PURCHASING STRATEGY FOR REFURBISHED GAS CHROMATOGRAPHY INSTRUMENTS

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Engineering Management
Regional Centre for Manufacturing Systems Engineering
Faculty of Engineering
Chulalongkorn University
Academic Year 2017

กลยุทธ์การจัดซื้อสำหรับเครื่องแก๊สโครมาโทกราฟีตกแต่งใหม่

นางสาวชไมพร ปานเหล็ง

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาการจัดการทางวิศวกรรม ภาควิชาศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2560

Thesis Title	PURCHASING STRATEGY FOR REFURBISHED GAS CHROMATOGRAPHY INSTRUMENTS
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Field of Study	Engineering Management
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ชไมพร ปานเหล็ง : กลยุทธ์การจัดซื้อสำหรับเครื่องแก๊สโครมาโทกราฟีตกแต่งใหม่ (PURCHASING STRATEGY FOR REFURBISHED GAS CHROMATOGRAPHY INSTRUMENTS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. สมชาย พัวจินดาเนตร, หน้า.

งานวิจัยนี้จัดทำขึ้นโดยมีวัตถุประสงค์ เพื่อที่จะพัฒนากลยุทธ์ในการจัดซื้อเครื่องแก๊สโครมาโตกราฟีใช้แล้วสำหรับนำมาตกแต่งใหม่ เพื่อความได้เปรียบในการแข่งขันขององค์กร แผนการพัฒนากลยุทธ์ในการจัดซื้อ มีทั้งหมด 5 ขั้นตอน คือ การวิเคราะห์ข้อมูลการใช้จ่าย การกำหนดความต้องการของลูกค้า การประเมินอุปทานของตลาด การสร้างกลยุทธ์การจัดซื้อ และ การนำกลยุทธ์ไปปฏิบัติและปรับปรุง ซึ่งกลยุทธ์การจัดซื้อ ประกอบด้วย วิสัยทัศน์ ภารกิจ วัตถุประสงค์ แผนปฏิบัติงาน และดัชนีชี้วัดผลความสำเร็จของงาน ในกรณีศึกษาได้ดำเนินการโดยใช้ การสั่งซื้อระบบลีไจล์ (Leagile) และกระบวนการเพื่อรอคำสั่งซื้อ (assemble-to-order) รวมทั้งวิธีการเลือกผู้จัดส่งสินค้า และวิธีการจัดหาสินค้า นอกจากนี้ ยังใช้บัตรควบคุมสินค้าในกระบวนการควบคุมสินค้าคงคลัง

จากการศึกษาวิจัยพบว่า เมื่อนำกรณีศึกษาไปปฏิบัติ สามารถลดต้นทุนของเครื่องแก๊สโครมาโตกราฟีตกแต่งใหม่ได้ประมาณ 10.35% และสามารถสร้างมาตรฐานกระบวนการจัดซื้อโดยที่สามารถคัดสรรผู้ส่งมอบสินค้าที่เหมาะสมได้ 3 ราย จากการการศึกษาและพัฒนากลยุทธ์การจัดซื้อในครั้งนี้ สามารถนำไปเป็นแนวทางในการจัดซื้อสินค้าประเภทอื่นๆ ต่อไปในอนาคต

ภาควิชา ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต ลายมือชื่อนิสิต .....

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สาขาวิชา การจัดการทางวิศวกรรม

ปีการศึกษา 2560

5871239521 : MAJOR ENGINEERING MANAGEMENT
KEYWORDS: PURCHASING STRATEGY / PURCHASING PROCESS / GAS CHROMATOGRAPHY / REFURBISH GAS CHROMATOGRAPHY INSTRUMENT / GAS CHROMATOGRAPHY INSTRUMENT / ASSEMBLE-TO-ORDER / LEAGILE / SOURCING / PROCUREMENT / SUPPLIER SELECTION / SUPPLIER / CUSTOMER REQUIREMENT

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The aim of this study is to develop purchasing strategy for procurement of used Gas Chromatography (GC) instrument for refurbishing in order to enhance company's competitive advantages. The purchasing strategy study is developed by 5 steps, which are (1) analysis of spending data, (2) determining customer requirements, (3) assessing supply market, (4) formulating purchasing strategy, and (5) executing and refining strategy. The purchasing strategy consists of (1) vision, (2) mission, (3) objectives, (4) action plans, and (5) key performance indicators. Implementation on the case study company was done by applying Leagile purchasing portfolio model and assemble-to-order systems, as well as established guidance for selecting qualified suppliers and sourcing. Moreover, the inventory is controlled by stock cards.

The results of this paper show that the case study company is able to (1) reduce cost for refurbished GC instrument approximately by 10.35%, (2) set a standard purchasing process, and (3) qualify 3 main suppliers. This study provides guidelines for similar purchasing for other purchases in the future.

Department:	Regional Centre for Manufacturing Systems Engineering	Student's Signature	.....
		Advisor's Signature	.....
Field of Study:	Engineering Management		
Academic Year:	2017		

ACKNOWLEDGEMENTS

I would like to express my gratitude to my thesis advisor, Assistant Professor Somchai Puajindanetr, Ph.D. for consultation and direction all through this thesis compilation. In addition, I would like to show my appreciation to the thesis committee, Professor Parames Chutima, Ph.D. (Chairman), Associate Professor Jeerapat Ngaoprasertwong (Examiner), and Associate Professor Vanchai Rijiravanich, Ph.D. (External Examiner) for all the useful recommendations and knowledge during the defense this thesis. The guidance makes the thesis a more completed version and helps me grow profoundly in the area of engineering business management. To everybody who is included in the journey of this study, my sincere affirmations. Finally, to my beloved family and friends to would like to express my deepest gratitude for their caring, supporting, and encouraging throughout my Master's degree program.

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Chapter 1
Introduction

This chapter provides the overview of this study, which consists of a brief company background followed by Chromatography market. Moreover, the problem statement, research questions, hypothesis development, research objective, assumption of the study, scope of research, and expected outcomes will be presented in this chapter.

1.1 Company Background

The case study company is located in Bangkok, Thailand, and has been supplying scientific equipment, consumables, software, accessories and life science instrument for over 25 years. Their expertise in the supply of analytical consumables, instruments, and laboratory products for scientific research, academic, diagnostics, clinical, and industrial markets is attributed to their team of highly experienced and qualified technical support specialist and application chemist teams providing customers with a high level of trust in the products and services throughout the product's entire lifetime. The company imports extensive brands and ranges of quality laboratory products from all over the world such as the UK, the USA, Germany, Japan, and China. As a SME business, the company works closely with customers, enabling them to quickly respond and satisfy end-user's needs.

In general, the company mainly focuses on offering brand-new chromatography products (Figure1), including High Performance Liquid Chromatography (HPLC), Gas Chromatography (GC), Thin Layer Chromatography (TLC). The chromatography products are widely used throughout chemical laboratories to prepare, handle, and analyze samples in many different industries such as the petrochemical industry, environment testing industry, pharmaceutical industry, as well as food and beverage industry (Ebbing, 1990). Moreover, the company also offer refurbished analytical instrument, namely Gas Chromatography instrument in order to support customer with small budget.

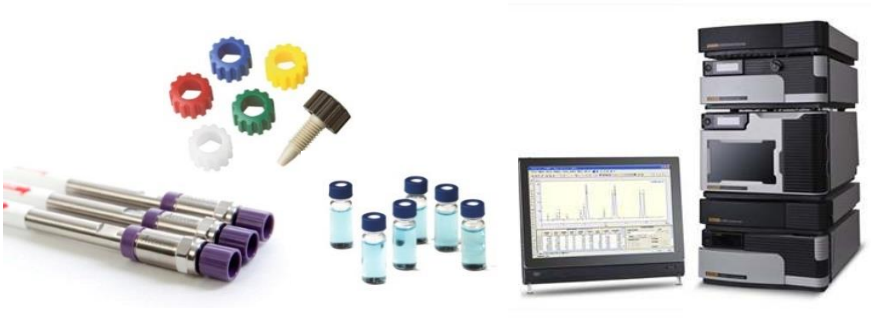

Figure 1 Company's Product

1.2 Chromatography Market

According to an industrial instrument market research report, the gas chromatography instrument market is showing a rapid growth, up from 2.64 billion dollars by 2016 and expected to reach 3.67 billion dollar by 2022, with an annual growth rate of 6.2%. This growth of global separation technique market has been driven by the increasing production of crude & shale oil, increasing funding of treatment and disposal of domestic wastewater, growing market of drug testing and R&D activities, growing concerns of environment pollution reduction, and growing concern of importance of food safety. These chromatography markets can be categorized into 3 parts namely, instrumentation, accessories & consumables, and reagents. Moreover, it can be segmented geographically into 4 areas, consisting of North America, Europe, Asia-Pacific, and the Rest of the World, in which North America is its largest market share in 2016 (MarketsandMarkets 2017).

One of the factors contributing to market growth is support from the government. This year, the Thai government encourages and supports R&D in 10 industries to be new engines in developing the country. The 10 targeted industries include next-generation cars, smart electronics, affluent medical and wellness tourism, agriculture and biotechnology, food, robotics for industry, logistics and aviation, biofuels and biochemical, digital, and medical services. Through these projects, the government wants to develop more domestic R&D and build the creation of the IP Innovation-Driven Entrepreneurship Centre (IP-IDE) in order to promote both small & large Thai firm to serve market within the country as well as the global market (Investment(BOI) 2017). Out of those 10 industries, 4 industries utilities chromatography in their laboratory to develop their products, including agriculture and biotechnology, food, biofuels and biochemical, and medical services. Therefore, this is an opportunity for company to expand their market. According to Thai Customs, it shows that Thailand imports GC instruments more than 800 million baht every year as illustrated in Figure 2.

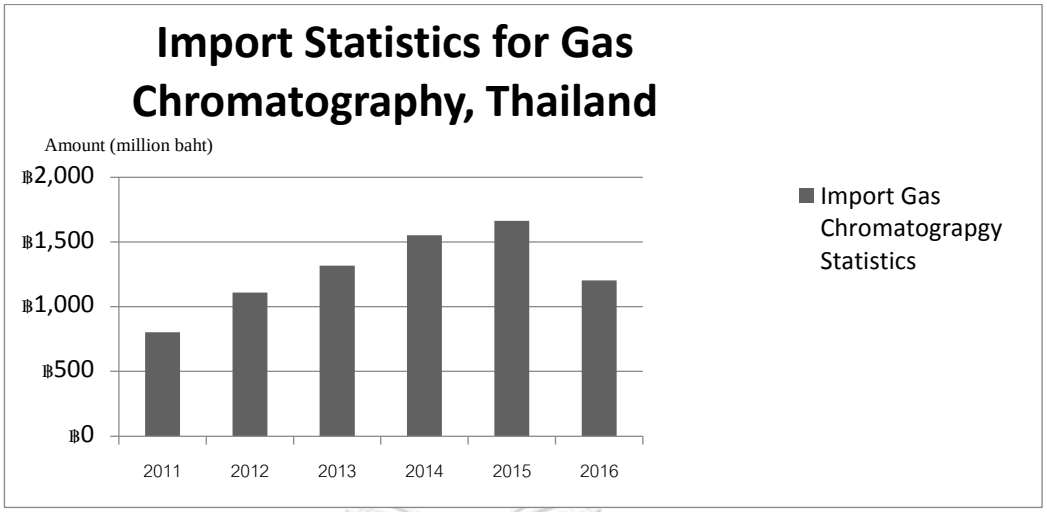

Figure 2 Thailand Import Gas Chromatography Statistics (source Thai Customs, 2017)

1.3 Statement of the Problem

The company would like to set a new process of purchasing used GC instrument since the current purchasing process is not effective resulting in a number of GC instruments in their inventory. Although the company has offered several refurbished GC instruments for many years, there are some issues about the purchasing department and marketing department. It lacks effective purchasing process to decide whether the company should buy new inventory. The process of refurbished GC instrument (Figure 3) is the company buy used GC instrument before carefully check, repair, replace broken parts, clean and pass it to the customers as they require. When the refurbished GC instruments are sold, the purchasing department will look for new used GC instruments to refurbish. Out of fear of losing a good deal, the procurement will usually immediately purchase all cheap GC units without having even clearing their inventory and customer demand. Price of used GC is one of the main factors for the company in purchasing decision, which may not fit the suggested models such as the international post purchase industrial behavior model suggested by Lucero (Figure2). This may cause many issues to the company in the long run regarding purchase decisions. In addition, although Sangeet, Nicholas & Eric., 1997 tried to determine and rank the importance of marketing tools for high-technology (Sangeet, Nicholas & Eric 1997), there is no academic research that straightly investigates the marketing of refurbished GC instruments, which provides a difficulty for the company to determine the market.

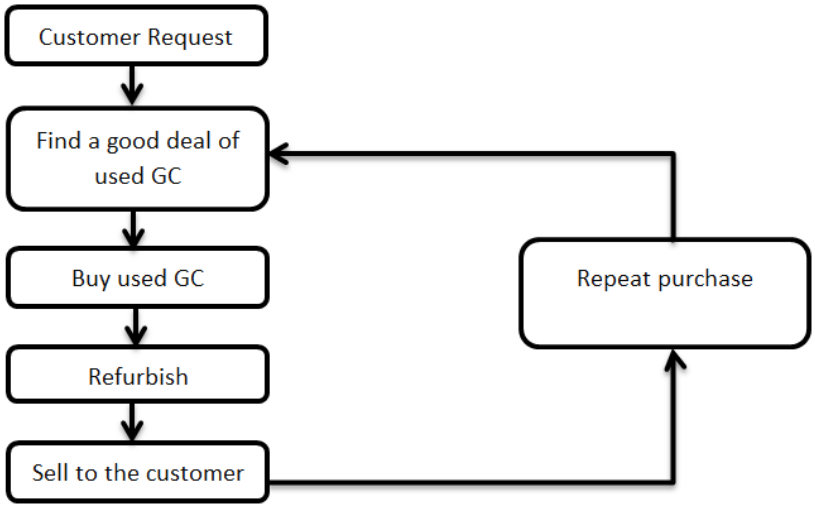

Figure 3 Company's Current Purchasing Process

Currently, the company has 20 GC instruments in the inventory. The procurement bought only HP 5890 model because the company is experienced with this model. Moreover, it is the best-selling GC instrument of all-time, which is still one of the most active instruments used in the laboratory and marketplaces. However, in order to expand the market, and control the number of refurbished GC instruments in the inventory, the company has to find the customer' needs in wider area apart from customer's request.

1.4 Research Question

What are the requirements of using GC instrument?

What are the critical factors that affect consumers' decision in purchasing refurbished GC instrument?

1.5 Hypothesis Development

1. The customers require GC brand, which is well-known in the market.
2. After sale services are provided all the refurbished GC instrument's lifetime.

1.6 Research Objectives

The objective of this research is to develop purchasing strategy of procurement used Gas Chromatography instrument for refurbishing.

To successfully achieve the objective, the research aims to carry out the following tasks: studying the current process of procurement for used Gas Chromatography instrument of the case study company, understanding the demand and requirements of using refurbished GC

instrument of target group through empirical research, analyzing the collected data and identify the requirements of using refurbished GC instrument, and recommending the best purchasing process of procurement for used Gas Chromatography instrument for refurbishing.

1.7 Assumptions of the Study

1. Target customers: the organization that uses gas chromatography instrument, which can categorized into 7 industries:

(1) Food/feed

(2) Petroleum/petrochemical

(3) Pharmaceutics

(4) Environment

(5) Forensic science and toxicology

(6) Academics/university

(7) Laboratory and testing service

2. Specifications of Gas Chromatography (GC) Instrument

The instrument is used to analyze, identify, prepare, and separate vaporized compounds in analytical laboratory. The main body of GC Instrument includes

(1) Sample inlet and sampling devices (injector)

(2) Control temperature zones (oven)

(3) Detectors

However, a gas chromatographic system also needs other components in order to run the system, namely carrier gas, flow control, column, and data work station (software).

3. Team members in this study consists of managing director, procurement manager, procurement officer, sales and marketing manager, salesperson, accountant, stock keeper, and researcher.

Table 1 Team Members

Position	Department	Working Experience
Managing director	-	39
Procurement manager	Procurement	26
Procurement officer	Procurement	6
Sales and marketing manager	Sales and marketing	17
Salesperson	Sales and marketing	2
Salesperson	Sales and marketing	4
Accountant	Account and Finance	14
Stock keeper	Stock	14
Researcher	-	4

1.8 Scope of the Research

This research is focus on recommending the best purchasing process of procurement for used Gas Chromatography instrument for refurbishing through studying the demand and requirement of target market. The empirical survey is conducted from 100 technicians who are using GC instrument from 100 laboratories. The technicians should have authority in purchasing decision in buying new GC instruments.

1.9 Expected Outcomes

The expected outputs of this research is to reduce cost of refurbish GC instruments and identify the demand and requirement of using refurbished GC instrument in order to recommend the specification and best way to procure used GC instrument. In addition, the company is able to control their inventory level.

Chapter 2
Literature Review

This chapter explains and summarizes the current stages of knowledges on relevant topics as found in journal articles and academic books. The discussing topics include organizational purchasing behaviour, market tools of high technology products, internal purchasing and post-purchase behaviour, purchasing process, purchasing portfolio models and GC.

