logistics performance

OP = Operational performance

The coefficients of determinant (R2) indicated that RFID utilization had an effects on supply chain management with the accuracy of 79%, RFID utilization had an effects on logistics performance with an accuracy of 82%, supply chain management and logistics management had an effect on operational performance with an accuracy of 86%.

4.2.5.3 Summary of Model Analysis

According to the model one, the research finding of the relationship between RFID utilization on operational performance was that RFID utilization has the positive direct effects on operational performance.

As for the model two, the research finding of the effects of RFID utilization on operational performance through supply chain management and logistics performance, first of all, RFID utilization had a positive effect on supply chain management (H1), and RFID utilization had a positive effect on logistic performance (H2), supply chain management had a positive effect on logistic performance (H3),

supply chain management had a positive effect on operational performance (H4), logistics performance had a positive effect on operational performance (H5). However, RFID utilization had a positive indirect effect on operational performance through supply chain management and logistics performance as presented in figure 4.5.

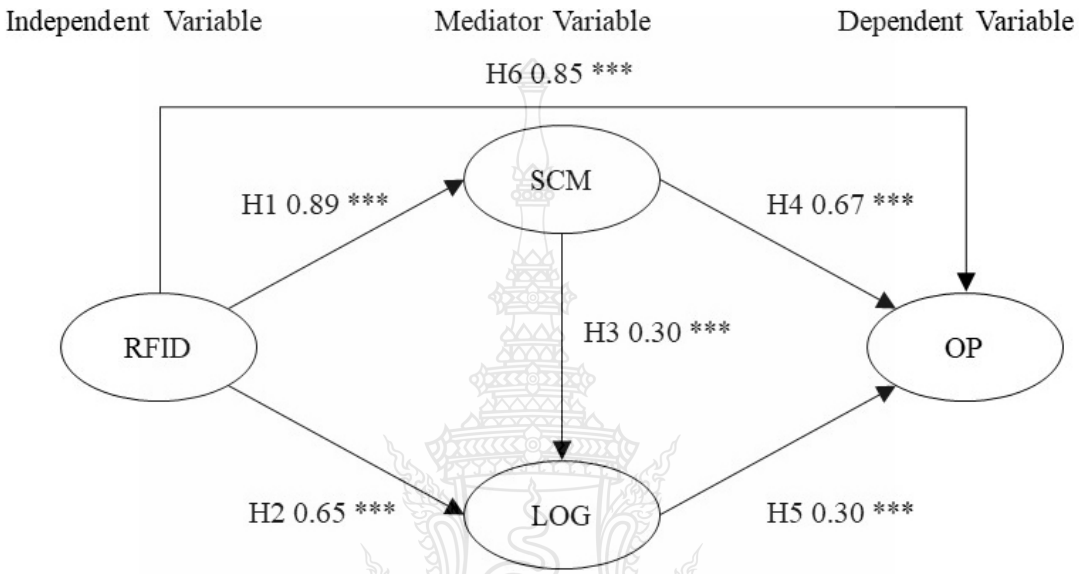

Figure 4.5 Model Analysis

4.2.6 Hypothesis Testing

According to the three research questions including 1) How does RFID utilization affect operational performance in the automotive parts industry?, 2) How does RFID utilization affect operational performance through supply chain management and logistics performance in the automotive parts industry?, and 3) How does supply chain management affect logistics performance in the automotive parts industry? The hypotheses shown in figure 4.4 (Model analysis) were then tested to answer the research questions, and these hypotheses were the following:

H1: Using RFID can have a positive impact on supply chain management.

The result of the analysis of the relationship between RFID and SCM, the result showed that the model had β = 0.89, indicating that RFID utilization had a positive effect on supply chain management, so the hypothesis H1 was supported.

Considering the relationship found above and based on the aspect of paying attention to RFID technology usage, it could be explained that business pays attention to RFID technology adoption to reduce the errors in the business operation, and business pays attention to RFID technology adoption to check for the sources of the auto-mobile parts origin. As for the aspect of business vision, business considers three things as important including (1) RFID adoption into the management of raw materials quantity in inventory, (2) RFID adoption into the inventory management, and (3) RFID adoption in the management of the amount of ready-product. Due to the aspect of strategy planning, it revealed that business considers an importance of (1) establishment of strategic plan for the use of RFID technology, and (2) supporting of management by RFID technology. Consequently, these variables influenced the process of supply chain management.

H2: Using RFID has the positive impact on logistics performance.

According to the analysis of the relationship between RFID and LOG, the result showed that the model had $\beta = 0.65$, indicating that RFID utilization had a positive effect on logistics performance, so the hypothesis H2 was supported.

Considering the relationship found above and based on the aspect of paying attention to RFID technology usage, it could be explained that business pays attention to RFID technology adoption to reduce the errors in the business operation, and business pays attention to RFID technology adoption to check for the sources of the auto-mobile parts origin. As for the aspect of business vision, business considers three things as important including: (1) RFID adoption into the management of raw materials quantity in inventory, (2) RFID adoption into the inventory management, and (3) RFID adoption in the management of the amount of ready-product. Due to the aspect of strategy planning, it revealed that business considers an importance of (1) establishment of strategic plan for the use of RFID technology, and (2) supporting of management by RFID technology. Consequently, these variables influenced the process of logistics performance.

H3: Supply chain management has a positive impact on logistics performance

According to an analysis of the relationship between SCM and LOG, the result showed that the model had $\beta = 0.30$, indicating that supply chain management had a positive effect on logistics performance, so the hypothesis H3 was supported.

Considering the relationship found above and based on the aspect of expenditure management, it could be concluded that business considers the importance of the lower cost of inventory management. Regarding administrative management aspect, business considers the importance of (1) the information into real-time with better reliability and accuracy and (2) counting of inventory. Finally, in terms of personal management, business considers the importance of (1) reducing employees' error in operation. Consequently, these variables influenced the process of logistics performance.

H4: Supply chain management has a positive impact on operational performance.

According to an analysis of the relationship between SCM and OP, the result showed that the model had $\beta = 0.67$, indicating that supply chain management had a positive effect on operational performance, so the hypothesis H4 was supported.