2.1 Organizational Purchasing Behaviours

Since GC instrument is used in the laboratory, the organizational buying behavior is different from personal buying behavior. According to (Wind & E. Webster Jr 1972), organizational purchasing behavior is a sophisticated process that involves many people and multiple objectives to be criteria for making decision. It also requires a lot of information from many sources, takes a period of time, and includes inter-organizational relationships. The organizational purchasing process is a form of problem-solving that organization members have to define a purchasing situation before identifying, evaluating, and selecting the appropriate supplier and brand. There are relationships among variables in the purchasing process that should be studied. As shown in Figure 4, the variables determining the organizational purchasing behavior can be categorized into 4 classes; individual, social, organizational, and environmental.

- The Environmental Factor

The environmental factors are found outside the businesses that give information about opportunities and limitation when the company perceives a purchasing situation. The environmental influences encompass physical, technological, economic, political, legal, and cultural factors. Moreover, the fundamental in the high-technology sector is another important dimension (Viardot 2004). These factors have many impacts on purchasing behavior and situation. First, they determine the availability of the products and services. Second, they determine the general business condition such as the economic growth rate, unemployment rate, and political forces. Third, they determine values and norms within the organization and relationships among buying and selling organizations as well as other institutions including trade association and government. Lastly, they control the information

flow into the buying organization, which includes marketing communication from the suppliers.

- The Organizational Factor

The organizational factor is the customer's organizational dimension, which is directed by goals of the organization and forced by its finance, technology, and human resources. There are four groups of interacting variables, which consists of buying tasks, organizational structure, buying technology, and buying actors.

Buying Task – Buying task is performed to solve the purchasing problems in the purchasing process. The process comprises of 5 stages: (1) identify the needs, (2) establish the specification, (3) identify alternatives, (4) evaluate alternatives, and (5) select the most suitable supplier. Each stage requires different information and participating members in order to decide whether or not to purchase.

Organizational Structure –organizational structure includes authority in the company, status, rewards, workflow, and communication. Communication helps information, command, persuasion, and integration to flow within the company. They are the pattern of interpersonal interaction that influences the member behavior along the task. Status shows the hierarchical structure of the organization, while rewards define the responsibility related to personal goals.

Buying Technology – Technology defines the nature of organization process, what is bought, plant, and equipment of the company. It helps to determine the information and management systems, which is concerned in the decision making process.

Buying center – It is the organizational actors that involves in the purchasing decision process. This interaction among actors contributes to unique behavior of each organization.

- The Social Factor

It is variables within the organization that involves in the buying problem. The five roles in the organization center include;

Users – Individuals who use the products and services

Buyers – Individuals who contract the supplier

Influencers – Individuals who provide the information for evaluating the brands and suppliers.

Deciders– Individuals who has authority to choose the products and services.

Gatekeeper – Individuals who control the information flow.

- The Individual Factor

The individual behavior plays an important role in decision making through the basic mental process such as learning, recognition, personality, and preference.

The framework (Figure4) helps to analyze organizational purchasing behavior that helps to plan purchasing and marketing strategy.

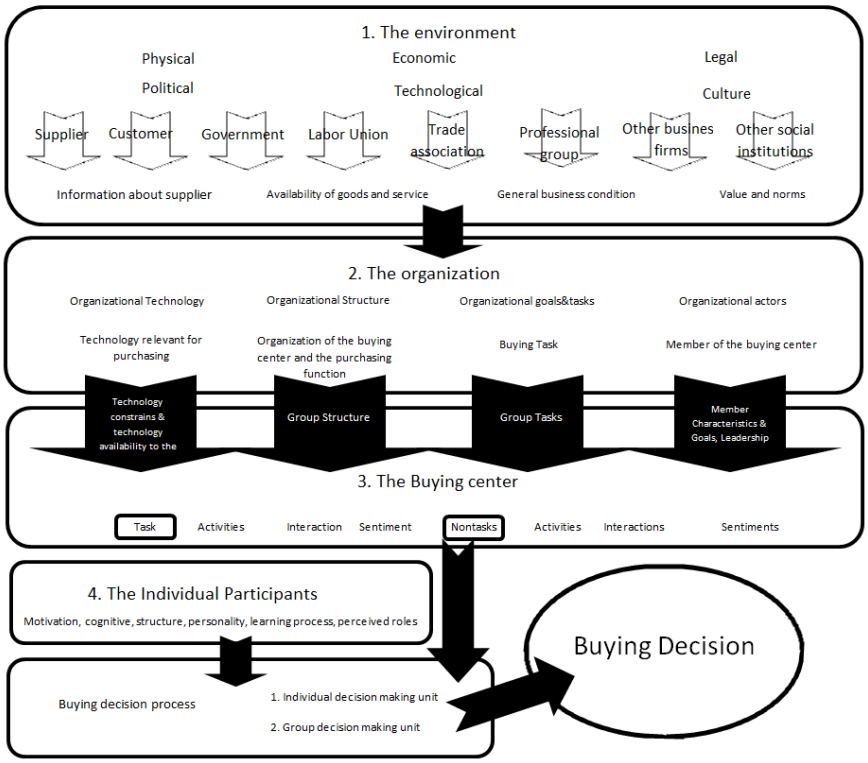

Figure 4 Model of Organizational Buying Behavior (source Wind&E. Webster,1972)

2.2 Marketing Tools of High Technology Products

According to (Kotler 2003), marketing is defined as "determining the needs and wants of the appropriate markets and to profitably produce the desired product or services by being more efficient than the competition". Marketing focuses on planning and implementing the product, pricing, promotion, and distributing the goods, services, and idea in order to make them acceptable and available at the right place, at the right time, and at the right price to the target customers. Most of the companies believe that the acceptable products will be purchased, if they are available at the right price.

High Technology products refer to any product manufactured with any types of advanced technology. The main characteristics of high technology products contain distinctive features, which include;

(1) It requires a sophisticated technology. It has to apply know-how or scientific knowledge to the functionality, marketing, and manufacturing.

(2) It is updated frequently. The product has to be developed and change at a high rate. The improvements of the existing technologies are exponential achieved by the researchers.

(3) It is innovative for the market. It has to bring new change or innovation to the market. One of the benefits of innovation is making competitiveness to its product and company. It can be sustaining innovation or disruptive innovation that improves the establish market's performance or creates a new market.

(4) It requires high investment in R&D. It is very costly because the company has to put a lot of money and knowledgeable expertise. It was found that the life science industry is the one of the top spending industries on R&D activities. Figure 5 shows the increasing of global life science R&D spending from 2015 to 2017. It has to create technological solution and new product for manufacturing pharmaceutical, commercial research and testing, animal and agricultural bioscience products, biotech products, and medical instruments and devices (Bernstein 2017).

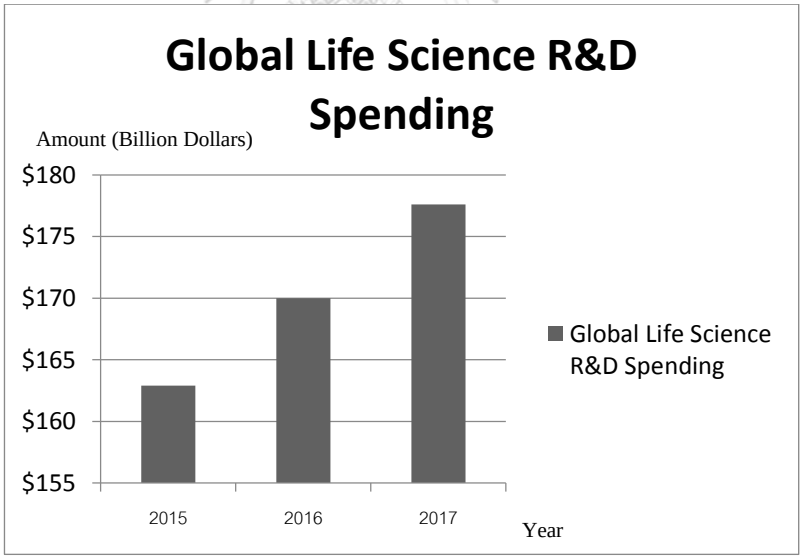

Figure 5 Global Life Science R&D Spending (source Bernstein, 2017)

(5) It is intended for specific markets. Since it has to deal with an advance and sophisticated technologies, the specific market will be approach. The most important criteria for purchasing decision are performance of the product. The customers will look for innovations or the development of the product's performance.

(6) It is integrated into high-tech applications. The components of the product are just raw materials that are distinguished from the system. The systems are finish products that are sold directly to the end-users. Moreover, the standard product should be flexible in order to adjust to changing demands.

Table 2 The Importance of Marketing Tools to High-Tech Firm (source Sangeet, Nicholas & Eric., 1997)

Rank	Marketing tools
1	Product image (reputation)
2	New product development
3	A competent sales force
4	Having state-of-the-art technology
5	Having a strong service organization
6	Reputation of firm's distributors
7	Completeness of product line
8	Having strong patent protection
9	Use of market research
10	Price competitiveness
11	Creativity of advertising message
12	Extensive advertising

According to Sangeet, Nicholas & Eric., 1997, the marketing tools of high-technology (Table 2), which the importance are raked accordingly (Sangeet, Nicholas & Eric 1997). The high technology companies is defined by a high spend on R&D background or a percentage of sales (Zakrzewska-Bielawska 2010). For this study, gas chromatography is a professional and scientific instruments considered as a high technology, which frequently used for analysis in the R&D laboratory. Therefore, the company who regularly uses gas chromatography can also consider as a high technology company. The market of gas chromatography is different from low technology products. Sangeet, Nicholas & Eric., 1997 who investigates about marketing approaches used by high-tech and low-tech companies in the UK, stated that there are significant differences between the market of low technology products and the market of high technology products due to the nature of quickly changing of high technology markets and products.

2.3 International Purchasing and the Post-purchase Behaviours

According to Lucero, the international purchase faces 4 main problems that lead to Post-purchase behavior (Figure 6). Cost, logistics, government, and cultural factors influence the buying decision in the next purchase. Moreover, there are 3 types of behavior in the post-purchase process: purchase is repeated without modification, purchase is repeated with modification, and there is no rebuy (Lucero 2008).

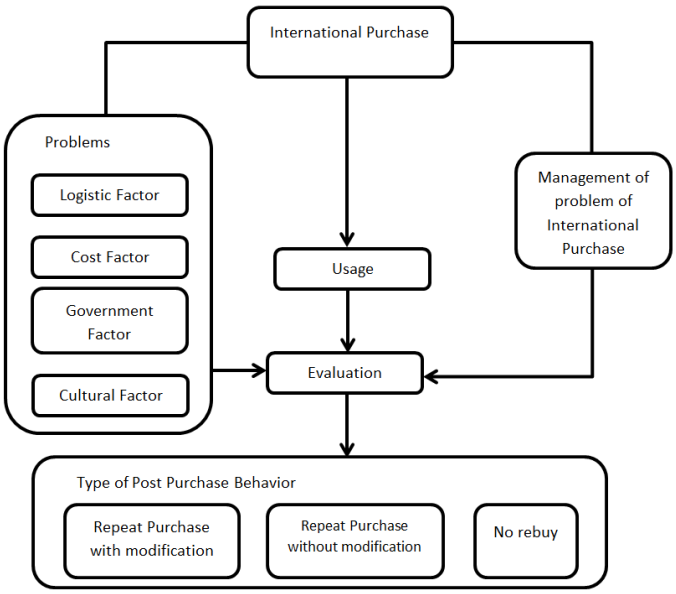

Figure 6 A Model of International Post-purchase Industrial Behavior (source Lucero, 2008)

2.4 Purchasing Process

Purchasing is a key activity that enables the company to provide high variety, great quality, low cost and fast delivery of product(A. & Kailash 2005). The company have to develop purchasing strategy based on the basic of its business's strategy and the nature of the products and their components in order to achieve strategic purchasing (Drake & Lee 2009). Pazirandeh (2017) suggests a model of purchasing process. The framework in Figure 7 shows different steps of purchasing functions and specifies what kind of decisions will be made in each step. Therefore, the purchasing process is the combination of all decision concerning sourcing a product from analyzing customer and market needs, defining the specifications and requirements, developing strategies, selecting suppliers, negotiating and contracting, expediting and controlling the order, and Evaluating the suppliers (Pazirandeh 2017). The end customer needs and requirements have to be considered as an input in the purchasing decision. The specification refers to the quantity and quality of the products that the company will purchase. It is often based on technical requirement. In addition, the company needs to understand the market by learning and analyzing the supplier market. The company may use

some tools such as requests for information (RFI) and request for quotations (RFQ) from available suppliers in order to realize the market price. Next step, the company should have a routine process to easily identify alternative and clearly select the most appropriate suppliers. Then the selected supplier needs to negotiate in order to get competitive price, payment terms, delivery condition and time, and other agreement. The last step of the purchasing process is the company suggested to follow and monitor the purchase order and product delivery, as well as evaluate the supplier's product and service and develop good relationship with the suppliers.

Figure 7 Purchasing Process Framework (source Pazirandeh, 2017)

According to Pazirandeh (2017), first stage of purchasing process is the most significant stage in the entire process. The company needs to determine the customer requirements and market demands in order to establish purchasing strategy.

The purchasing strategy exhibits how the company runs its purchasing function, which shows the overview of the company's roadmap in conducting its purchasing activities. The purchasing strategy should align with the business strategy and governance framework of the company. This strategy enables the company to review processes such as strategic planning, operational planning, benchmarking, performance evaluation, and productivity improvement in managing the purchasing activities of the company. It is structured and assistive process of company spending, as well as information in order to make decision about how the company acquires goods and services more efficiency and effectively. Normally, the purchasing strategy is reviewed annually. It is a "living document" that can be changed and modified over time to reflect a number of factors affecting the business. The factors will include internal and external changes such as the operation and roles within the company, the dynamics of the market, and complexity of purchasing activities (McCully 2017).

2.5 Purchasing Portfolio Models

In order to consider about professional purchasing strategy, purchasing portfolio models are considerable used by academic writers in literatures and mangers. Many advantage and disadvantage of each criteria are revealed, put forwards to discuss for setting business direction. There are many Purchasing portfolio models, which are introduced to determine purchasing strategy.

2.5.1 The Kraljic Purchasing Portfolio Matrix

One of the most popular purchasing portfolio models is the Kraljic purchasing portfolio matrix. Kraljic (1983) suggested purchasing approach to classify a firm's purchasing items in the four quadrats on "the importance of purchasing" and "the complexity of the supply market". Each quadrants show different supply strategies. The importance of purchasing is in the vertical axis, which considers cost of materials, value added profile, and profitability profile, while the complexity of the supply market reflects supply, monopoly and oligopoly condition, pace of technological advance, entry barrier and logistics cost to determine the complexity of purchasing. Four strategies are applied to each quadrant to optimize the supply (Kraljic 1983). He categorized purchasing material requirement into four categories (Figure 8):

2.5.1.1 Strategic Items (Supply Management)

The items give important value to the organization that has a large impact on high supply risk and high profitability. In most case, strategic items often can purchase from only one or two suppliers that cause a high supply risk. Therefore, the company needs to mitigate risks and build long term relationship with suppliers to maintain a strategic supplier.

2.5.1.2 Leverage Items (Material Management)

The items are relatively low supply risk since the products can be obtained from multiple suppliers. The company has the ability to negotiate with suppliers that can share the end product's cost price. These characteristics allow the company to set buying strategy through exploiting the buying power. However, strategic partnership is recommended for this quadrant.

2.5.1.3 Bottleneck Items (Sourcing Management)

The items are moderate impact on the end product's cost because they have medium effect on the financial result. Nevertheless, the supply risk is very high. Suppliers have power over the company making dominant power position. The recommend purchasing strategy depends on acceptance of negative effects, which the company should try to move this situation to non-critical quadrant and find other suppliers.

2.5.1.4 Non-Critical Items (Purchasing Management)

The items have low supply risk and low impact on financial results that have a small value per unit making them the lowest priority in a purchasing strategy. There many

alternative suppliers to support these items, so they may cause only few commercial problems. In this case, the company is suggested to pool purchasing requirement that can reduce the administrative and logistics costs. Moreover, purchasing power can be enhance by standardize purchasing requirement.

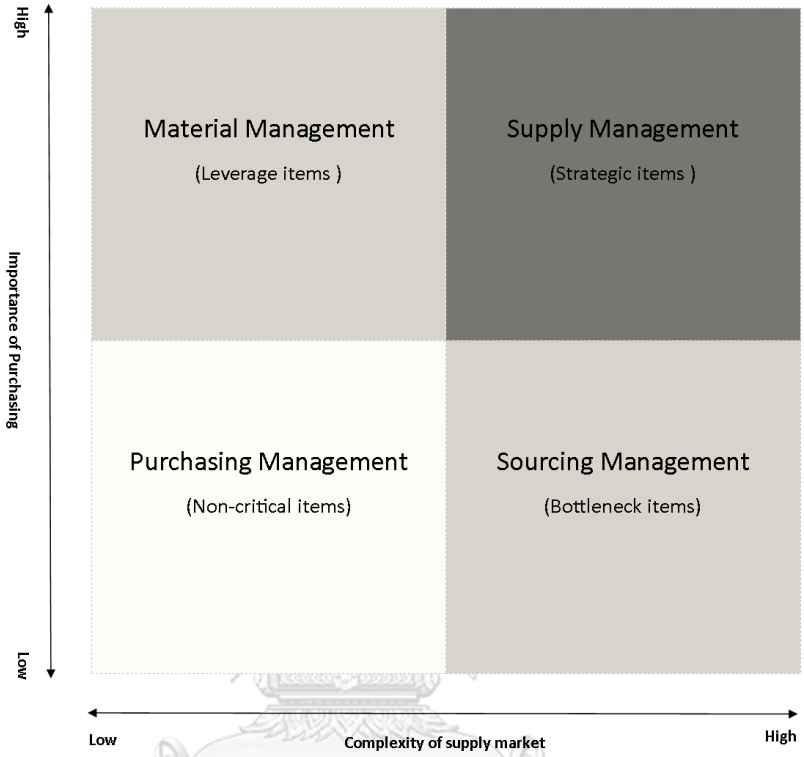

Figure 8 Stages of Purchasing Sophistication (source Kraljic, 1983)

2.5.2 Types of Product

Understanding the nature of the products enable the company to set purchasing strategies. Considering nature demand of the product leads to effective strategy. The corporate performance could not succeed without right lying direction of purchasing and product strategies. According to (L. Fisher 1997), he introduces a relationship between supply chain strategy and uncertainty's degree of product demand. Bundled the end product into two or more categories help companies to enhance profit, market position and increase product value to the customers (Blattberg & Neslin 1990). Consequently, Fisher classifies products into 2 types; functional product and innovative product. He suggested that it is significant to take a right approach in determining the product whether they are functional or innovative products.

The functional product is predictable demand patterns in a physically efficient supply chain. It can be found in wide range of retail store that people buy it to satisfy basic needs. The stable, low variety, long life cycle, and easy to forecast attracting competitors to the

same market leads the function product to low profit margin. Predictable demand easily makes function product to be perfect match between supply and demand. Distributors and end companies can shape certain schedule to produce, assemble, and launch their products. This allows company to commit with suppliers and customers for ordering, production, and delivering the products. In term of physical and mediation costs that occurs during production, transportation, and inventory storage, function product also can decrease concerns when costs arise, when the demand is shortage and supply is excess resulting in loss profit during pushing product to the market. Moreover, the visible supply chain can maximize production efficiency and minimize inventory along the chain(L. Fisher 1997).

The innovative product is contrast with functional product that is high variety, short life cycle, volatile demand, and high profit margin. The company has to devise technology and fashion innovative to satisfy customers. Although fashion enables the company to gain more profit, it is hard to retain their product in the market as just a few months causing its life cycle is short. The short life cycle and variety of product increase failure in market forecasting and obsolescence of the product. The demand of the innovative may quickly disappear before the product is introduced to market. This uncertain market increase risks of excess and shortage supplies since the company cannot forecast exact demand. The success of this kind of product depends on changing buying behavior, trend, lifestyle, and perceiving value from the customers. The unpredictable demand pattern and high profit margin require different strategy and supply chain from the functional product causing supply chain to be a market responsive. Information flow is important, not only within the supply chain, but also from the market into the chain. Quick responses, speed, and flexibility are crucial more than minimizing cost (L. Fisher 1997).

Table 3 Characteristics of Functional and Innovative Products (source L. Fisher, 1997)

	Functional Product	Innovative Product
Demand Aspect	Stable/Predictable Demand	Unstable/Unpredictable demand
Product Life Cycle	Long (More than 2 years)	Short (3 months to 1 year)
Variety	Low (10-20 variants/category)	High (millions of variants/category)
Volume	High	Low
Manufacturing Strategy	Make to stock	Make to order
Lead Time Required for Make to Order	6 months to 1 year	1 day to 2 weeks
Average stock rate	Lower (1-2%)	Higher(10-40%)
Average Margin of Error When Production is Committed	10%	40-100%
Purchasing Strategy	Lean	Agile

Although there are obviously differentiations between function products and innovative products, Fisher has found that many companies also face with some issues. Some products that have same physical appearances can be either function or innovative products. For example, clothes, cars, food and beverages, and telephone can be categorized to be sold as basic function products or innovative products. The company has to consider product strategy through changing environments. The company has to be aware of unsold inventories, declined services, and competitors' strategies.

2.5.3 The Supply Option

The successful management of supply results from relationship between suppliers and customers(F. & J. 2005). It occurs when the firms aim to develop and improve products and services, processes, and established system for emergent procedure. Apart from these aspects, firms are concerns with the desired outcome of any inputs and relationship structure between firms. The relationship between suppliers and customer are significant for effective long-term development for supplier capabilities and production system development (Scannell, Vickery & Droge 2000). The suppliers directly receive impacts from customers or buyers' business strategies such as quality, cost, delivery, technology, profit, and flexibility (R. Krause, Scannell & Calantone 2007). In some case, the cost of raw materials is the significant

overhead, which contributes to around 70 percent of company's overall costs. Therefore, choosing supply option can maximize company's profit and maintain an enterprise's survival. The customers should focus on relationship with their suppliers since developing and maintaining relationship can enable them to achieve business goals through compliance and collaboration with their suppliers. The success collaboration requires trust, information sharing, mutual commitment in order to improve performance. Power of buying is the mechanism for accomplishing collaboration, while trust gives a basis for accomplishing compliance (R. Krause, Scannell & Calantone 2007). Each supply option may not use only one single purchasing strategy to propose, but characteristics of each strategies are used to concern how fit with the assertion and develop specific applications (Paul, Dong Myung & Matloub 2013).

2.5.4 Lean Purchasing Portfolio Model

Lean supply strategy relates to how to supply quality products and minimize cost. The aim of Lean supply is to produce good quality product at low cost by reducing non value added and remove waste. The Lean approach is applied to enhance optimize and sustainable supply (Kazi & A.M.M. 2014). The relationship with supplier should be long-term agreement on improving quality and cost. The product should be standard components that can be purchased in batch size. Suppliers can maximize production batch size resulting in economics of scale for both production and purchasing sides. The inventory cost can be reduced when producing the products in large scale. Lean customers order multiple and large demand from their suppliers and expect to receive reliable quality, price and delivery. Byyongho (2004) suggests that standard components should buy in large quantity from global suppliers since it can dramatically improve cost and quality, immediately (Byoungho 2004). However, in order to retain themselves competitively in a long-run, global firms need to have purchasing strategic approach(Kun & Paul 2007). The effective approach for managing global supply is to take re-order point stock control method. The characteristics of Lean supply relationship are closed bond, open communication, and standardization. Suppliers should be always aware of the status of their relationship with their manufacturers and customers and try to improve their performance to prevent business loss. From Table 3, the Lean supply is suitable functional products since stable and predictable demand with standard components is able to order with a large quantity. The cost and quality of standard products will be reduced by Lean supply. When the demand is predictable and stable, a push production system is more proper than pull production system(Paul, Dong Myung & Matloub 2013).

Manzouri et al. (2013) stated that supply costs today need to be deducted in order to satisfy customers' requirements since pressure from the end customers on the retailers. It is necessary for the entire supply chain to involve from the suppliers of components to manufacturers, wholesalers, distributors, and retailer to reduce the costs. All tool and technique helping to reduce the cost and add values should implements by the suppliers and customers that leads to satisfy end customer's needs (Malihe et al. 2013).

2.5.5 Agile Purchasing Portfolio Model

Agile supply strategy related to offer quick and flexible product to more variable customer needs by emphasizing on service level and lead-time. The products that depend on flexibility and time are suited to Agile supply. Agile approach is able to apply every aspects of practices, which characteristics of Agile involve responsiveness, flexibility, change, speed, mobilization ,and customization (Sherehiy, Karwowski & K. Layer 2007). The organization can design and apply Agile to its own business goals, purchasing strategies, managements, and business processes. The aim of Agile supply is to satisfy customers and employees with ability to rapidly respond volatile environments in customer demands and market that occur in their business(Lin, Chiu & Chu 2006). Closed and long term relationships are appropriate to this strategy since the components require modification and change. The closed contact can enhance ability to make wide range of the end products. Local suppliers are suggested to the company, which can offer higher flexibility than global suppliers. Robert M. Monczka (2011) presented that local supplier helps customers to reduce delivery time, while reliability is increased to response flexible requirements. Small suppliers are also suitable source for Agile supplies resulting from the suppliers are responsive and pay more attention in detail to the specific customers(Robert M. Monczka 2011). Lin, Chiu & Chu (2006) have proposed a conceptual model of Agile supply chain as shown in Figure9.

Different businesses face with different environments, which create unique change drivers to them. The common Agile drives include customer need and requirements, intense competition factors, volatile market, and accelerating technological innovation. Base on changing in business environments, the required Agility level is determined by each company that results in Agile capabilities.

In order to measure Agile supply chain, the Agility pillars are identified to show required Agile capabilities for the company to become an Agile supply chain. The Agility enablers/pillars are categorized into 4 aspects including (1) collaborative relationship: the strategy that forms ability to attract suppliers and customers to share information and create innovative products together by collaboratively working. (2) Process integration: the

foundation of process integration and supply chain network that link entire partners together to found a network of collaboration. (3) Information integration: the infrastructure of the supply chain that establish ability to utilize information technology to share data between suppliers and their customers. This create information-based as a virtual supply chain rather than inventory-based. (4) Customer/marketing sensitivity: the mechanism of the supply chain that is ability to respond customer demands, changes, and uncertainties in business environments.

After considering Figure 9 Agility level and Agility enablers/pillars, agile supply chain needs various capabilities to cope with change, unpredictability, and uncertainty occurring within its business. The Agility capabilities are four elements, including (1) responsiveness: the ability to analyze and respond to uncertainty rapidly and ability to cover them quickly. (2) Competency: the ability to know objectives of the business efficiently and effectively. (3) Flexibility: the ability to accomplish the business' goals by working different procedures and using different facilities. (4) Quickness: the ability to get the job done as fast as possible. Goal of Agile supply chain is to enrich and satisfy customers in volatile environments including cost, time, function, and robustness.

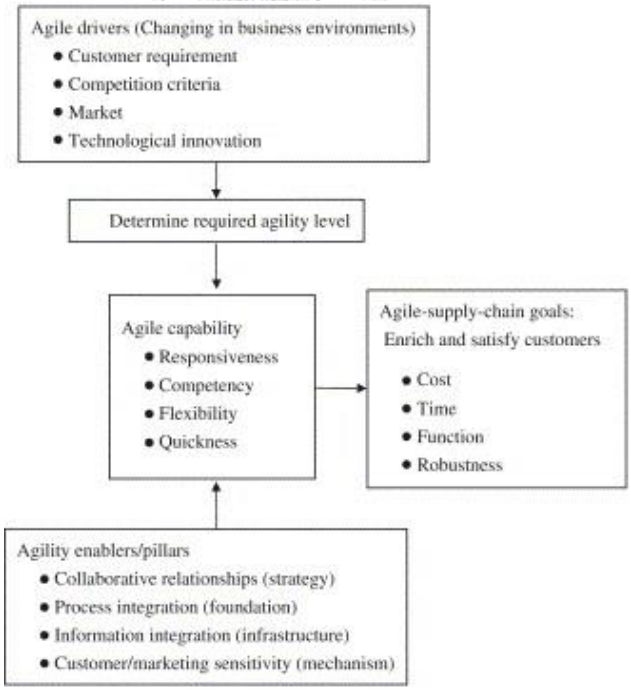

Figure 9 A Conceptual Model of Agile Supply Chain (source Lin, Chiu & Chu, 2006)

2.5.6 Leagile Purchasing Portfolio Model

Leagile is a hybrid supply that combines “Lean” and “Agile” approach at the decoupling point for an optimal supply strategy. Leagile supply is appropriate for both Lean supply and Agile supply that does not concern only quality and cost, but supply concentrate on flexibility and time(Zhang, Wang & Wu 2012). Although products that focus on good quality and low cost cannot be factors to win business, they still need them to continuously improve the quality and reduce the cost in order to stay in the market. In a single company or entire supply chain, it is seldom to find a pure either Lean or Agile supply strategies in a real world. Normally, the company will consider both Lean and Agile to optimize their problems (Masoud & Ahmad 2016).

A key element of this model is a “decoupling point”, which separates the Lean processes from the Agile processes in the supply chain. The lean processes are on the upstream side of the decoupling point, and the Agile processes are on the downstream side. The decoupling point also acts as a strategic point for buffer stock, and its position changes depending on the variability in demand and product mix.

Ben Naylor, Naim & Berry (1999) suggested that Lean and Agile practices should be mix with a supply chain strategy by knowledge of market and a specific positioning of decoupling points. When combine Lean and Agile together, the strategy can quickly responds to batch production of upstream enterprises and changing customer demands of downstream enterprises on a decoupling point in supply chain. In order to develop Analytic Hierarchy Process (AHP), four criteria of Leagile capabilities are (1) ability to respond unpredictable demand, (2) ability to cope with variability in production, (3) ability to provide variability in products, and (4) managing a level of scheduling upstream from the decoupling points (Ben Naylor, Naim & Berry 1999).

2.5.6.1 Benefit of Leagile Strategy

- Reduce Inventory

Leagile supply chain makes company to realize an importance of sharing information in every stage along the supply chain from product design, raw material procurement, production, sales until delivery the end-product to the customers. E-commerce and information technology help information to connect and share in the network that can prevent asymmetry and defective information. They also enhance collaboration between suppliers and customers and improve ability to respond flexible demands in the market. Thus, the

suppliers in Leagile supply chain are no need to deal with inventory risk because of forecasting direct demand, resulting in reduce inventory effectively.

- Shorten the Length of Supply Chain

According to Wu et al. (2012), the author ignores the role of distributors and retailers in the Leagile supply chain model since this Leagile strategy use direct selling mode. Leagile supply initiate production from customer requirements. The production, procurement, sales, and delivery are directly required from the end customers. Therefore, these shorten length of supply chain of Leagile strategy can improve efficiency and lower the cost. In addition, as the length of supply chain create the bullwhip effect, shorten the length can help to avoid amplification of demand.

- Order Guidance and Quick Response to Market Demand

As the Leagile supply chain produces the products based on the end-customer orders, both Lean and Agile are applied to the process. The company will use Lean method to purchase raw material and produce standard product, before assembly standardized modules with a specialized parts to invent a new product as the customer requirements. This approach can reduce complexity of the design, reduce complexity of production, reduce lead-time, increase efficiency, and increase flexibility and variety of the end-products to satisfy specific demand of each customer.

- Close Cooperation Between Enterprises

Leagile supply is recommended to locate suppliers' warehouses around the core assembler or manufacturer in order to decrease transportation time. The suppliers can decrease cost of operation and delivery, while the quality of product and service will increase. This method can also tighten cooperation between suppliers and their customers since they located near to each other and rapidly share information.

2.5.7 Decoupling Point in Value Chain Management

Customer order decoupling point (CODP) refers to the point in value chain where the customer order ties to production activities. The decoupling point separate the part of supply chain between the part of planning and the part of satisfying customers. It is the buffer between the variety of product output and the fluctuation of customer demands. The positioning of decoupling point can enhance efficiency and effectiveness of the value chain due to postponement of manufacturing operation(Rachel, Ben & R. 2000). The postponing product differentiation can also decrease stock issues such as holding excess inventory and stock-outs. However, the diversity of product differentiation depends on moving the

decoupling point(Davis 1998). The decoupling point is the last point that the inventory is held. Thus it is a strategic point to show stock availability, lead-time, and capacity availability in order to support customer-order driven activities. The different position of CODP create manufacturing situations including make to stock (MTS), assemble to order (ATO), make to order (MTO), and engineering to order (ETO)(Olhager 2010).

- Make to Stock (MTS) refers to products are produced to stock before there are order from the customers. It is regarded as push strategy. The suppliers may produce a large quantity and all categories of products. The advantage of this strategy is that products are always available when customers need. It can prevent stock-out resulting in opportunity loss. Nevertheless, one of issues that may cause from MTS is inventory management. The company has to handle their supply as not to have excess stock. Thus, small-batch supply is required to manage this strategy(van Donk 2001).
- Make to Order (MTO) refers to some or all of the design and production taking place after customer order the products. It can customize the products resulting in increased flexibility to meet the specific demand for individual customers. Normally, the customers will provide the information about characteristics and function of the required product. The company will design the product according to customer requirements. Kingsman et al. (1996) proposed that two characteristics of the company that use MTO strategy are: (Kingsman et al. 1996)

(1) The order from customers requires different process of work. The order are small number of product units, which it is difficult to forecast the facility loads long way.

(2) The company has to bid the order. The customer will make an enquiry for the products by asking several suppliers. Then, they compare the quotes before deciding to choose the supplier and place the order.

- Assembly to Order (ATO) refers to the companies delay of the final assembly of the end products until they receive customer demand. Most of the companies that use this strategy are in the high technology and automobile industries since they can postpone the final assembly to quickly deal with responses and customer demands. The characteristic of the company applying this strategy is the components have long lead-time. However, the company should keep inventory of the components in order to increase capability to respond to customer in time. In addition, the company can offer variety of the end-product and reduce cost of multiple end-products from keeping stock of the components. This type of strategy, the process has two main steps, which are component procurement, and assembly. Normally, the system composes of multiple components, which are used to produce complex subassembly and various end-products. The difficulties of the assembly-to-order are correlation of component used requirements, the differences of each component lead-time, and differences

in availability of components and demand. One of the assembly-to-order models, suggested by Atan et al. (2017) is periodic-review model (Atan et al. 2017).

2.5.7.1 Periodic-review Model

Periodic-review model is classified by Atan et al. (2017) into two categories depending on number of component orders including one-period and multi-period systems.