Considering the relationship found above and based on the aspect of expenditure management, it could be concluded that business considers the importance of the lower cost of inventory management. Regarding administrative management aspect, business considers the importance of (1) the information into Real-time with better reliability and accuracy and (2) counting of inventory. Finally, in terms of personal management, business considers the importance of reducing the employees' error in operation. Consequently, these variables influence the process of supply chain performance.

H5: Logistic performance has a positive impact on operational performance.

Regarding the analysis of the relationship between LOG and OP, the result showed that the model had $\beta = 0.30$ indicating that logistics performance had a positive effect on operational performance, so the hypothesis H5 was supported.

Considering the relationship found above and based on the aspect of transportation, it could be concluded that business considers the importance of (1) RFID technology adoption in checking for the routes of auto-mobile parts and (2) RFID technology adoption to recall for the damage or under standard automobile parts. Finally, in terms of effectiveness in transportation, business considers the importance of (1) RFID technology adoption on the aspect of customer satisfaction toward

competitiveness in transportation, (2) RFID technology adoption on the aspect of speed toward competitiveness in transportation, (3) RFID technology adoption on the aspect of reliability toward competitiveness in transportation and (4) RFID technology adoption on the aspect of ability toward competitiveness in transportation. Consequently, these variables influenced the process of operational performance.

H6: Using RFID has a positive impact on operational performance.

Regarding an analysis of the relationship between RFID and OP, the result showed that the model had $\beta = 0.85$ indicating that Using RFID has the positive impact on operational performance, so the hypothesis H6 was supported.

Considering the relationship found above and based on the aspect of paying attention to RFID technology usage, it could be explained that business pays attention to RFID technology adoption to reduce the errors in business operation, and business pays attention to RFID technology adoption to check for the sources of the auto-mobile parts origin. As for the aspect of business vision, business considers the importance of three things including (1) RFID adoption into the management of raw materials quantity in inventory, (2) RFID adoption into the inventory management, and (3) RFID adoption in the management of the amount of ready-product. The aspect of strategy planning revealed that business considers the importance of (1) establishment of strategic plan for the use of RFID technology, and (2) supporting of management by RFID technology.

Consequently, these variables influenced the process of operational performance. The summary of hypothesis testing is presented in table 4.24.

Table 4.19 Summary of Hypothesis Testing

Hypothesis	Result
H1: Using RFID can have a positive impact on the supply chain management.	Supported
H2: Using RFID has a positive impact on logistics performance.	Supported
H3: Supply chain management has a positive impact on logistics performance.	Supported
H4: Supply chain management has a positive impact on operational performance.	Supported

Table 4.19 Summary of Hypothesis Testing (Cont.)

Hypothesis	Result
H5: Logistic performance has a positive impact on operational performance.	Supported
H6: Using RFID has a positive impact on operational performance.	Supported

4.3 The Qualitative Result

This section contains the qualitative research result that used the in-depth interview with the IT leaders. The result confirmed the result of the quantitative research. The results of all interviews are shown in the following:

Table 4.20 Results of In-Depth Interview Question 1 How does your business give importance to RFID technology usage?

Respondents	Answer
IT Leader Company1	The company pays attention to using RFID on the part of manufacturing to help increase the potential of traceability as well as to quickly recall the data from RFID.
IT Leader Company2	The company pays attention to RFID usage to increase the correctness in product counting and the part of transportation.
IT Leader Company3	The company uses RFID technology to know the background of any parts from finished good.
IT Leader Company4	Using RFID in the firm for the need of speed in work no matter the aspect of product delivery. Before, the company could not deliver products on time, so the company was fined. Then, RFID is also used to reduce the mistake in work.

Table 4.20 Results of In-Depth Interview Question 1 How does your business give importance to RFID technology usage? (Cont.)

Respondents	Answer
IT Leader Company5	The company begins to use RFID on the part of logistics first by using with the part of finished goods in follow up or transportation.

Table 4.21 Results of In-Depth Interview Question 2 What is the main objective of using RFID?

Respondents	Answer
IT Leader Company1	Use for product traceability in since the production line of car compressor air condition in automation production. RFID technology is so important because the system will automatically record the data into RFID.
IT Leader Company2	The company wants to adopt it to use for the correctness in products counting and protecting products loss in delivery process.
IT Leader Company3	The objective of using RFID consists of two parts which are: 1. Traceability and 2. To reduce the problem of parts loss.
IT Leader Company4	Mostly, for the traceability of part in manufacturing. This makes the company know how much is product is produced, manufacturing date, and help make it easier to find information. If the company has bad traceability, it could be fined.
IT Leader Company5	It is the policy of SCG management.

Table 4.22 Results of In-Depth Interview Question 3 Why does your business use RFID technology?

Respondents	Answer
IT Leader Company1	Because the products are different in each piece, RFID is then used in data collection and record. Essentially, the essence of RFID is on the part of traceability.
IT Leader Company2	As RFID technology is used according to the standard of ISO/TS 16949: 2002 system and automobile company under this standard much adopt RFID.
IT Leader Company3	A guideline for logistic tasks as in Wal-Mart company.
IT Leader Company4	The reason RFID is used is that customer's need. The customer here is Honda company because in SCM process at Honda; RFID is used to receive the product from the firm.
IT Leader Company5	The company has to pay attention to innovation and new technology, so RFID technology is used in the firm.

Table 4.23 Results of In-Depth Interview Question 4 What are your business products that make use of RFID technology?

Respondents	Answer
IT Leader Company1	Air condition of the car is produced for Ford, Mazda, Nissan, and MG.
IT Leader Company2	Lower arm of the front wheels and speed foot gear and clutch.
IT Leader Company3	On the part of product that company uses RFID, relates to other composition such as spoiler, exterior parts such as tank in the car.

Table 4.23 Results of In-Depth Interview Question 4 What are your business products that make use of RFID technology? (Cont.)

Respondents	Answer
IT Leader Company4	The parts that use RFID is exhaust system, smoke filter of the engine.
IT Leader Company5	Now it is not used since it still be in the testing process but RFID tag is used in pallets of finished goods that would be shipped to the customer's company.