2.5.7.1.1 One-period System

As the technology has rapidly changed, the company has to consider individual order for each customer. The components purchasing are considered one by one case to serve different demands. One-period system allows company to purchase components only once. The quantity of purchasing depends on uncertainty, but demand of the end-product is associated. After the company knows the demand of the end-product, the components are assembled and delivered to customers. The problem of this system is each component has different lead time, which is hard to coordinate the arrival time. In addition, one-period system is divided into two aspects (Atan et al. 2017);

(1) Single End Product

Single end product is the component used to produce only one type product. The product price normally depends on delivery time. The faster the product is delivered, the higher a product price can be charged from the customers. Thus, the company has to order components in advance before the demand is realized. The company also has to assemble some part of the products or some quantity of the final products before the actual order has arrived. Moreover, to prevent stock-out problem, the company should use multiple sourcing channels in ordering components. It offers different lead-time and price, which can avoid risks that may occur when ordering from a single supplier. Multiple sourcing channels give more benefits than single sourcing channels, when demand uncertainty is high. It gives more options to acquire the components. Another problem that may occur from one-period model with single end product is limited assembly capacity. When the demand received or full shipment of the components arrived, the company will heavily assemble the end-product resulting in an insufficient capacity of assembly.

(2) Multiple End Products

Multiple end products are some components are required to produce more than one product. The common components that are used in several end-products are more expensive than special components because the company has to stock a lot of the common components causing pooling risks. However, optimizing the component prices will help to minimize the total holding and shortage costs. Generally, in assembly-to-order system, the components are primarily assembly into a module, and then the modules are assembled into final products.

The components and module are assembled into the final product, when the demand is realized. This strategy allow the company to rapidly respond to the requirement from customers and diverse the final products. According to Fu, Ning Hsu & Lee (2006), they test the multiple end products with limited assembly capacity in automobile industry. The final products are made up by following individual customer order (Fu, Ning Hsu & Lee 2006).

To sum up, in the one-period model with multiple end-products, the commonality level of components and optimizing the inventory level for components and modules are very significant for allocating and ordering decisions.

2.5.7.1.2 Multi-period System

This system means in the beginning of every period, the company place the order for components, then the demand for final products will received at the end of the period. Backlogs of components and final products as well as the inventories are carried to the next period. Same as the one-period system, multiple-period system is divided into two aspects; single end product and multiple end products.

(1) Single End Product

Single end product means the company produces only one type of the end product. If the product uses one component, the price may be different in each period. Thus, the company has to determine quantity and price in every period. For multiple components, this situation will result in price sensitive demand. Shao and Dong (2012) stated that the companies that use multiple components have to contain a certain policy for backup sourcing, backordering, late delivery compensation. Moreover, High Technology Company should make technology and inventory decisions that sequentially decision making in strategic level is more suitable in coordination, while jointly decision making in operational level is fit when there is high demand variability.

(2) Multiple End Products

First Come First Serve (FCSF) is the most popular principle that is used for multiple end products. The two major decisions that the company has to make are the allocation of the common components and replenishing the quantity of components. The company should allocate the components for producing the end product that use small number of components first. This system will work well when there is high variance in demand, which share common components.

2.5.8 Market Pull and Technology Push

Market-pull strategy is an approach that the company develops a product depending on an observed market demand. The company brings the ideas of the products from the

environment or market. Sarah et al. (2012) found that most of the companies recognized the opportunity from their own experience. This strategy helps the company to better realized how to compile its existing resources with the new product. Moreover, it enables the company to shorten the time for gaining revenue and launching its new product(Sarah et al. 2012).

Technology-push strategy is an approach that the companies try to commercialize a certain emerging technology. The company brings the ideas from existing or developing technology. Most companies are established by academics, which are inspired by the technology that they develop in their researches. It disrupts existing market and creates a new value chain. The technology-push approach has to challenge with higher market risks and failure in the technology itself. However, it gives higher return on investment (ROI), better long-run movement, and higher market penetration when the business is successful (Sarah et al. 2012).

Sarah et al. (2012) found that the companies that turn to apply market-pull strategy since they collaborate with new partners, receive new information, and change management priorities because of pressure from financial strain or investor. In contrast, the companies that turn to apply technology-push strategy because they want to improve their product and process in order to meet specification, respond demand for complementary product, and enhance productivity of the company. However, the company should balance these two strategies in order to create efficiency and effectiveness.

2.5.9 Porter's Five Forces

According to Porter (1979), he describes a "five forces" that form a structure of all industries and the root cause of profitability. Porter's Five Forces model is a tool that helps to understand the competitiveness of business environment and enables the company to identify potential profitability. If the company realizes the factors that have effects on profitability, it helps to adjust the purchasing strategy accordingly. Porter's five forces model pays attention to five forces influencing all industry that are the threats posed by competitive rivalry, bargaining power of buyers, bargaining power of suppliers, threat of new entrants, and threat of substitute products (Porter 1979).

2.5.10 SWOT Analysis

It is one of the most often used techniques to capture information and make it easier to communicate between people within the company and external people such as suppliers and customers. It is a significant tool to utilize at the outset of the strategic sourcing, which helps to highlight issues to be closer attention and clarifies the action that support company to have

an effective purchasing strategy. As general, SWOT composes of four areas: strengths, weaknesses, opportunities, and threats.

2.6 Cronbach's Alpha Value

It is important to ensure reliability and validity of the questionnaires that are consistent. The correlation of the question affects the Cronbach's Alpha value. The result of the Cronbach's Alpha analysis presents from 0 to 1 value, which the acceptable value should not lower than 0.7. The Cronbach's Alpha value will increase when the correlation among question items increase. Therefore, the higher scores give higher reliability and better internal consistency (J. Cronbach 1951).

2.7 Gas Chromatography

Gas chromatography (GC) is one of the most popular techniques, which is widely used as a separation technique in an analytical laboratory. Due to high sensitivity and selectivity of separated volatile compound, GC is the most accurate and precise technique used in routine laboratory. As shown in Figure 10, the instrument composes of 7 main parts: carrier gas, flow control, injector or sample inlet and sampling devices, column, oven or temperature control system, detector, and work station or data systems. The principle of GC is a sample is vaporized and injected into the injection port and travels through the column by the flow of carrier gas. The column itself contains a liquid stationary phase. While the sample is being transported by the gaseous mobile phase, it is absorbed by the surface of the column before detected by the detector (Acree 1998).

2.7.1 History of Gas Chromatography

Chromatography is firstly described by two researchers, Ramsey and Michael Tswett. At the beginning, Ramsey tried to separate the mixture of gases and vapors by using charcoal as absorbents. Tswett who later known as "father of chromatography" separated color of plant pigments by using liquid chromatography. His process was coined and described the term of chromatography, which literally means color writing. The importance of his work makes his paper has been published and translated into other languages like English. However, nowadays, chromatography is conducted in various fields on materials, not only for color separation (Bartle & Myers 2002).

Gas chromatography (GC) is one of the chromatography forms that use gas as an essential part. It is attributed to A.J.P. Martin and his colleague, A.T. James who presented the separation of volatile fatty acids by using partition chromatography supported on diatomaceous earth with silicone oil/stearic acid as a stationary phase and nitrogen gas as the

mobile phase. It was firstly exhibited at a meeting of the Biochemical Society on 20 October 1950, and then Chemical Industry society brought up this interesting issue again in September 1952 at a meeting in Oxford. Martin continuously worked on this field 11 years earlier on his Nobel - prize - winning paper on partition chromatography before discovering the simplicity, fast, and various applicability to many gas and volatile materials. In fact, Martin and R.L.M. Synge are the first group who discovered the principle of GC in 1941 that showed in the publication as "Very refined separations of volatile substances should be possible in a column in which permanent gas is made to flow over gel impregnated with a non-volatile solvent."(Issaq 2002).

The separation of petrochemicals was the most preferable GC technique at that time. In 1950s, the petroleum industry quickly adopts GC technique for their composition of petroleum analysis and replaces the main source of chemical feedstocks and liquid fuels by coal. It became more popular and gave rise to more advanced field and theories (Sneddon, Masuram & Richert 2007). For example, the researchers at Shell and British Petroleum are the forefront who develop and apply the GC to their works. The demand of GC instrument spread to other new industries, contributing to rapidly improve capabilities of the instrument and develop new gas chromatographs techniques. Biochemistry is one of the industries who let GC intensively grow in their area for natural product analysis, food and flavor analysis and amino-acid analysis. It was found that, in 1960, more than 200 papers were researched on fatty acids and fatty acid esters by using GC. This exponential growth was still continuing which showed in the development of capillary GC column in the 1980s. Presently, GC is a very crucial technique that the worldwide GC instrument market is estimated to be over 78,000 instruments annually(Bartle & Myers 2002).

2.7.2 Configuration of Gas Chromatographic System

The components of gas chromatographic system consist of carrier gas, flow control, injector or sample inlet and sampling devices, column, oven or temperature control system, detector, and work station or data systems (Acree 1998).

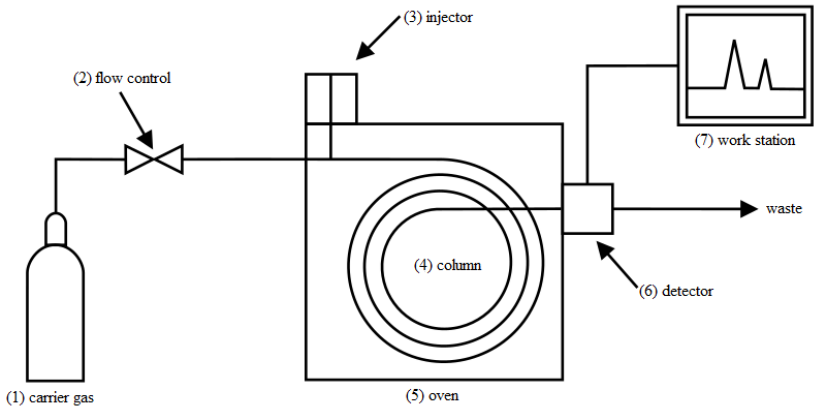

Figure 10 Configuration of Gas Chromatographic System

2.7.2.1 Carrier Gas

Carrier gas is used to carry a sample through the injector, the column, and the detector and to give a suitable mixture when the detector measures the sample. It is called mobile phase, which requires high purity in order to avoid oxygen and water attack the liquid phase in column. Different types of detector require different gas types. For example, electron capture detector need to use nitrogen gas with free oxygen, while Flame ionization detector requires Helium. The common carrier gases are Helium (He), Nitrogen (N_2), and Hydrogen (H_2) (Acree 1998).

2.7.2.2 Flow Control

Flow control is used to control flow of carrier gas, which is essential for qualitative analysis and column efficiency. The controller helps to reduce the pressure from tank of 2500 psi down to 20-60 psi that is usable pressure level. Moreover, it helps to maintain constant flow rate that flow through a column. An electronic pressure control (EPC) is applied to detect the flow rate with an electronic sensor(Acree 1998).

2.7.2.3 Injector

Injector (sample inlet and sampling devices) is used to introduce sample into the carrier gas stream. The sample can be gas, liquid, or solid. There are a variety of sample injection method such as manual, auto samplers, headspace, and gas sampling(Acree 1998).

- Manual: a syringe is used to inject the solution into the system.
- Auto samplers: sample is injected automatically with a mechanical device, which is normally placed on top of the GC instrument.
- Gas sampling: it requires the entire sample to be a gas phase under the condition in use. The mixtures of sample should heat in order to convert all the components to become gases.

- Headspace: a technique used to concentrate and analyse the volatile organic compound that the components diffuse into the gas phase until it reach a state of equilibrium before being introduced into the system (Figure 11).
- Pyrolysis: a thermal decomposition technique that heats the sample to reduce molecular size in an inert atmosphere. It is useful to identify involatile compounds
- Thermal Desorption: a technique that heat the solid sample to separate and remove contaminants. The volatile compound will be destroyed by heat or collected.

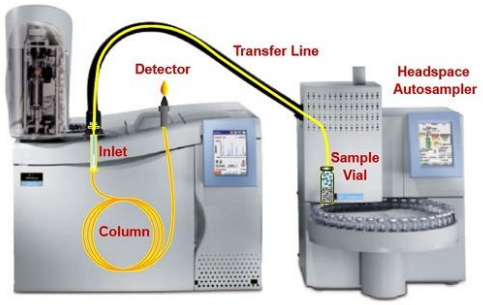

Figure 11 Headspace GC Instrument Diagram (Rigdon 2014)

2.7.2.4 Column

Column is equipment that used to separate mixture compound based on differences of compound's adsorption. The compound will move through the column containing stationary phase (adsorbents). The column is widely applicable, owing to many different stationary phases. There are 2 types of column, namely packed column and capillary column (Acree 1998).

2.7.2.5 Detector

Detector is an essential part that measures the sample in the gas stream before sending the signal to provide a record in form of chromatogram. The signal of detector can illustrate quantity of each compound in the sample providing quantitative analysis (Acree 1998).

- Mass spectrometry detector (MSD): a technique that converts chemical compound to ions and sort them by magnetic fields and external electric based on their mass-to-charge ratio. It measures the masses within the sample.
- Flame ionization detector (FID): the most common detector that is inexpensive and simple. The detector will measure organic compound ions during the combustion in hydrogen flame.

- Thermal conductivity detector (TCD): the detector compares thermal conductivity of the sample flow through column to a reference flow of carrier gas. The common carrier gases are helium or hydrogen.
- Electron capture detector (ECD): the technique used to detect electron-absorbing components of the sample
- Nitrogen-Phosphorus Detector (NPD): the design is quite similar to FID, but NPD use thermionic NPD bead in order to produce in hydrogen and air.
- Flame Photometric Detector (FPD): the design is also similar to FID, equipped with additional of photomultiplier tube, as well as selected phosphorus and sulfur wavelength to go through
- Pulsed discharge ionization detector (PDD): it uses helium for pulsed DC discharge gas as an ionization source that flow encounters the sample from column.

2.7.2.6 Work Station or Data Systems

Work station or data systems are used to measure the signal of GC. Normally, the systems can be divided into two types, which are integrators and computers. The computer system is now used in the chromatography laboratory, which enable the users to handle single and multiple chromatographic systems, acquire data, control instrument, display, and transfer data to other devices (Acree 1998).

Chapter 3
Research Methodology

This chapter describes how the study was conducted. The primary step in establishing a purchasing strategy is to collect and analyze the company's spending and data. The first 3 steps, the author will gather information from both internal and external sources in order to provide the most comprehensive look for developing the purchasing strategy. From developing purchasing strategy framework, the case study company needs to gather data and information from four sources including internal company, customers, suppliers, and market. As the case study company offers a variety range of chromatography products, this study will focus only on refurbished gas chromatography instrument.

The author proposes a process that consists of 5 steps, which includes: (1) analyzing spending data, (2) determining customer requirements, (3) assessing supply markets, (4) formulating purchasing strategy, and (5) executing and refining the strategy.

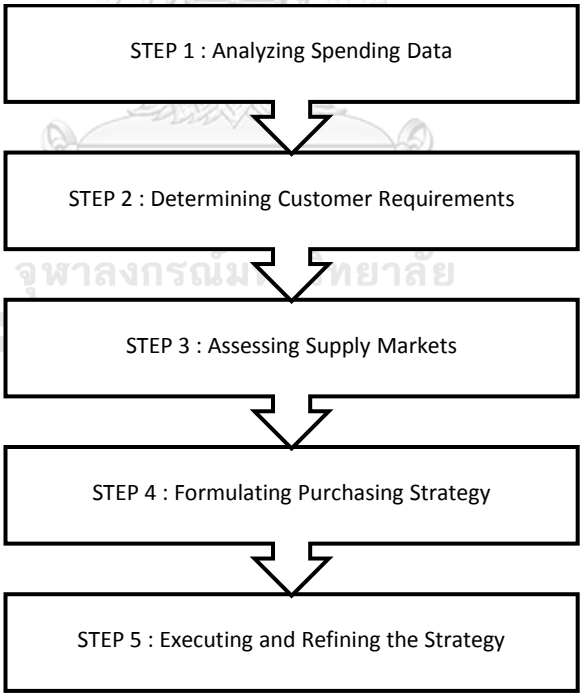

Figure 12 Developing Purchasing Strategy Framework

3.1 STEP1: Analysing Spending Data

Procedure

1.Discuss with participants

2.Collect data from the case study company

3. Analyze cost classification

4. Analyze spending categories

5. Analyze vendor analysis

Participants

1. Researcher

2. Managing director

3. Accountant

Firstly, brainstorming is held to discuss direction of this study and how to gather internal information. In term of analyzing spending data, the data will be collected from finance and administration department. The data will be gathered and consolidated in the same language and currency since all of the gas chromatography materials are imported from several countries such as United States of America, China, and Japan. All of the information will be translated into English language and Thai baht is set as the standard currency. Then, the data will be cleaned to find and eliminate the errors before classifying the products and group the same supplier together. The data is categorized with related to the business. Finally, the data spend is analyzed.(Aberdeen Group 2004)

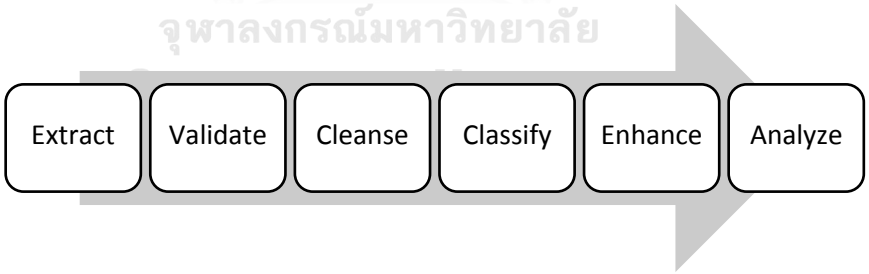

Figure 13 Spending Data Management Framework (Aberdeen Group 2004)

3.2 STEP 2 : Determining Customer Requirements

Procedure

1. Brainstorm with case study Company to develop questionnaires
2. Conduct pilot test
3. Survey administration
4. Analyze survey results by IBM SPSS statistics program

Participants

1. Researcher
2. Managing director
3. Procurement manager
4. Procurement officers
5. Sales and marketing manager
6. Case study Company's staffs
7. Professor
8. Experienced respondents in 100 companies using GC instruments

In order to determine customer requirements, questionnaires are developed to survey attitude towards refurbished gas chromatography. The survey is modified and adapted from Traynor & Traynor (2004), who studied about the use of marketing practices used by high-tech firms (Traynor & Traynor 2004).