Table 4.24 Results of In-Depth Interview Question 5 How is RFID technology crucial in your SCM and Logistics processes?

Respondents	Answer
IT Leader Company1	It is important to have data management related to key qualifications of the parts such as dimensions which is the detailed task.
IT Leader Company2	RFID technology in the company presently consists of the part of WIP, asset tracking, warehouse and the part of inventory.
IT Leader Company3	RFID is important for the SCM and logistics process in the aspect of work in process.
IT Leader Company4	The company can know about the manufacturing date, the amount of production from the manufacturing process until the process of shipping the products to customer.
IT Leader Company5	As the company tests to use RFID system on Logistics, it has found that RFID usage is very efficient in product transportation since it can lessen time for product count compared to manual working.

Table 4.25 Results of In-Depth Interview Question 6 What part of your business has RFID taken the main role in SCM and Logistics management?

Respondents	Answer
IT Leader Company1	RFID plays the crucial role in SCM in the manufacturing process since it has the ability of traceability which so crucial instead of using manual to check for required number of employees.
IT Leader Company2	RFID technology takes the role on SCM in transportation aspect at most.
IT Leader Company3	RFID takes the most role in work in process, warehouse, inventory and logistics / transportation
IT Leader Company4	On the production, the company uses RFID in the manufacturing process mostly outgoing of part of production for products distribution to customers.
IT Leader Company5	Currently, RFID has been used in logistics for one year and being developed to Full SCM form.

Table 4.26 Results of In-Depth Interview Question 7 How can RFID increase the competitive potential for automobile parts manufacturing industry on SCM and Logistics?

Respondents	Answer
IT Leader Company1	It can help on productivity, correctness of information, quick traceability, more convenience in work, and consume less time.
IT Leader Company2	Bringing RFID technology to use can increase the efficiency for the firm on the aspect of speed and work efficiency. Besides, it has high correctness and reduces the problem of loss for almost 100%.

Table 4.26 Results of In-Depth Interview Question 7 How can RFID increase the competitive potential for automobile parts manufacturing industry on SCM and Logistics? (Cont.)

Respondents	Answer
IT Leader Company3	After RFID use began around July 2008, it was found that there were less mistakes in operation as well as the company can get the information in real-time as well as the sources where the parts came from.
IT Leader Company4	Complex task turns to be easier and data from manufacturing process are more correct.
IT Leader Company5	Increasing the ability in products delivery and data tracking, reducing users, costs and products in stock in more effective way.

Table 4.27 Results of In-Depth Interview Question 8 Does your business gather existing information technology to connect with RFID?

Respondents	Answer
IT Leader Company1	Bringing SPC (statistical process control) system which is a single system that connects with RFID system.
IT Leader Company2	The company brings RFID technology to use with Stock control system of the firm.
IT Leader Company3	It is also connected with SAP (system and kamban system).
IT Leader Company4	The company has not merged with existing IT system since it is complicated and the firm now uses RFID only in manufacturing.
IT Leader Company5	Recently, RFID system is used in the part of Pallet tacking in Logistics which is the first part that in the future it may be connected with the firm's IT system such as SAP etc.

Table 4.28 Results of In-Depth Interview Question 9 What are the benefits of RFID technology in efficiency weation for SCM and Logistics in your business?

Respondents	Answer
IT Leader Company1	Benefits from RFID are traceability that makes it easier for products information searching and to give a highly correct result. Besides, this makes it easier in product data searching and gives a highly correct information. Besides, it can save cost in hiring staff for products checking.
IT Leader Company2	Benefits from RFID technology adoption can result in the company operation on the aspect of intangible benefit such as allowing the company to work in more convenient ways and reducing problems for almost 100 %.
IT Leader Company3	The benefits of bringing RFID to use makes it useful for products delivery to customers as it reduces time of transportation and allows the company to know about products in stock and location.
IT Leader Company4	Adopting RFID helps us know the inventory amount on how much products have been used and it is the correct stock counting. Besides, it has the ability of traceability that can tell if the products are shipped to customers by RFID quickly confirms the data.
IT Leader Company5	The RFID can reduce time for products seeking, help control access and save time that allows for the quick response to customers.

Table 4.29 Results of In-Depth Interview Question 10 How can RFID technology usage affect the operational performance after SCM and Logistics processes?

Respondents	Answer
IT Leader Company1	It gives speed on the aspect of information recording, cost saving in employees hiring for data recording into system.
IT Leader Company2	It can increase the potential of the company on the aspect of Lead time to work faster with higher capacity in products manufacturing.
IT Leader Company3	Using RFID results on the part of inventory since it allows us to know the amount of inventory. Besides, it saves time and resources in stock checking and to get data in real-time.
IT Leader Company4	Using RFID in the company can help reduce the cost of employee hiring and using lesser employees to check products as well as reducing waste in the manufacturing system. Besides, increasing speed in operation.
IT Leader Company5	For the effectiveness in the operation, since the company has not yet fully used RFID, we only know the effectiveness of some part such as to reduce time in products count and better speed in response to customer needs.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

This chapter is divided into four parts. The first part is a summary of the methodology and research finding. The second part contains the discussions of the research questions. The third part discusses the limitation of the study. The last part provides the implication of the finding and presents the benefit of the research finding and guideline for business firm operation as well as suggestion for future research.

This study aimed to investigate the effects of RFID utilization through supply chain management and logistics performance. The research proposed the assumptions that operational performance may come from RFID utilization through supply chain management and logistics performance. There were three research questions: 1) How does RFID utilization affect operational performance in the automotive parts industry?. 2) How does RFID utilization affect operational performance through supply chain management and logistics performance in the automotive parts industry?. 3) How does supply chain management affect logistics performance in the automotive parts industry?.

Independent variables was RFID utilization whereas operational performance was the dependent variable, and the mediating variable was supply chain management and logistics logistic performance.

There were six hypotheses including: H1: Using RFID can have a positive impact on the supply chain management; H2: Using RFID has a positive impact on logistics performance; H3: Supply chain management has a positive impact on logistics performance; H4: Supply chain management has the positive impact on operational performance; H5: Logistic performance has a positive impact on the operational performance; and H6: Using RFID has a positive impact on operational performance.