The questionnaires are designed to gather information on the use of gas chromatography and attitude towards refurbished gas chromatography by high-tech companies. Chief executive officers, procurement officers, GC users, and professors in universities are asked to rate the factors to consider in purchasing refurbished GC. The data were collected via questionnaires from experienced respondents in 100 companies using GC instruments from different industries including food/feed, petroleum/petrochemical, pharmaceutics, environment, forensic science and toxicology, academics/university, and laboratory and testing service. The respondents were randomly selected from the case study company's customers. The survey implements personal interviews that ask respondents to complete the questionnaire.

3.2.1 Questionnaire Development

The questionnaires are composed of three sections: (1) interviewer information, (2) behavior and information on using the current GC, and (3) attitude and interest in refurbished GC. A number of questions were designed to profile each respondent in the first section: gender and position of respondents, type and size of business he/she is in, and experience in using GC. The second section was asked about the current use of GC in their organizations: specification of current GC, the number of GC, life time, frequency, demand of using internal and external GC, and satisfactory of GC and distributors. The last section consists of two parts including specification of refurbished GC and attitude towards refurbished GC. The Likert scale is conducted to express the factors that respondents will consider when they are going to purchase a refurbished GC. The question items using a Likert scale to measure attitudes and opinion with five level of agreement (Likert 1932). The respondents are asked to rate question items on strongly agree, agree, neutral, disagree, and strongly disagree.

3.2.2 Pilot Test

The pilot test is conducted to measure the viability of the survey administration and properties of the survey questionnaires. It enables to test the suitability of questions that has been designed and highlight a number of problems that may occur when conducting the survey to be tested. The pilot test are done by submitting to three type of people: industry expert, colleagues, and target respondents (Karlsson et al. 2016). Industry expert in this case, the pre-test questionnaires are provided to managing director of the case study company and a professor at School of Chemical Engineering, King Mongkut's Institute of Technology Ladkrabang in order to check whether the questionnaires can be able to accomplish the study objectives, as well as suggest and revise the questions about the terms, industry, and market of the GC. The role of colleagues is submitted by staffs at case study Company to correct accuracy in using language systems. Lastly, the target respondents help to check the answer of the questions and provide feedback on the questionnaires. The pre-test is done by face-to-face, which is easy to modify and revise the questions. Those three pre-test respondents are asked to complete the question as they are a part of the real survey. The researcher explains the objectives and procedure of the study before observing the respond what and how they fill in the questions. Then, the respondents are asked about the clarity of the instruction and questions, the problem in understanding and filling in the answers, and effective of the time in survey administration. The preliminary analysis is tested to measure the quality and adequacy of the obtained information. In addition, Alpha value developed by Cronbach

(1951) is used to measure an internal consistent structure of the questionnaires, which IBM SPSS statistics program is used to analyze Cronbach's Alpha value.

3.2.3 Survey Administration

The survey is conducted by 100 experienced GC users from 100 organizations. The survey site is in Samut Prakan Province, Nonthaburi Province, and Rayong Province, but mostly in Bangkok, Thailand. The organizations are in different business fields namely food/feed, petroleum/petrochemical, pharmaceutics, environment, forensic science and toxicology, academics/university, and laboratory and testing service. The GC is used to analyze the material sample for their work in the laboratory. Firstly, the respondents are briefly explained the purpose of this study, objectives of the survey, and definition of the refurbished GC. Then, the respondents are asked to answer the questionnaires, while interviewer is beside in order to observe and explain if the respondents have question.

3.3 STEP 3 : Assessing Supply Markets

Procedure

Brainstorm with participants to analyze Porter's Five Forces and SWOT

Participants

1. Researcher
2. Managing director
3. Procurement manager
4. Procurement officers
5. Sales and marketing manager

3.3.1 Porter's Five Forces

Porter's five forces model is used to analyze threats, including competitive rivalry, bargaining power of buyers, bargaining power of suppliers, threat of new entrants, and threat of substitute products. Each aspect is raised to discuss among participants. The company analyzes the supplier market through this tool in order to improve their position, take advantage of having effective purchasing strategy, and avoid risks in the future.

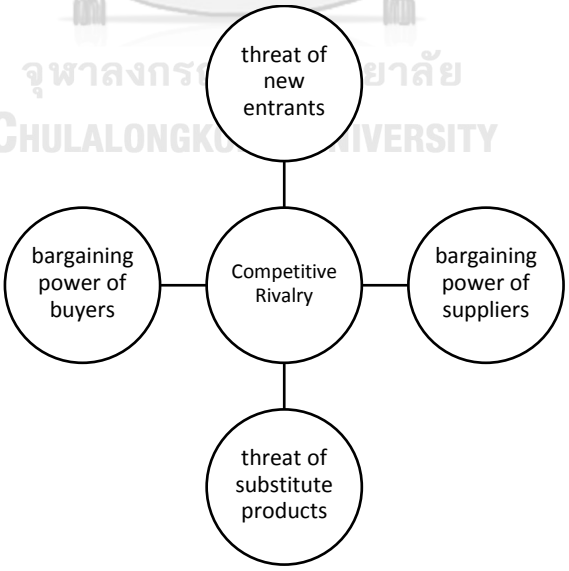

Figure 14 Porter's Five Forces Model (source Porter, 1979)

3.3.2 SWOT Analysis

Another tool that the case study company takes into account for developing purchasing strategy is SWOT analysis model. The participants brainstorm and discuss SWOT that consists of four parts: strengths, weaknesses, opportunities, and threats.

Table 4 SWOT Analysis

Strengths In-house characteristics that have a positive influence on purchasing strategy	**Weaknesses** In-house characteristics that have a negative influence on purchasing strategy
Opportunities External factors that help purchasing strategy to meet company's goal	**Threats** External factors that have damage effect on purchasing strategy to meet company's goal

3.4 STEP4: Formulating Purchasing Strategy

Procedure

Brainstorm with participants to develop purchasing strategy

Participants

1. Researcher
2. Managing director
3. Procurement manager
4. Procurement officers
5. Sales and marketing manager

After determining the spend data, customer requirement, and supply market, a purchasing strategy is developed. Purchasing strategy composes of various sourcing tools that were applied appropriately to purchase second-hand GC. Brainstorm with participants is conducted to come up with direction and plan for purchasing process. The elements for developing purchasing strategy include mission, vision, objectives, action plan, and KPI.

3.5 STEP 5 : Executing and Refining the Strategy

Procedure

Brainstorm with participants to implement purchasing activities

Participants

1. Researcher
2. Managing director
3. Procurement manager
4. Procurement officers
5. Sales and marketing manager
6. Salesperson
7. Stock keeper

After the strategy is developed from the previous step, the next step is to execute, manage, and refine it. When the strategy is executed, other functions in the case study company need to be participated such as marketing, sales, stock and finance. Moreover, the strategy should be visible, quickly changeable, and refinements made if necessary. The purchasing portfolio model is considered to provide appropriate allocating components,

resulting in better understanding the type of product that company is selling. Besides, suitable supply options are achieved from determining the decoupling point and thereby the most proper purchasing strategy for refurbished GC instrument is obtained. The progress and success of the strategy can measure by reducing the cost of goods sold.

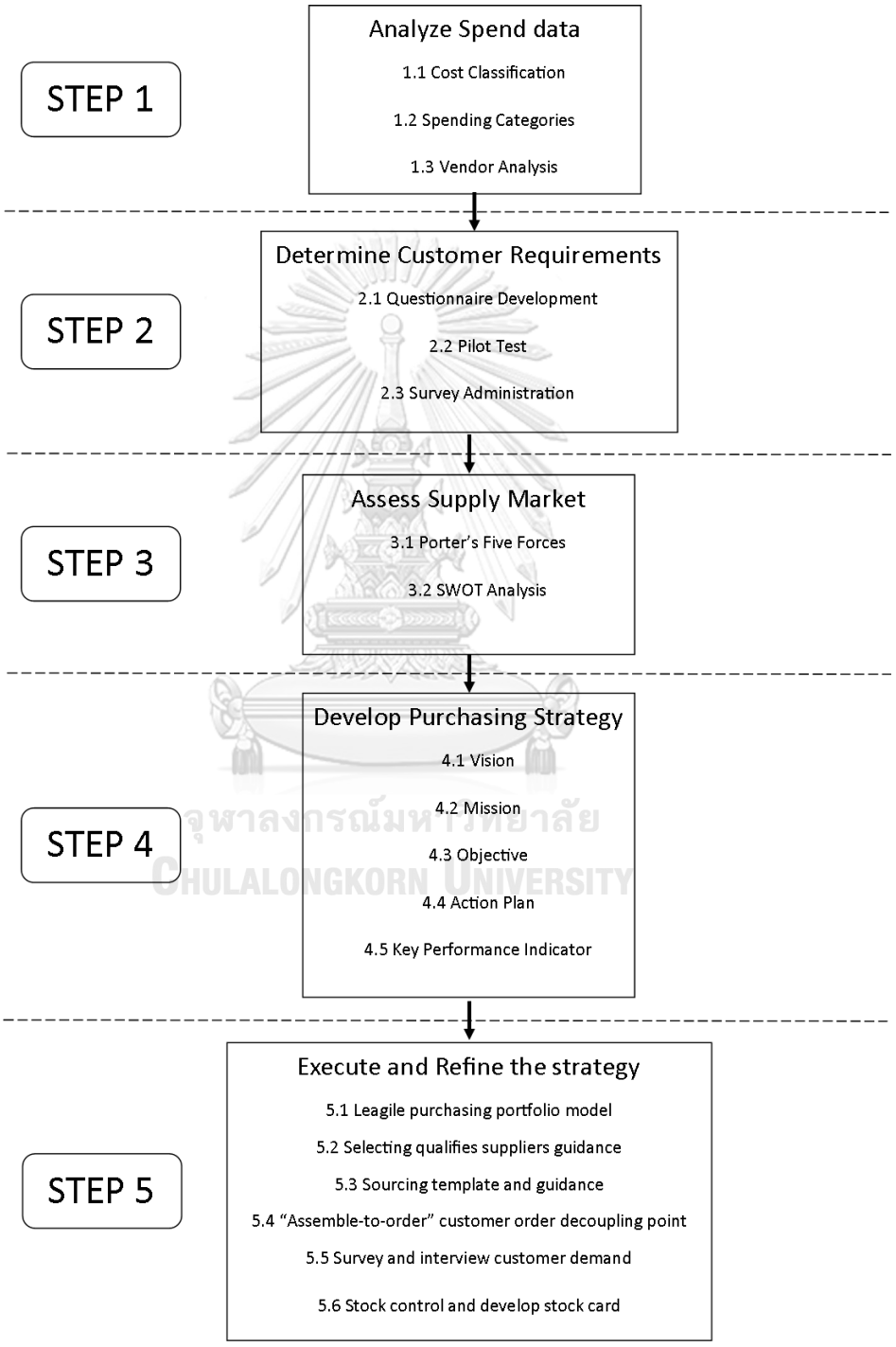

Figure 15 Developing Purchasing Strategy Steps

Chapter 4
Results and Discussion

This chapter presents results and discussion of the five steps explained in the previous chapter. Regarding to proposed methodology, the process in developing purchasing strategy for used gas chromatography instrument for refurbishing consists of 5 steps, which includes

(1) analyzing spending data,

(2) determining customer requirements,

(3) assessing supply markets,

(4) formulating purchasing strategy, and

(5) executing and refining the strategy

4.1 STEP 1 Analysing Spending Data

After discuss with the team members, the first step is to analyze spending data of the case study company to realize the cost that should focus and reduce. Therefore, cost classification, spending categories, and vendor analysis are taken into account.

4.1.1 Cost Classification

Table 5 Cost Classification that Company Spends to Produce a Refurbished GC

Spending list	Unit	Amount (Thai Baht)	Percent
1. Direct material (DM)			
1.1 Second-hand GC instrument	฿/unit	80,000	29.6%
1.2 Chromatography data work station (Software)	฿/unit	45,160	16.7%
1.3 Computer and printer	฿/unit	18,640	6.9%
1.4 Spare parts for refurbished	฿/ set	10,000	3.7%
1.4 Site Installation devices	฿/ set	2,000	0.7%
1.5 Helium gas (inc. tank and regulator)	฿/ set	15,500	5.7%
1.6 Hydrogen gas (inc. tank and regulator)	฿/ set	10,500	3.9%
1.7 Nitrogen gas (inc. tank and regulator)	฿/ set	9,000	3.3%
1.8 Purified air (inc. tank and regulator)	฿/ set	9,000	3.3%
2. Direct Labor (DL)			
2.1 Lathe service	฿/ time	10,000	3.7%
2.2 Paint service	฿/ time	10,000	3.7%
3. Factory Overhead			
3.1 Gas for testing (He, H2, N2, and Air)	฿/ time	800	0.3%
3.2 Chemical standard for performance checking	฿/ time	500	0.2%
3.3 Testing Instrument (e.g. flowmeter and thermometer)	฿/ time	500	0.2%
3.4 Air freight charge	฿/ time	20,000	7.4%
3.5 Duty (Tariff code: 9027-9099)	฿/ time	0	0.0%
3.6 Custom clearance fee	฿/ time	3,000	1.1%
Total Product Costs (1)+(2)+(3)		244,600	90.5%
4. Administrative expenses (10% of Product Costs)	฿/ time	24,460	9.0%
5. Selling expense (5% of Product Costs)	฿/ time	1,223	0.5%
Total spending	฿/unit	270,283	100.00

The table 5 shows costs that the case study company spends in order to produce a refurbished GC instrument. The spending list is obtained from costs that the case study

company spend, starting from contacting a supplier to order a used GC, transporting, refurbishing, testing, until installation of the refurbished GC at the customer site. The majority of the costs come from raw material, which the highest spending is second-hand GC instrument; approximately 29.6% of the total spending. Normally, the company imports one instrument per shipment. Thus, the second-hand GC instrument is entirely imported by air freight that cost around 20,000 baht per box. However, duty for Tariff code: 9027-9099 as a chromatography instrument is 0%. The total spending on product consists of direct material cost, direct labor cost, and factory overhead, giving a 90.5% of the total spending. The total spending in production of a refurbished GC instrument is 270,283 baht.

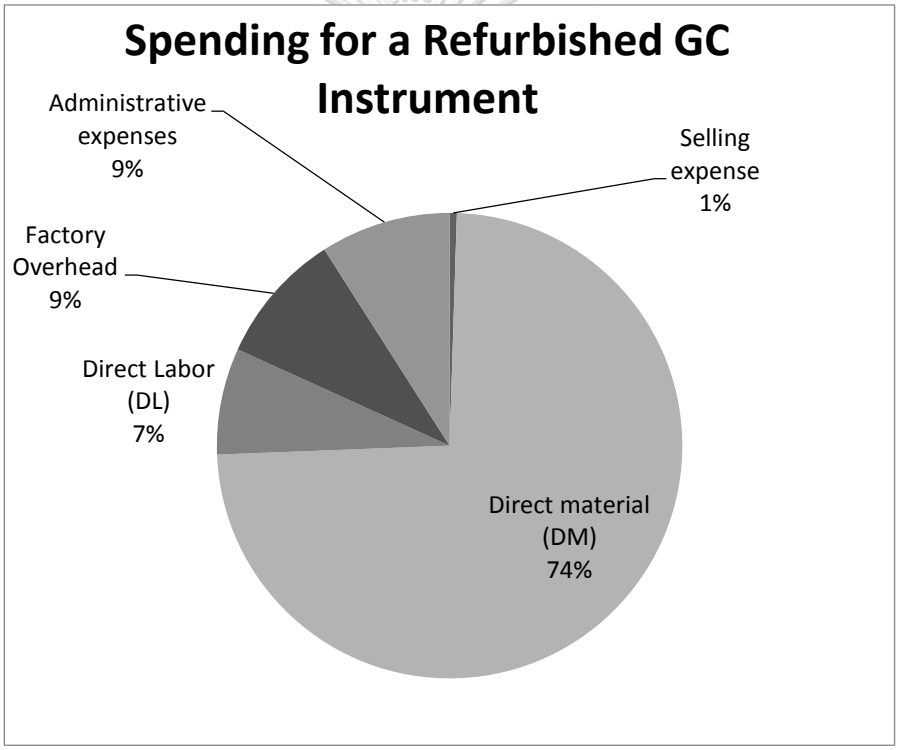

Figure 16 Spending for a Refurbished GC Instrument

The graph illustrates percent of each cost. The majority of spending is for direct material cost that is 74% of the total spending. The company provides 10% of the total spending for administrative and selling expense, while factory overhead and direct labor expenses are 9% and 7% of the total spending, respectively (Figure16).