The populations was 1,975 business firms in the Department of Business Development, Ministry of Commerce of Thailand. Sample size was computed with the Yamane Formula at 95% confidence level. The study initially targeted approximately 335 automotive parts industries in Thailand. The questionnaires were returned by 208

firms, which accounted for 13.86 percent response rate. After data cleaning, there were 144 questionnaires left.

From the demographic data, regarding the business size of the respondents, the results revealed that 70 respondents (48.6%) had the business size of small-sized, followed by 49 respondents (34.0%) with large-sized, 25 respondents (17.3%) with medium-sized. Thus, it showed that the majority of the business size were small-sized.

Regarding the registered capital of the respondents, the results revealed that 53 respondents (36.8%) had a registered capital of less than 10 million, followed by 50 respondents (34.7%) with a registered capital of more than 100 million, 27 respondents (18.7%) with a registered capital of 10-50 million, 14 respondents (9.7%) with the registered capital of 51-100 million. Thus, it showed that the majority of the registered capital were less than 10 million. The nature of investment revealed that 69 respondents (47.9%) were local companies, followed by 39 respondents (27.0%) being joint venture, and 36 respondents (25.0%) with foreign direct investment. Therefore, it showed that the majority of the companies were local companies.

Finally, in terms of the RFID application in operation response, the results revealed that 116 respondents (80.5%) have RFID application in operation of 1-5 years, followed by 22 respondents (15.2%) with RFID application in operation of 6-10 years, 6 respondents (4.1%) had RFID application in operation of 11-15 years. Therefore, it showed that the majority of RFID application in operation were 1-5 years.

The top three firm types which were respondents of the study are as follows: 95 firms from other parts and accessories manufacturing without category, 19 firms from tires and wheels manufacturing, 16 firms from motorcycle engine, parts and accessories manufacturing.

5.1 Discussion of the Research Findings

This section provides research discussions regarding the research questions on both hypothesis testing.

5.1.1 Discussion of Research Question 1

Research question is: How does RFID utilization affect operational performance in the automotive parts industry?. The results of the hypothesis testing of

H6 showed that the business firms consider the importance of RFID utilization on operational performance. Besides, the use of RFID technology, business vision and strategy planning turned out to have positive effects on operational performance comprising benefit to inventory expense, operating expense, lead time, inventory level and throughput. Business firms consider the importance of RFID utilization including (1) establishment of strategic plan for the use of RFID technology, (2) supporting management by RFID technology, (3) reducing the errors in the business operation, (4) checking for the sources of the auto-mobile parts origin, (5) RFID technology adoption into the management of raw materials quantity in inventory, (6) RFID technology adoption into the inventory management, and (7) RFID technology adoption in the management of the amount of ready-product. Business firms consider the importance of operational performance including (1) reducing the cost of inventory, (2) reducing the cost of operation, (3) generating more preciseness and punctuality in the operation, and (4) recognizing the levels of inventory in the operation.

The research finding supported the research of Jaska, Reyes, Zelbst, Green Jr, and Sower (2010) who conducted the study on the impact of RFID technology utilization on operational performance. It divided the dimensions of RFID technology into three aspects as inventory management, tracking capability and supply chain requirement. Moreover, it divided the dimensions of operational performance into five aspects: throughput, expense, time, inventory and cash flow. The findings indicate that RFID technology utilization directly impact operational performance as hypothesized. The adoption of RFID technology leads to improvements in organizations operational performance. In addition, it also supported the research of Yeung, Lo, Yeung, and Cheng (2008) which suggested that technology that provides information can help to improve not only efficiency but also effectiveness in operational performance.

The research of Huckman and Zinner (2008) was also supported suggesting that organizations focusing on underlying technologies find an improvement in throughput, inventory expense, and operating expense resulting in a positive impact on operational performance. Furthermore, it supported the research of Mabin and Balderstone (2003) which identified some measures of operational performance as throughput, inventory, and operating expense.

5.1.2 Discussion of Research Question 2

Research question include: How does RFID utilization affect operational performance through supply chain management and logistics performance in the automotive parts industry?. The result of the hypothesis testing of H1, H2, H4 and H5 revealed that the business firms consider the importance of RFID utilization affecting operational performance through supply chain management and logistics performance. In other words, the uses of various aspects including RFID technology, business vision, and strategy planning has a positive on supply chain management in terms of cost, operation, and employees. And has a positive on logistics performance in terms of transportation management, transportation performance. Consequently, supply chain management and logistics performance have a positive effect on operational performance, which comprises benefit of inventory expense, operating expense, lead time, inventory level and throughput.

In addition, the business firms consider the RFID utilization through supply chain management and logistics performance. Moreover, they consider the importance of (1) Establishing strategic plan for the use of RFID technology, (2) supporting management by RFID technology, (3) reducing the errors in the business operation, (4) checking for the sources of the auto-mobile parts origin, (5) RFID technology adoption into the management of raw materials quantity in inventory, (6) RFID technology adoption into the inventory management, (7) RFID technology adoption in the management of the amount of ready-product.

In addition, they also consider the importance of (1) RFID technology adoption in checking the routes of automotive parts, (2) RFID technology adoption to recall for damages or under standard automotive parts, (3) RFID technology adoption on the aspect of customer satisfaction toward the competitiveness in transportation, (4) RFID technology adoption on the aspect of speed toward the competitiveness in transportation, (5) RFID technology adoption on the aspect of reliability toward competitiveness in transportation, (6) RFID technology adoption on the aspect of reliability toward competitiveness in transportation, (7) lowering the cost of inventory management, (8) information into real-time with better reliability and accuracy, (9) helping in better follow up of products movement, and (10) reducing employees theft.