4.1.2 Spending Categories

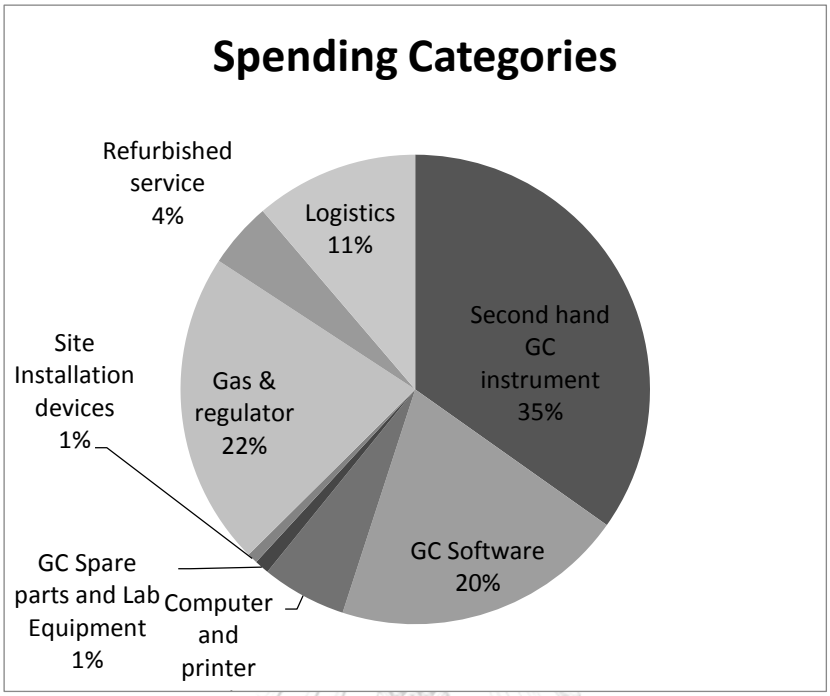

Figure 17 Spending Categories

According to the graph, the top three categories that company spends are for second-hand GC instrument, gas & regulator, and GC software. Therefore, the company should focus on these three categories in order to reduce the cost. Nevertheless, the company purchase gas & regulator and GC software from large companies that they neglect to give a discount for small purchasing. Thus, second-hand GC instrument will be the only one category that company should focus to develop strategy for creating big cost saving (Figure17).

4.1.3 Vendor Analysis

The used GC instrument has the highest number of suppliers. From July 2017 to Dec 2017, the company bought used GC instrument from 10 suppliers. Each supplier offer different prices between 120,000 baht to 38,000 baht for each instrument. The price is likely to swing because the second-hand products have a variety of quality, lifetime, condition, and completeness of components. The company had to decide whether it could accept the price and condition or not. In addition, the company has to purchase GC software from Software1 Company since it is the only largest company in the world who produce universal chromatography software. Most of the GC users are familiar with the program. Besides, the program is produced to compile with every brand and model of the GC. Gas & regulator

were also purchased from Gas1 Company since it is the biggest company in Thailand who supply quality gas for chromatography and laboratory uses.

Table 6 Vendor Analysis

Categories Spend	Number of Vendors	Vendors	Amount of Spend (July2017-Dec2017)	Total Spend (July2017-Dec2017)
Second-hand GC Instrument	10	GC 1	115,000	777,900
		GC 2	80,000	
		GC 3	120,000	
		GC 4	40,000	
		GC 5	38,000	
		GC 6	73,400	
		GC 7	53,000	
		GC 8	95,000	
		GC 9	84,000	
		GC 10	79,500	
GC Software	1	Software 1	451,600	451,600
Computer and Printer	3	Com1	69,534	130,480
		Com2	53,412	
		Com3	7,534	
GC Spare parts and Lab Equipment	3	Spare part1	11,000	22,500
		Spare part2	6,000	
		Spare part3	5,500	
Site Installation Devices	2	Device1	11,500	16,050
		Device2	4,550	
Gas & Regulator	1	Gas1	484,000	484,000
Refurbished Service	2	Paint	48,994	101,039
		Lathe	52,045	
Logistics	3	Freight1	179,442	251,590
		Freight2	52,045	
		Freight3	20,103	
			Total	2,235,159

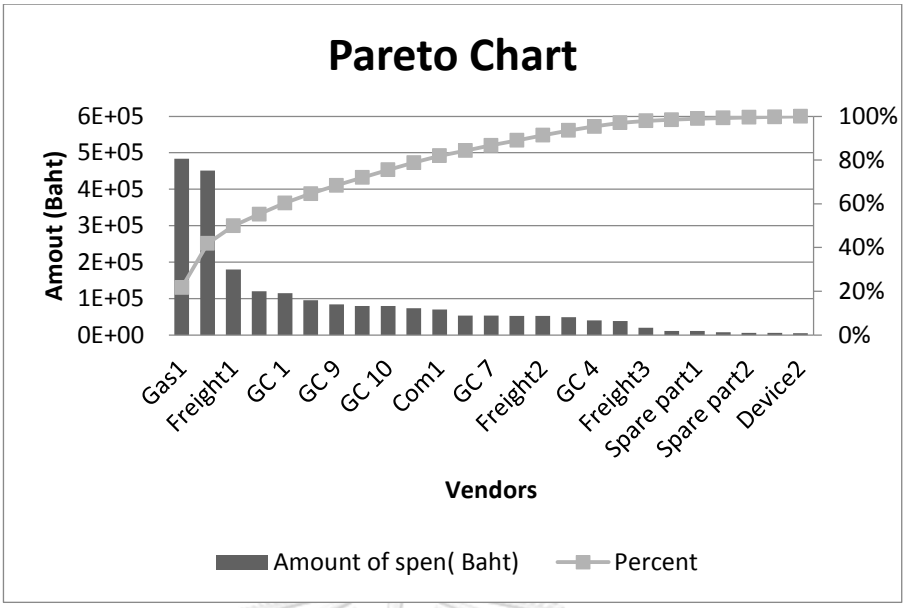

Figure 18 Pareto Chart

Table 6 and Pareto chart (Figure 18) show amount of spending from July 2017 to Dec 2017 for each supplier and spending money. The company can reduce total the cost of ownership by focusing on reduce cost of used GC instrument and freight as the cost of Gas and software are fixed.

4.2 STEP2 Determining Customer Requirements

Before conducting a survey, the questionnaires are checked for reliability and validity by pilot test.

4.2.1 Cronbach's Alpha Result

Table 7 Cronbach's Alpha Result
Reliability Statistics

Cronbach's Alpha	N of Items
.892	26

The result of Cronbach's Alpha done by pilot test is acceptable, which the value is 0.892. The questionnaires are reliable and valid. Therefore, it is effective enough to be conducted in the next process.

4.2.2 Survey Results

The survey is done by 100 respondents who experiences and concerned with GC instrument from 100 organizations. Most of the respondents work in the organization in Bangkok, and the rest are in Samut Prakan Province, Nonthaburi Province, and Rayong Province.

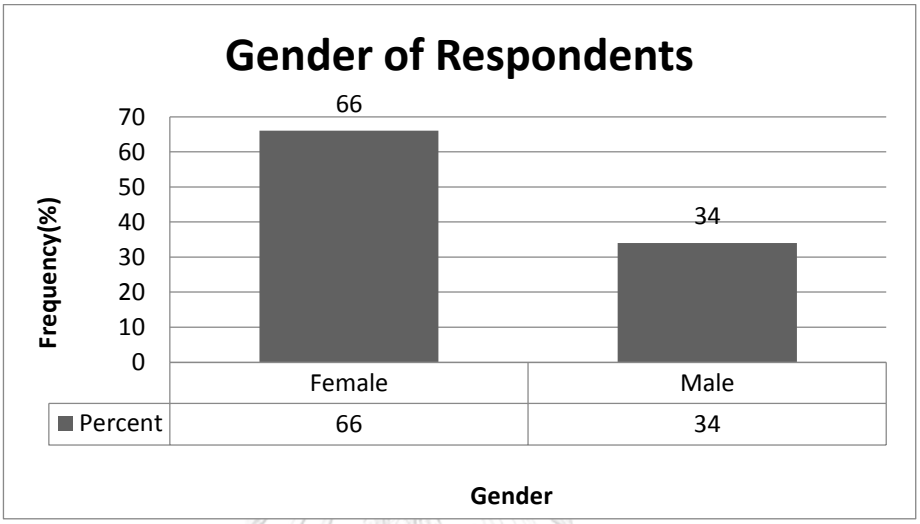

Figure 19 Gender of Respondents

The graph shows 66% of the respondents are female, while 34% are male (Figure 19).

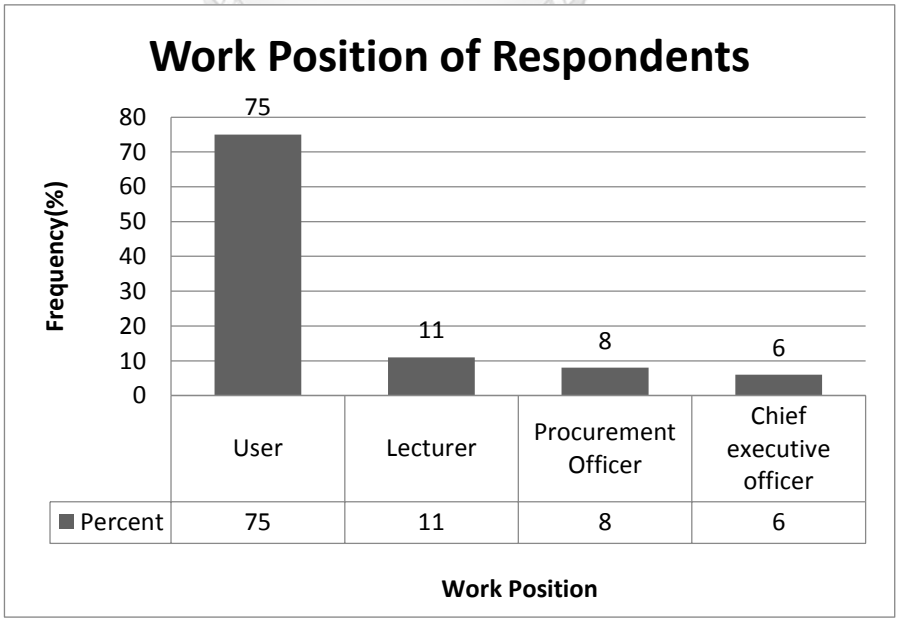

Figure 20 Work Position of Respondents

The graph shows 75% of the respondents are GC users who are laboratory technician working in R&D, QC, and QA laboratories. 11% are lecturers in universities that do research by using GC instrument. 8% are procurement officers that frequently purchase GC consumable equipment for their organizations. Lastly, 6% are chief executive officers that their organizations have GC instruments in their laboratories. All of them are important participants in making decision when their organization plans to purchase a new GC instrument (Figure 20).

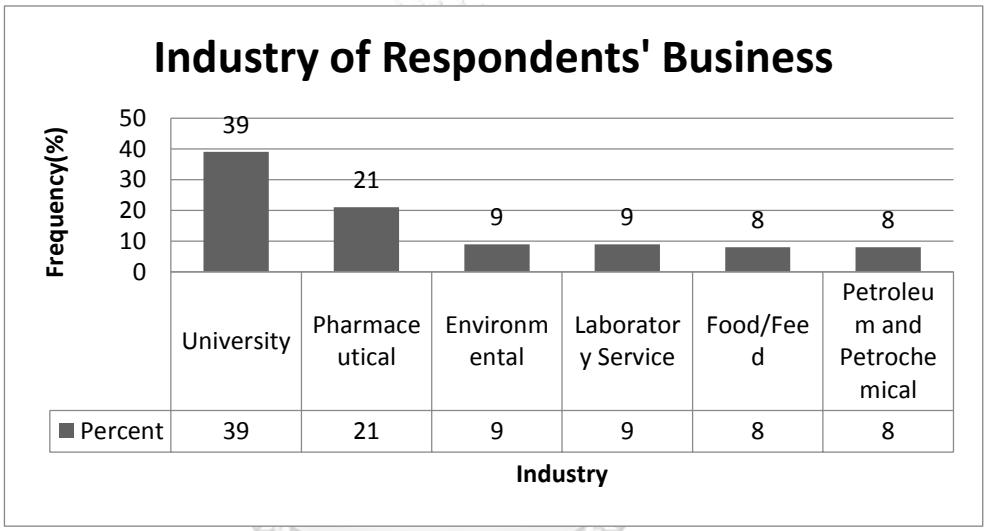

Figure 21 Industry of Respondents' Business

Most of the respondents work in university, which is 39%. 21% are in pharmaceutical and cosmetics industry, while the rest are in environmental industry, laboratory and testing services, food/feed industry, and petroleum/petrochemical industry (Figure 21).

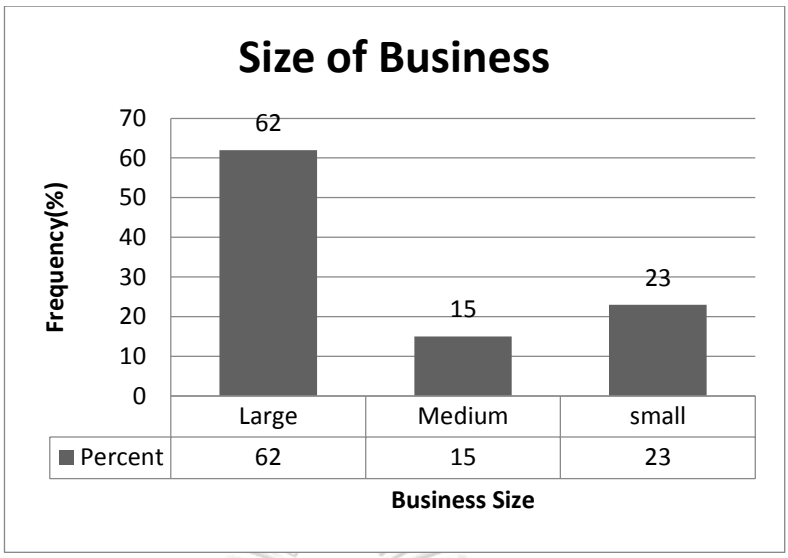

Figure 22 Size of Business

The large business size is defined by big size enterprises that have more than 200 staffs or total asset more than 200 million baht. The medium business size is defined by medium size enterprises that have 51-200 staffs or total asset more than 51-200 million baht. For small business size, it is defined by small size enterprises that have up to 50 staffs or total asset up to 50 million baht (Figure 22).

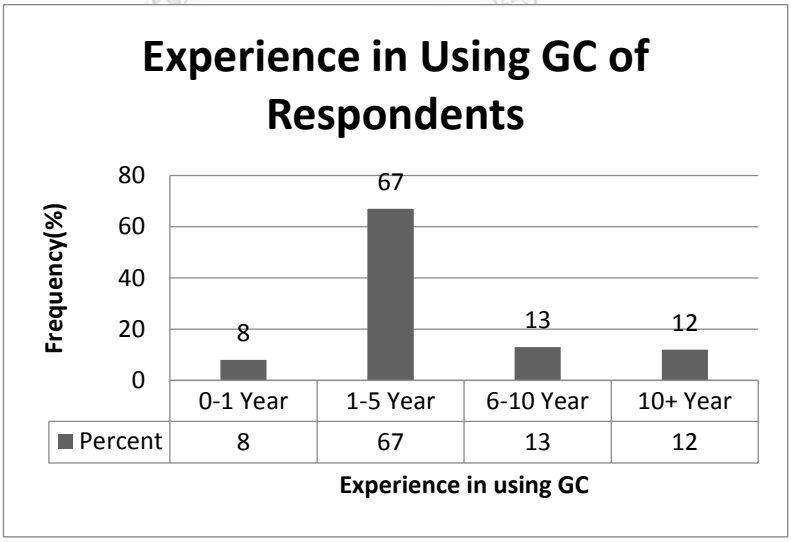

Figure 23 Experience in Using GC of Respondents

The majority of respondents have experience or knowledge in using GC around 1-5 yeas. However, 12% of respondents are expert in GC who have used GC more than 10 years (Figure 23).

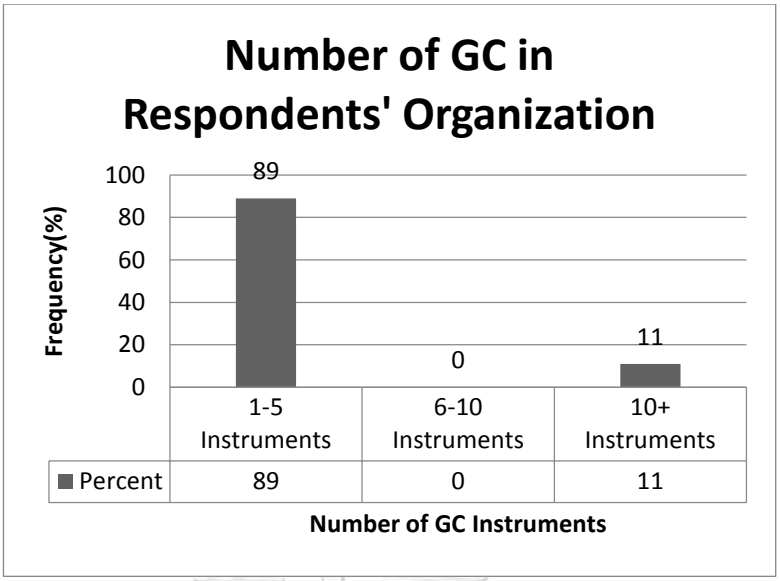

Figure 24 Number of GC in Respondents' Organization

Most of the organization have GC instrument around 1-5 instruments in their laboratory, while 11% have more than 10 instruments due to a being a large organization regularly run the GC instruments (Figure 24).