The research finding supported the research by Michael and McCathie (2005) who suggested that, using RFID in the organization can increase the efficiency in supply chain management leading to operational performance. It also supported the research by Pelton et al. (2010) which suggested that RFID helped create better changes in supply chain management process such as changes and data response in the whole supply chain process which also linked to other related departments such as production, purchasing, and logistics process. It led to the better organizational efficiency. In addition, it also supported the research by Attaran (2007) who suggested that RFID is a supporting technology for supply chain since RFID can increase the Return on Investment (ROI) for the organization and the result of change lead to the real-time supply chain management.

It supported the research of Kim, Hwang, and Rho (2016), suggesting that RFID utilization improves supply chain information sharing which has a positive effect on supply chain performance. On the other hand, RFID utilization has a negative direct effect on supply chain performance, as well as a positive indirect effect. These results are partly consistent with the findings of previous research (Pelton et al., 2010).

Furthermore, it supported the research of Mingxiu, Chunchang, and Minggen (2012), suggesting that RFID is the key technology of tripartite logistics information and automation. RFID-based logistics system can enlarge the logistics operation capacity, and improve labor productivity to reduce logistics operations mistakes. It also supported the research of Cheung, Choy, Lau, and Leung (2008), suggesting that RFID has been widely adopted in logistics and supply chain management. The impact of RFID on logistics activities, and more importantly on logistics strategy, is that RFID and logistics activities are interrelated.

5.1.3 Discussion of Research Question 3

Research question 3: How does supply chain management affect logistics performance in the automotive parts industry?. The result of the hypothesis testing of H3 showed that business firms consider the importance of supply chain management on logistics performance. Besides, the cost, operation, and employees turned out to have positive effects on logistics performance in terms of transportation management, transportation performance.

The result of hypothesis testing of H3 showed that business firms consider the importance of logistics performance including (1) RFID technology adoption to check for the routes of auto-mobile parts, (2) RFID technology adoption to recall for the damage or under standard automotive parts, (3) RFID technology adoption on the aspect of customer satisfaction toward the competitiveness in transportation, (4) RFID technology adoption on the aspect of speed toward the competitiveness in transportation, (5) RFID technology adoption on the aspect of reliability toward competitiveness in transportation, and (6) RFID technology adoption on the aspect of ability toward competitiveness in transportation. Business firms consider the importance of supply chain management including (1) lower cost of inventory management, (2) information into real-time with better reliability and accuracy, (3) helps in better follow up of products movement, and (4) reduces employees theft.

The research finding supported the research of Green Jr, Whitten, and Inman (2008), suggesting that supply chain management strategy has a positive direct effect on logistics performance. By the process of logistics, it links between supplier and customer which is crucial for supporting strategic supply chain management and improve efficiency. It also supported the research of Chalotra (2016) suggesting that products sale can have an impact on the price of product because of the costs of packaging, supply chain management and logistics performance. It is fundamentally important to work within supply chain. Therefore, improving the efficiency may enhance transportation effectiveness. This is good supply chain management to reduce the cost of logistics performance.

5.2 Limitation of the Study

It is necessary to address certain limitation of this study to help advance future research. The limitations of this study come from companies that responded to the questions but had no knowledge about RFID technology or companies with knowledge about RFID but led not adopted technology. In addition, the automotive parts industry had differences in their operation thus; bringing RFID technology to use was up to their strategic operation. Moreover the success of applying RFID technology need more time in management of complex tasks or the differences in product value. Finally, limitations

in the items applied with each observed variables, despite the thorough relevant literatures review, there could be opportunities for the items to be chosen as the tool for data collection while the model may not well represent the observed variables and could give bias outcomes.

5.3 Implication for Practice and Future Research

5.3.1 Implication

RFID (Radio Frequency Identification) is a technology that has gained much interest and it is related to business operation. RFID technology can be brought to apply in various ways for instance, in retail and wholesale systems, manufacturing, in supply chain and logistics systems management, security & access control as well as to apply in other areas. RFID technology is a dominant key as it is a microchip that can record information. Using RFID system efficiency would help reduce the costs of manufacturing. Besides, RFID technology can help in giving convenience to businessperson and consumers because it has better qualification than barcode since the code cannot be erased and can collect more information. Presently, RFID technology is used in supply chain management and logistic system in business and industrial factories.

The characteristics of manufacturing are diverse in the process of management. Selecting RFID to use especially on the part of internal distribution center administration will help reduce the process and repetition as well as enhance for more convenience in the management. Besides, it is brought to use in access control in the characteristic of personal identification that controls access and exit of building or any place. It can also be applied in work hours checking for the human resource department. At the same time, it is the characteristic of personal identification to link to the issue of e-passport and e-citizen which will become the future trend. Besides, it can be used as member card for applying RFID technology with credit card and e-purchasing business. From all the above mentioned, it can be seen that RFID technology can be applied in all businesses and services to help reduce capital costs of the business. Moreover, information from RFID could be used in the analysis and business decision too.

This study suggests the benefits from both theoretical and implementation guidelines. In regard of the theoretical guideline as can be seen in the previous study on the four theories of RFID utilization, supply chain management, logistics performance, and operational performance, the author found both direct and indirect influences that each theory showed with effects on operational performance.

According to the research, RFID utilization has direct impact on operational performance and indirectly impacts supply chain management and logistics performance. Thus, conformance with RFID utilization in supply chain management and logistics performance would influence operational performance. For the automotive parts industry, guidelines and suggestions for adjusting their operations to increase the effectiveness of operational performance are as follows:

Firstly, it requires the organization to pay attention to policy launching in conformance to strategic operational objectives by using RFID to work procedure.

Secondly, RFID technology is used as the sensor system but with its qualification, RFID technology can record and store information into the database and bring those information for information technology analysis. This includes bringing information under the database to use in processing and information analysis on the business aspects, thus many organizations give importance to it. Therefore, there is the potential to increase the processing process, information analysis and to improve for the use in the automobile industry for the successful competition.

Thirdly, more attention should be paid to the effectiveness in supply chain management and logistics performance. In doing so, strategy RFID utilization would reflect the effectiveness of the supply chain management and logistics performance.

Next on the part of executive management, they should take part in strategy planning and RFID utilization within the organization. They should take lead to drive toward the changes acceptable and place the long-term plan on supply chain management and operational performance for the efficiency of operational performance. Moreover, short-term and long-term planning for RFID technology investment must be included in the organization of strategy to allow the flexibility in change acceptance either on the aspect of economic conditions or the higher competitive environment. The results of this study should be adopted for further analysis for the utmost benefits of the

future strategic plan. Finding consistent government report related to the efficiency enhancement in the internal logistics system management of the organization, RFID can lessen the entrepreneurial costs of logistics, especially the inventory cost.

Lastly, the government or other government agencies can apply the discovery of this RFID utilization through supply chain management and logistics performance research in the future to develop supply chain management and logistic system policy of industry.

Besides, bringing RFID technology to use in the whole industrial value chain from the raw material seeking, goods and services production and distribution of goods and services to consumers as well as to integrate all works with other relevant units; these would generate competitive ability and higher national economic development. Furthermore, it can also be replicated in other countries with similar environment as Thailand.

5.3.2 Future Research

Currently, RFID technology is applied to help increase the effectiveness and efficiency of operation or any services. RFID is a technology with the aim to develop and support or replace Barcode technology (Asif, 2005). This includes checking back on the day that the parts are produced by whom. If there are any mistakes in the manufacturing, it could be checked quickly. Besides, RFID can reduce potential damage and protect potential errors from the operation. From the ability of RFID technology as stated above, RFID technology has a wide application such as in automobile industry, to increase operational usage and the speed effectiveness. In an era in which businesses are faced with business fluctuation, any investment whether on manufacturing, marketing activities arranging or advertisement as well as distribution channels need to form the most worth returns on business. One thing that can help the investors make decision is seeing the results of investment in the long term, that is, the profits from investment or more work effectiveness.

The key motivation in bringing RFID technology to use is the automatic operation and speed of processing that can be traced back thus, RFID is installed in any parts of automobile such as airbag by Heng (2006); installing in the airbag controls the pressure of the airbag.

Automobile manufacturing like Mercedes Benz uses RFID technology in safety test by values setting for car equipment to be sure that all parts have the proper values according to the processes and conditions that the company has set for example, setting airbag and pressure in tires to prevent the accident that may result from flat tires or tires explosion. Besides, RFID technology partly helps increase the ability of data recording, internal business data gathering and help support management decision. Also, RFID can record data and present it in form of real-time.

This research presents a guideline for those who are interested in RFID research. The researcher has summarized into four key issues.

The first issue is that future research can use of RFID technology as recorded in database daily from various sources as it becomes a big data. Thus, (Asay, 2014) stated that the decision to use big data in the organization shall be planned together with the decision to invest in creating big data. Data gathering from internal business processing comes from various sources such as from the computer system that is used in the organization, any sensor such as Tag RFID that collects products information which so crucial to help support the management decision such as sale rate in the past year and the main effects on sales.

Second issue is that many researchers have studied by adopting RFID technology in supply chain process in the automobile industry, thus the future research can study the impacts of operational performance on supply chain management on the aspect of inventory cost reduction and better customer service to generate more profit, increasing more competitive ability and service efficiency.

Besides, future researcher should study the part of strategic supply chain management using relevant strategies like Total Quality Management (TQM), Just in Time (JIT), supply chain information sharing, efficiency outcome and effectiveness outcome.

It allows the researcher to understand the context of RFID usage in all the process of the operation for the higher efficiency.

Third issue is bringing RFID technology inside supply chain management and logistics since the costs plays crucial part in setting products price. Thus, effective

supply chain management and logistics have mainly helps in reducing the cost of manufacturing and product price.

Therefore, research in the future should be conducted on the factors that influence supply chain management and logistics such as tangible cost and intangible cost.

The last issue is the study on the assessment of worthiness in using RFID technology; investing in RIFD technology would lead to different returns. The returns can also be divided into tangible and intangible. The results may contribute to the development of Thailand's automotive parts industry.

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APPENDICES

APPENDIX A

Questionnaire

Survey questionnaire for the opinions toward RFID technology usage

Subject: The utilization of radio frequency identification (RFID) on operational performance through supply chain management and logistics performance of automotive industry

Please mark ✓into ☐ you have selected

Section 1 In which levels your business gives importance to the adoption of RFID technology?

1 = the least 2 = less 3 = rather less 4 = neutral 5 = rather much 6 = much 7 = the most

Questions	levels of importance						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Paying attention to RFID technology usage							
1. Your business pays attention to RFID technology adoption to response to the speediness in the business operation.	1	2	3	4	5	6	7
2.Your business pays attention to RFID technology adoption to reduce the errors in the business operation.	1	2	3	4	5	6	7
3.Your business pays attention to RFID technology adoption to check for the sources of the auto-mobile parts origin.	1	2	3	4	5	6	7
Paying attention to the business views toward RIFD technology adoption							
4.Your business pays attention to RFID technology adoption into the management of raw materials quantity in inventory.	1	2	3	4	5	6	7
5.Your business pays attention to RFID technology adoption into the inventory management.	1	2	3	4	5	6	7
6. Your business pays attention to RFID technology adoption in the management of the amount of ready-product.	1	2	3	4	5	6	7

Questions	levels of importance						
	1	2	3	4	5	6	7
Paying attention on the RFID technology adopting strategic plan							
7. Your business pays attention to the establishment of strategic plan for the use of RFID technology.	1	2	3	4	5	6	7
8. Your business pays attention to the supporting of management by RFID technology.	1	2	3	4	5	6	7
9. Your business pays attention to RFID technology adoption into the decision for the operation.	1	2	3	4	5	6	7
10. Your business pays attention to the maintenance and data backup from the operation by RFID technology.	1	2	3	4	5	6	7

Section 2 In which levels your business pays attention to RFID technology adoption into Logistics performance ?