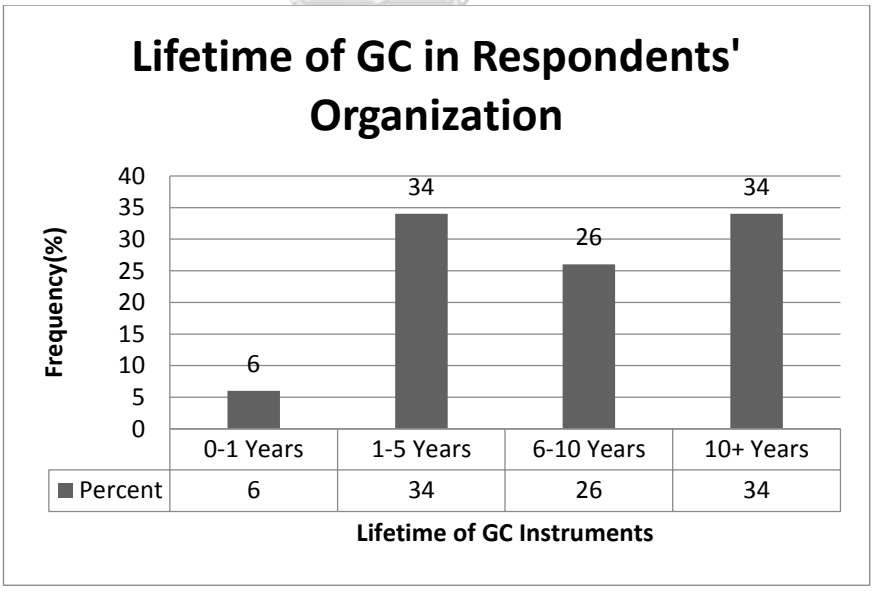

Figure 25 Lifetime of GC in Respondents' Organization

The lifetime of GC is very long as the graph shows 34% of GC instruments are more than 10 years and the rests tend to use for long term. However, 6 % of organization has just bought a new GC instrument.(Figure 25).

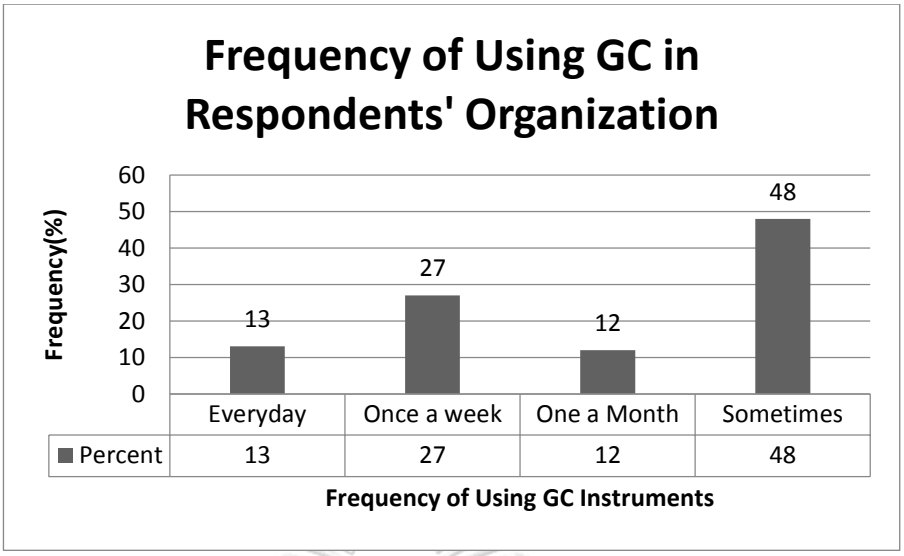

Figure 26 Frequency of Using GC in Respondents' Organization

Half of the organization use GC instrument for sometimes to analyze, checking or testing samples, while 13% use GC instruments for routine analysis (Figure 26).

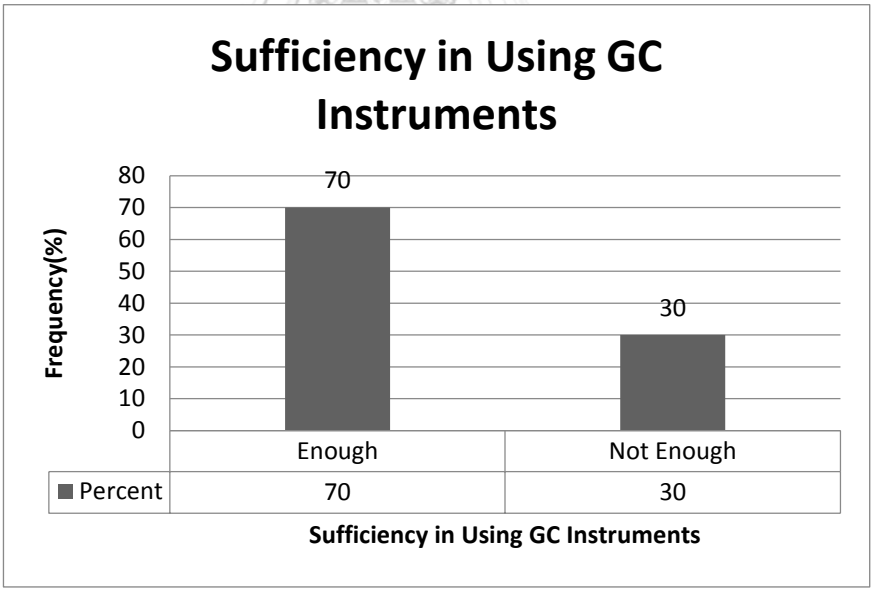

Figure 27 Sufficiency in Using GC Instruments

70% of the respondents told that their organizations have enough GC for using, while 30% told that GC in their organization is not enough for using, which can be an opportunity for the case study company to offer a new GC to support their work (Figure 27).

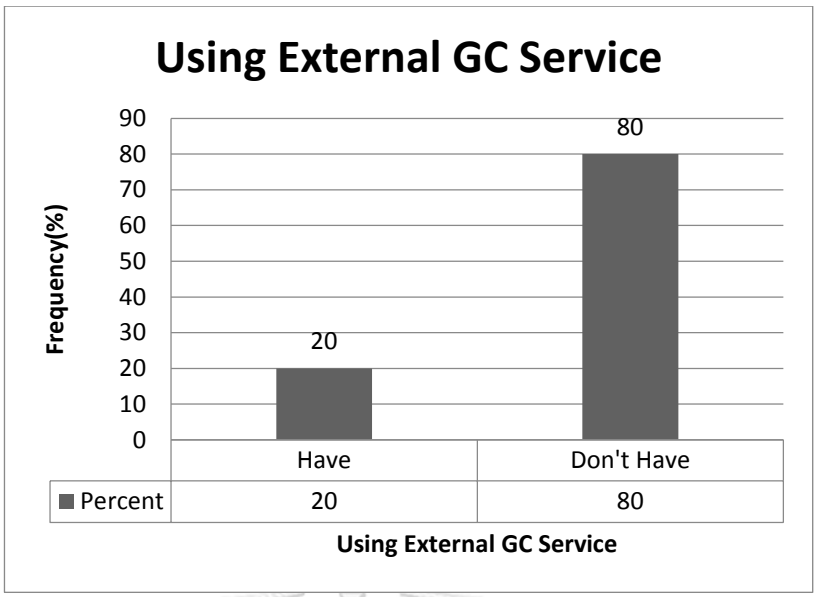

Figure 28 Using External GC Service

The majority of organization does not use laboratory and testing services to analyze their samples. However, 20% of them use external laboratories, which is an opportunity for the case study company to present alternatives that the organization can bring the budget from paying the laboratory services to buying a new affordable GC instrument (Figure 28).

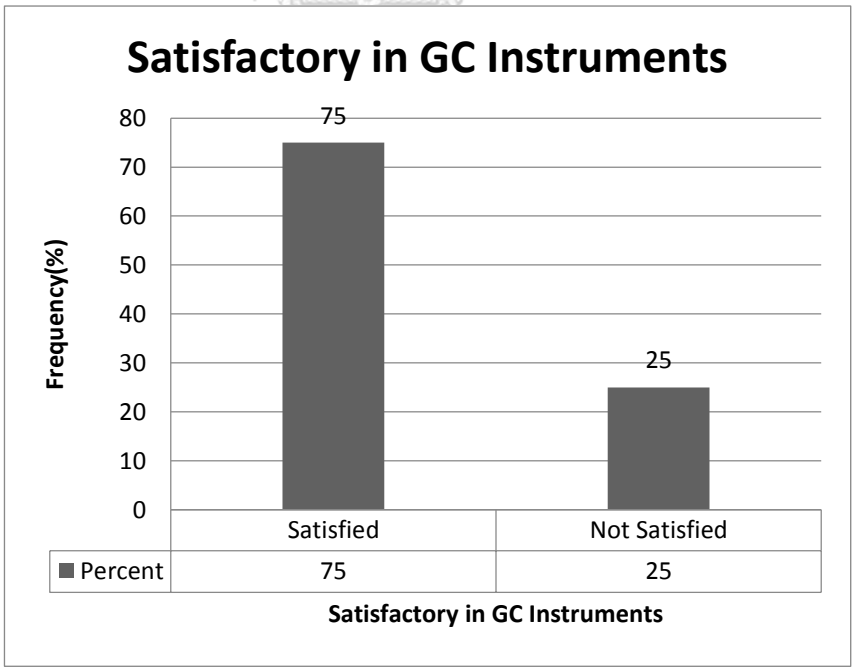

Figure 29 Satisfactory in GC Instruments

Most of the respondents are satisfied with GC instrument that they are using in their laboratory (Figure 29).

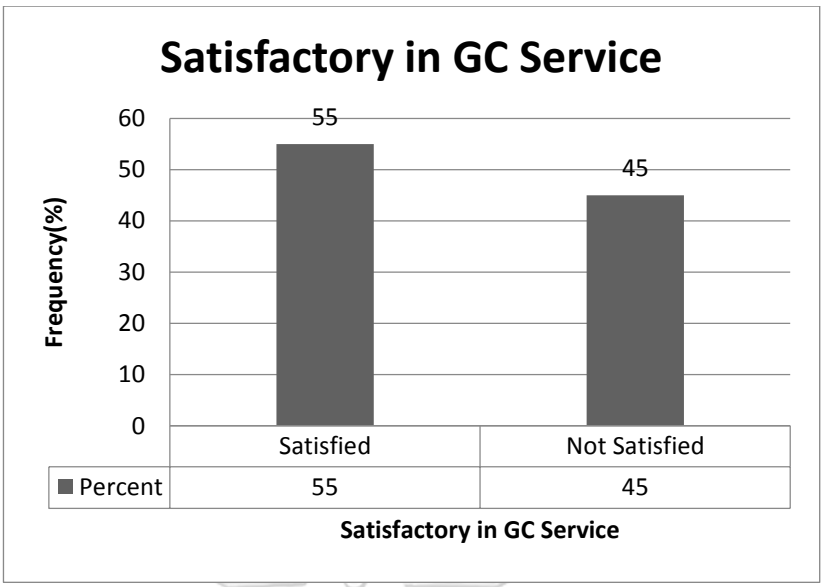

Figure 30 Satisfactory in GC Service

The graph illustrates that distributor of new GC instrument in Thailand can satisfy customers around 55% of the customers, while 45% of the customer are not happy with the services (Figure 30).

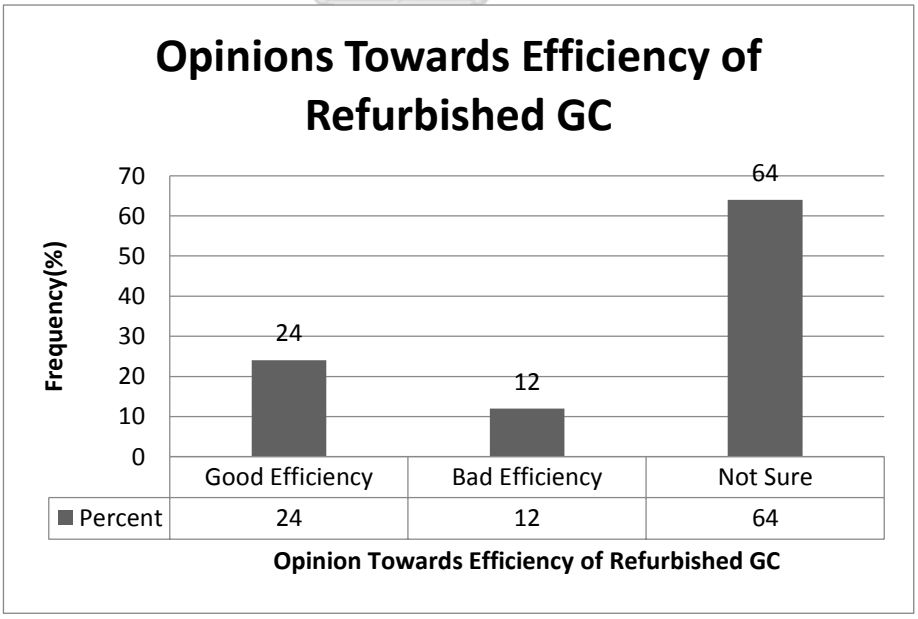

Figure 31 Opinions Towards Efficiency of Refurbished GC

After surveying customers, the 12% customers think that using a refurbished GC instruments does not provide good results when compared to new GC instruments. 24% of customers think that the refurbish GC instruments could provide them with an experience

comparable to the new ones. The rest of the customers at the time that we surveyed them were not sure whether the refurbished ones will be the same or not with the new ones. This shows that 88% of the customers have a good opinion towards the refurbished GC instruments, which could turn into future potential buyers (Figure 31).

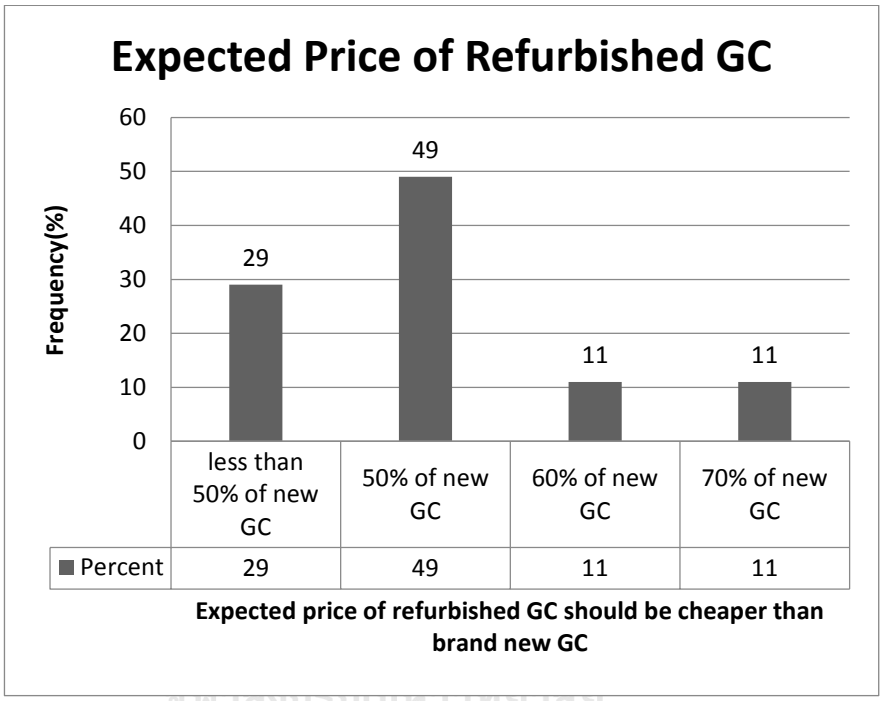

Figure 32 Expected Price of Refurbished GC

Our surveys that were done on our customers also showed the expected price for a refurbished GC units. From the results, about 49% of our customers think that the price should be at about 50% from the new GC instruments, while 29% of the customers think that that the price should be lower than 50%. However, 22% of the customers think that the price should be higher than 60% (Figure 32).