1 = the least 2 = less 3 = rather less 4 = neutral 5 = rather much 6 = much 7 = the most

Questions	levels of importance						
	1	2	3	4	5	6	7
RFID technology adopting into transportation management							
11. Your business pays attention to RFID technology adoption into the follow up of transportation process.	1	2	3	4	5	6	7
12. Your business pays attention to RFID technology adoption to check for the routes of auto-mobile parts.	1	2	3	4	5	6	7
13. Your business pays attention to RFID technology adoption to recall for the damage or under standard automobile parts.	1	2	3	4	5	6	7
Using RFID technology for the effectiveness of transportation							
14. Your business pays attention to RFID technology adoption on the aspect of customer satisfaction toward the competitiveness in transportation.	1	2	3	4	5	6	7

Questions	levels of importance						
	1	2	3	4	5	6	7
Using RFID technology for the effectiveness of transportation							
15. Your business pays attention to RFID technology adoption on the aspect of speed toward the competitiveness in transportation.	1	2	3	4	5	6	7
16.Your business pays attention to RFID technology adoption on the aspect of reliability toward competitiveness in transportation.	1	2	3	4	5	6	7
17.Your business pays attention to RFID technology adoption on the aspect of responsiveness toward competitiveness in transportation.	1	2	3	4	5	6	7
18. Your business pays attention to RFID technology adoption on the aspect of flexibility toward competitiveness in transportation.	1	2	3	4	5	6	7
19. Your business pays attention to RFID technology adoption on the aspect of ability toward competitiveness in transportation.	1	2	3	4	5	6	7

Section 3 In which levels your business pays attention to RFID technology adoption on the aspect of Supply chain management

1 = the least 2 = less 3 = rather less 4 = neutral 5 = rather much 6 = much 7 = the most

Questions	levels of importance						
	1	2	3	4	5	6	7
Using the benefits of RFID technology on the aspect of payment cost							
20. Using RFID technology results on the lower cost of wage.	1	2	3	4	5	6	7
21. Using RFID technology results on the lower cost of inventory management.	1	2	3	4	5	6	7

Questions	levels of importance						
	1	2	3	4	5	6	7
22. Using RFID technology results on the lower cost of products purchasing.	1	2	3	4	5	6	7
Using the benefits of RFID technology in the operation							
23. Using RFID technology results on the more transparent in level of products stock.	1	2	3	4	5	6	7
24. Using RFID technology turns information into Real-time with better reliability and accuracy.	1	2	3	4	5	6	7
25. Using RFID technology reduces the problems of out of stock event.	1	2	3	4	5	6	7
Using the benefits of RFID technology in the operation							
26. Using RFID technology helps in better follow up of products movement.	1	2	3	4	5	6	7
27. Using RFID technology in counting of inventory.	1	2	3	4	5	6	7
Using RFID technology on the personnel operation							
28. Using RFID technology reduces employees' product stolen.	1	2	3	4	5	6	7
29. Using RFID technology helps reducing the employees' error in operation.	1	2	3	4	5	6	7

Section 4 In which level your business gains the benefits from the use of RFID technology to increase the effectiveness?

1 = the least 2 = less 3 = rather less 4 = neutral 5 = rather much 6 = much 7 = the most

Questions	levels of benefit						
	1	2	3	4	5	6	7
Using RFID technology to increase the organizational effectiveness							
30. Using RFID technology in your business can help increase the effectiveness in the operation.	1	2	3	4	5	6	7

Questions	levels of benefit						
	1	2	3	4	5	6	7
Using RFID technology to increase the organizational effectiveness							
31. Using RFID technology in your business can help reduce the cost of inventory.	1	2	3	4	5	6	7
32. Using RFID technology in your business to help reducing the cost of operation.	1	2	3	4	5	6	7
33. Using RFID technology in your business to help generate more preciseness and punctuality in the operation.	1	2	3	4	5	6	7
34. Using RFID technology in your business to help recognizing the levels of inventory in the operation.	1	2	3	4	5	6	7

Section 5 Personal information and business information of the questionnaire respondents

1. Gender □ Female □ Male
2. Age □ Less than 20 years old □ 20 – 30 years old
   □ 31 – 40 years old □ 41 – 50 years old
   □ 51 – 60 years old
3. Education
   □ Vocational degree □ Bachelor degree
   □ Master degree □ Ph.D.
   □ Other please define _____
4. Position/responsibility
   □ Management □ Department manager
   □ Head of division □ Operator
   □ Other please define _____
5. How many years of RFID application in operation
   □ 1-5 Year □ 5-10 Year
   □ 10-15 Year
   □ Other please define _____

----- Thank you for your kindly participations -----

Description for questionnaire answering

Survey questionnaire for the opinions toward RFID technology usage

Subject: RFID technology usage to increase the organizational operation effectiveness

This questionnaire is part of Ph.D. dissertation conducting in information technology system, faculty of Business administration, Rajamangala University of Technology Thanyaburi. The aim is to study on the utilization of radio frequency identification (RFID) on the operational performance through supply chain management and logistics performance of automotive industry. The results from this research allow us to know about tendency of RFID technology using in supply chain management and logistics performance of automotive industry where the researcher aware and foresees that your information would be benefit for the automotive industry, the relevant units as well as people in general who interested in the subject. The researcher then wants to ask for your kindness to give your deliberate opinions in answering to this questionnaire in every items according to the instruction stated in the questionnaire.

Section 1: Questions related to the use of RFID technology in your business in three aspects:

1. To give importance to the use of RFID technology.
    1. RFID technology in the business is important at the least level.
    2. RFID technology in the business is important at the less level.
    3. RFID technology in the business is important at quite less level.
    4. RFID technology in the business is important at moderate level.
    5. RFID technology in the business is important at quite high level.
    6. RFID technology in the business is important at high level.
    7. RFID technology in the business is important at highest level.

2. The importance paid to the business perspective in the use of RFID technology.
    1. RFID technology in the business is important for the business at the least level.
    2. RFID technology in the business is important for the business at less level.
    3. RFID technology in the business is important for the business at quite less level.
    4. RFID technology in the business is important for the business at moderate level.

5. RFID technology in the business is important for the business at quite high level.

6. RFID technology in the business is important for the business at high level.

7. RFID technology in the business is important for the business at highest level.

3. The importance paid to strategic planning for RFID technology usage.

1. RFID technology is important for the business strategy at the least level.

2. RFID technology is important for the business strategy at less level.

3. RFID technology is important for the business strategy at quite less level.

4. RFID technology is important for the business strategy at moderate level.

5. RFID technology is important for the business strategy at quite high level.

6. RFID technology is important for the business strategy at high level.

7. RFID technology is important for the business strategy at highest level.

Section 2: Questions related to the use of RFID technology in products transportation in two aspects.

1. RFID technology usage in transportation management.

1. The importance paid on bringing RFID technology to use in transportation management at the least level.

2. The importance paid on bringing RFID technology to use in transportation management at less level.

3. The importance paid on bringing RFID technology to use in transportation management at quite less level.

4. The importance paid on bringing RFID technology to use in transportation management at moderate level.

5. The importance paid on bringing RFID technology to use in transportation management at quite high level.

6. The importance paid on bringing RFID technology to use in transportation management at high level.

7. The importance paid on bringing RFID technology to use in transportation management at the highest level.

2. Using RFID technology for the transportation efficiency.

1. The importance of bringing RFID technology to use for the transportation efficiency at the least level.

2. The importance of bringing RFID technology to use for the transportation efficiency at less level.

3. The importance of bringing RFID technology to use for the transportation efficiency at quite less level.

4. The importance of bringing RFID technology to use for the transportation efficiency at moderate level.

5. The importance of bringing RFID technology to use for the transportation efficiency at quite high level.

6. The importance of bringing RFID technology to use for the transportation efficiency at high level.

7. The importance of bringing RFID technology to use for the transportation efficiency at the highest level.

Section 3: Questions related to the use of RFID technology for inventory management on three aspects.

1. Using RFID technology for costs management.

1. RFID helps lessen the business cost at the least level.
2. RFID helps lessen the business cost at less level.
3. RFID helps lessen the business cost at quite less level.
4. RFID helps lessen the business cost at moderate level.
5. RFID helps lessen the business cost at quite high level.
6. RFID helps lessen the business cost at high level.
7. RFID helps lessen the business cost at the highest level.

2. Using RFID technology for business management.

1. RFID enhances for better inventory performance at the least level.
2. RFID enhances for better inventory performance at less level.
3. RFID enhances for better inventory performance at quite less level.
4. RFID enhances for better inventory performance at moderate level.
5. RFID enhances for better inventory performance at quite high level.
6. RFID enhances for better inventory performance at high level.

7. RFID enhances for better inventory performance at the highest level.

3. Using RFID technology for personnel operation.

1. RFID enhances work efficiency at the least level.
2. RFID enhances work efficiency at less level.
3. RFID enhances work efficiency at quite less level.
4. RFID enhances work efficiency at moderate level.
5. RFID enhances work efficiency at quite high level.
6. RFID enhances work efficiency at high level.
7. RFID enhances work efficiency at the highest level.

Section 4 uses the questions related to benefits from the use of RFID technology in one aspect

1. Using RFID technology helps increasing organization efficiency.

1. RFID helps increasing organization efficiency at the least level.
2. RFID helps increasing organization efficiency at less level.
3. RFID helps increasing organization efficiency at quite less level.
4. RFID helps increasing organization efficiency at moderate level.
5. RFID helps increasing organization efficiency at quite high level.
6. RFID helps increasing organization efficiency at high level.

7. RFID helps increasing organization efficiency at the highest level.

APPENDIX B

Abbreviations and symbols

Abbreviations and symbols	Explanation
RFID	RFID Utilization
SCM	Supply Chain Management
LOG	Logistics Performance
OP	Operational Performance
RFID Utilization	
RFID_2	RFID Utilization Variable Number 2
RFID_3	RFID Utilization Variable Number 3
RFID_4	RFID Utilization Variable Number 4
RFID_5	RFID Utilization Variable Number 5
RFID_6	RFID Utilization Variable Number 6
RFID_7	RFID Utilization Variable Number 7
RFID_8	RFID Utilization Variable Number 8
Supply Chain Management	
SCM_2	Supply Chain Management Variable Number 2
SCM_5	Supply Chain Management Variable Number 5
SCM_7	Supply Chain Management Variable Number 7
SCM_9	Supply Chain Management Variable Number 9
Logistics Performance	
LOG_2	Logistics Performance Variable Number 2
LOG_3	Logistics Performance Variable Number 3
LOG_4	Logistics Performance Variable Number 4
LOG_5	Logistics Performance Variable Number 5
LOG_6	Logistics Performance Variable Number 6
LOG_9	Logistics Performance Variable Number 9
Operational Performance	
OP_2	Operational Performance Variable Number 2
OP_3	Operational Performance Variable Number 3
OP_4	Operational Performance Variable Number 4
OP_5	Operational Performance Variable Number 5

Abbreviations and symbols	Explanation
%	Percentage
MIN	Minimum
MAX	Maximum
M	Mean
SD	Standard Deviation
VIF	Variance inflation factor
CFA	Confirm factor analysis
AVE	Average variance extracted
CR	Composite reliability
t	Criteria Ratio
R^2	R-Square
CMIN	Chi- Square
df	Degree of freedom
CMIN/df	Chi- Square / Degree of freedom
***p*-value**	Probability value
GFI	Goodness of fit indexs
AGFI	Adjusted goodness of fit index
RMR	Root mean square residual
RMSEA	Root mean square error of approximation
NFI	Normed fit index
CFI	Comparative fit index
Holelter	Critical N for a significance level of .05 or .01
β	Beta

APPENDIX C

Demographic Data

Demographic Summary

	Frequency	Percentage
Gender		
Female	56	38.8
Male	88	81.1
Age		
20-30	37	25.6
31-40	76	52.7
41-50	23	15.9
51-60	7	4.8
more than 60	1	0.7
Education		
Under Bachelor degree	16	11.1
Bachelor degree	104	72.2
Master degree	20	13.8
Doctoral degree	4	2.8
Position		
Administrator	15	10.4
Manager	44	30.5
Chief	37	25.7
Officer	29	20.1
Other	19	13.1
RFID application in operation		
1-5 years	116	80.5
6-10 years	22	15.2
11-15 years	6	4.1

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Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and beliefs, contains on material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my dissertation, when deposited in the university library, being available for loan and photocopying.

Sirichai Kingsida