Table 8 GC Brands that Customers are Using

GC Brands that customers are using	Frequency	Percent
Shimadzu	50	41.0%
Agilent	40	32.8%
Perkin Elmer	12	9.8%
Thermo Scientific	10	8.2%
Scion	9	7.4%
Total	122	100%

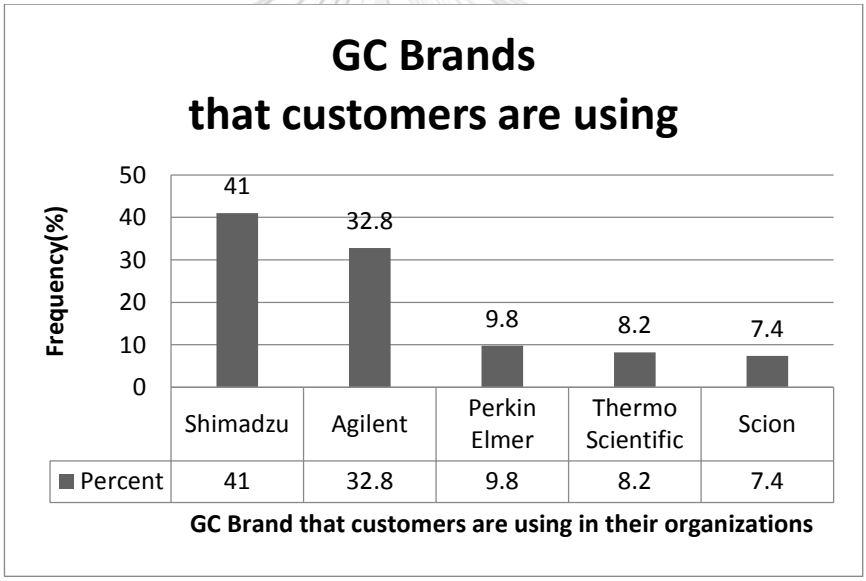

Figure 33 GC Brands that Customers are Using

The survey above shows popular brands of GC instruments among customers, with Shimadzu being the most popular brand used in organizations and laboratories. At second place is Agilent, where about 32.8% of customers use it. The rest uses Perkin Elmer, Thermo Scientific, and Scion. Below are tables explaining the amount of different GC brands in different industries (Table8 Figure 32).

Table 9 GC Brands that Customers are Using in the Food and Feed Industry

Food and Feed Industry		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large	1	2	1	3		1	8
	Medium				1			1
	Small							0
	Total	1	1	1	4	0	1	

In the food and feed industry, Shimadzu is the most popular brand (4 units total), while the other brands are used at a similar amount (0-1) (Table 9).

Table 10 GC Brands that Customers are Using in the Petroleum and Petrochemical Industry

Petroleum and Petro-chemical Industry		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large	4	1	2	2			8
	Medium				1			1
	Small				1			1
	Total	4	1	2	4	0	0	

In the petroleum and petrochemical industry, Agilent and Shimadzu are the most popular brands used (4 units). Perkin Elmer is the second most popular brand (2 units), with Thermo ranking third (1 unit) (Table 10).

Table 11 GC Brands that Customers are Using in the Pharmaceutical Industry

Pharmaceutical Industry		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large	3		3	6			12
	Medium	2	1		3			6
	Small	1			2		1	4
	Total	6	1	3	11	0	1	

In the pharmaceutical industry, Shimadzu is extremely popular (11 units), with Agilent being the second most popular (6 units). Perkin Elmer was rank third (3 units) (Table 11).

Table 12 GC Brands that Customers are Using in the Environmental Industry

Environmental Industry		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large	2		2				4
	Medium			1				1
	Small	2			4		1	7
	Total	4	0	3	4	0	1	

In the environmental industry, Shimadzu and Agilent ranked first (4 units), While Perkin Elmer is also popular (3 units). (Table 12)

Table 13 GC Brands that Customers are Using in the Forensic Science Industry

Forensic Science Industry		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large			1	2			3
	Medium	2						2
	Small	1	1		1			3
	Total	3	1	1	3	0	0	

In the Forensic science industry, the most popular brand is Agilent and Shimadzu (3 units), while Thermo and Perkin Elmer ranked second (1 unit). (Table 13)

Table 14 GC Brands that Customers are Using in the Universities

Universities		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large	14	2	2	12			47
	Medium	3	1		2			6
	Small	2		1	4			7
	Total	19	3	3	18	0	0	

In universities, Agilent ranked first (19 units) while Shimadzu ranked second (18 units) which shows that they are equally popular. A few units of Thermo and Perkin Elmer are also used in universities. (Table 14)

Table 15 GC Brands that Customers are Using in the laboratory and testing services

Laboratory Service		Brand						
		Agilent	Thermo	Perkin Elmer	Shimadzu	Dani	Scion	Total
	Large	1	1	2	2			6
	Medium							0
	Small	2	1	1	4			8
	Total	3	2	3	6	0	0	

In laboratory and testing services, Shimadzu is the most popular (6 units), while Perkin Elmer, Thermo, and Agilent and equally popular. (Table 15)

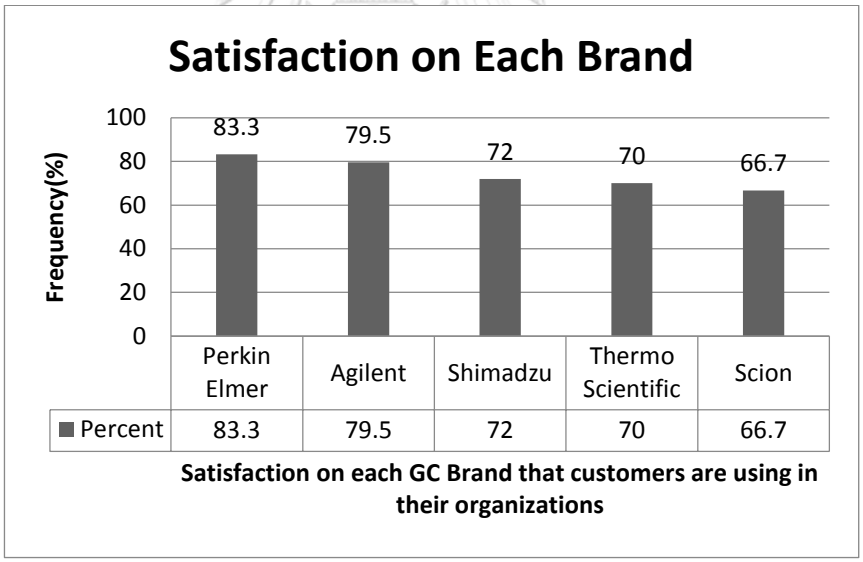

Figure 34 Satisfaction on Each Brand

From the analysis, customers are most satisfied at the efficiency and quality of GC instruments from Perkin Elmer, although it was not the most popular brand of GC instrument that was used in Thailand according to the survey. Agilent ranked second in satisfactory, which was higher than Shimadzu, even though the latter is the most popular brand used in Thailand (Figure 34).

Table 16 Types of Injector that Customers are Using

Types of Injector that customers are using	Frequency	Percent
Auto Sampler	69	42.1%
Manual	58	35.4%
Headspace	27	16.5%
Gas Sampling	8	4.9%
Thermal Desorption	2	1.2%
Total	164	100%

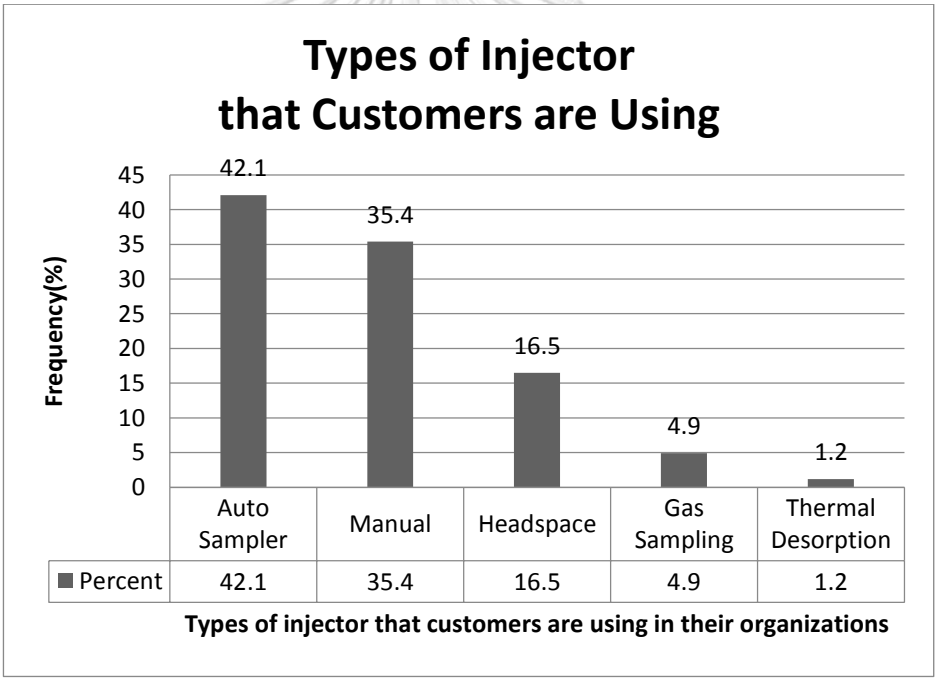

Figure 35 Types of Injector that Customers are Using

From the surveys, it was found out that the most popular type of injector is the auto sampler, which automatically injects samples into the system, and therefore is the most convenient GC instrument injector. A lot of customers also preferred manual injectors, due to the usage of syringes and simplicity of injecting samples into the GC instruments. Below are the different types of injector used in different industries (Table 16 and 35).

Table 17 Types of Injector that Customers are Using in the Food and Feed industry

Food and Feed Industry		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	Total
	Large	3	6	1				10
	Medium	1	1					2
	Small							0
	Total	4	7	1	0	0	0	

In the food and feed industry, auto sampler is the most popular injector (7 units total) and manual ranked second, while the other injectors are used at a similar amount (0-1). (Table 17)

Table 18 Types of Injector that customers are using in the petroleum and petrochemical Industry

Petroleum and Petrochemical Industry		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	Total
	Large	3	5	1				9
	Medium		1					1
	Small	1						1
	Total	4	6	1	0	0	0	

In the petroleum and petrochemical industry, auto sampler is the most popular injectors used (6 units). Manual is the second most popular injector (4 units), with headspace ranking third (1 unit). (Table 18)

Table 19 Types of Injector that Customers are Using in the Pharmaceutical Industry

Pharmaceutical Industry		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	Total
	Large	4	11	6		1	1	23
	Medium	2	2	2		1	1	8
	Small	2	2					4
	Total	8	15	2	0	2	2	

In the pharmaceutical industry, auto sampler is extremely popular (15 units), with manual being the second most popular (8 units). Headspace, thermal desorption, and gas sampling were rank third (2 units). (Table 19)

Table 20 Types of Injector that Customers are Using in the Environmental Industry

Environmental Industry		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	**Total**
	Large	1	1	1				3
	Medium		1					1
	Small	4	2	1				7
	Total	5	4	2	0	0	0	

In the environmental industry, manual ranked first (5 units), While auto sampler and headspace are also popular (4 and 2 units). (Table 20)

Table 21 Types of that Customers are Using in the Forensic Science Industry

Forensic Science Industry		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	Total
	Large		2	1				3
	Medium	1	1					2
	Small		1	1				2
	Total	1	4	2	0	0	0	

In the Forensic science industry, the most popular injector is auto sampler (4 units), while headspace ranked second (2 units). However, manual injection is in the third place (1 unit) (Table 21)

Table 22 Types of injector that Customers are Using in the Universities

University		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	Total
	Large	21	19	9			2	51
	Medium	4	4	1				9
	Small	6	4				2	12
	Total	31	27	10	0	0	4	

In universities, manual ranked first (31 units) while auto sampler ranked second (27 units) which shows that they are equally popular. However, headspace ranked third (10 units) with a few units of gas sampling is also used in universities (4units). (Table 22)

Table 23 Types of injector that Customers are Using in the Laboratory Services

Laboratory Service		Injector						
		Manual	Auto Sampler	Headspace	Pyrolysis	Thermal Desorption	Gas Sampling	Total
	Large	2	4	1				7
	Medium							0
	Small	3	2	2			2	9
	Total	5	6	3	0	0	2	

In laboratory and testing services, auto sampler is the most popular (6 units), while manual and headspace ranked second and third (5 units and 3 units). A few gas sampling are also used in this industry (2 units). (Table 23)

As it can be seen from the different types of industries specified above, in the case for injectors, auto sampler was the most popular injector used except for universities (31 manual units, 27 auto samplers) and the environmental industry (5 manual units, 4 auto sampler). In the both of these scenarios, they do not really require accurate results and therefore prefer to use manual sampler due to price issues and simplicity

Table 24 Types of Detector that Customers are Using

Type of Detector that customers are using	Frequency	Percent
FID	80	53.0%
TCD	31	20.5%
MSD	18	11.9%
ECD	11	7.3%
FPD	9	6.0%
NPD	2	1.3%
Total	151	100%

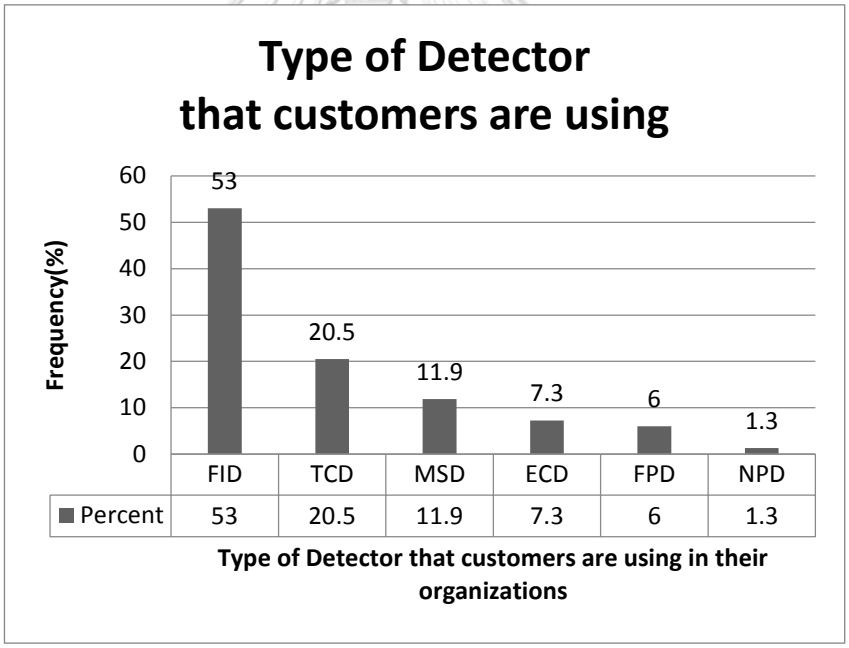

Figure 36 Types of Detector that Customers are Using

As can be seen in the survey, FID is the most commonly used detector because it can analyze many different types of samples and also it is simple to use. The rest (TCD, MSD, ECD, FPD, NPD) are only used in specific fields and therefore are much less commonly used. Below are the different types of detectors used in different industries. (Table 24 and Figure 36)

Table 25 Types of Detector that Customers are Using in the Food and Feed Industry

Food and Feed Industry		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large	1	5	1	2		1		10
	Medium		1	1					2
	Small								0
	Total	1	6	2	2	0	1	0	

In the food and feed industry, FID is the most popular detector (6 units total), while NPD and PDD do not used (Table 25).

Table 26 Types of Detector that Customers are Using in the Petroleum and Petrochemical Industry

Petroleum and Petrochemical Industry		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large	2	6	3					11
	Medium				1				1
	Small		1	1					2
	Total	2	7	4	1	0	0	0	

In the petroleum and petrochemical industry, FID is the most popular detectors used (7 units). TCD is the second most popular detector (4 units), with MSD ranking third (2 units) and ECD ranking forth (1 unit). (Table 26)

Table 27 Types of Detector that Customers are Using in the Pharmaceutical Industry

Pharmaceutical Industry		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large	2	10	2					14
	Medium	3	11	1					15
	Small		2	2	1	1	1		7
	Total	5	23	5	1	1	1	0	

In the pharmaceutical industry, FID is extremely popular (15 units), with MSD and TCD being the second most popular (5 units). However, PDD is not used in this industry. (Table 27)

Table 28 Types of Detector that Customers are Using in the Environmental Industry

Environmental Industry		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large	2	2		1		1		6
	Medium			1					1
	Small	1	5	5			1		12
	Total	3	7	6	1	0	2	0	

In the environmental industry, FID and TCD are popular detectors (7 and 6 units), while MSD, FPD, and ECD are also used in the environmental analysis. (Table 28)

Table 29 Types of Detector that Customers are Using in the Universities

Universities		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large	4	24	4	3	1	2		38
	Medium		5	1	1				7
	Small		5	3	1				9
	Total	4	34	8	5	1	2	0	

In universities, FID is the most used (34 units) while the rest types of detector are also found in universities except PDD. (Table 29)

Table 30 Types of Detector that Customers are Using in the Forensic Science Industry

Forensic Science Industry		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large	1	2	2					5
	Medium		2	1					3
	Small	1	1						2
	Total	2	5	3	0	0	0	0	

In the Forensic science industry, the most popular detector is FID (5 units), while TCD and MSD ranked second and third (3 and 2 unit). (Table 30)

Table 31 Types of Detector that Customers are Using in the Laboratory Services

Laboratory Service		Detector							
		MSD	FID	TCD	ECD	NPD	FPD	PDD	Total
	Large		4						4
	Medium								0
	Small	1	4	3	1		2		11
	Total	1	8	3	1	0	2	0	

In laboratory and testing services, FID is the most used (8 units), while TCD ranked second. MSD and ECD are equally popular (Table 31).

As can be seen from the survey, MSD is most commonly used in large industries due to its complexity and price. The benefit of MSD is that it can analyze samples thoroughly, yielding quality results.

Table 32 GC Brands that Customers Believe in Efficiency and Quality

GC Brands that customers believe in efficiency and quality	Frequency	Percent
Agilent	46	31.9%
Shimadzu	36	25.0%
Perkin Elmer	36	25.0%
Thermo Scientific	13	9.0%
Not sure	13	9.0%
Total	144	100%

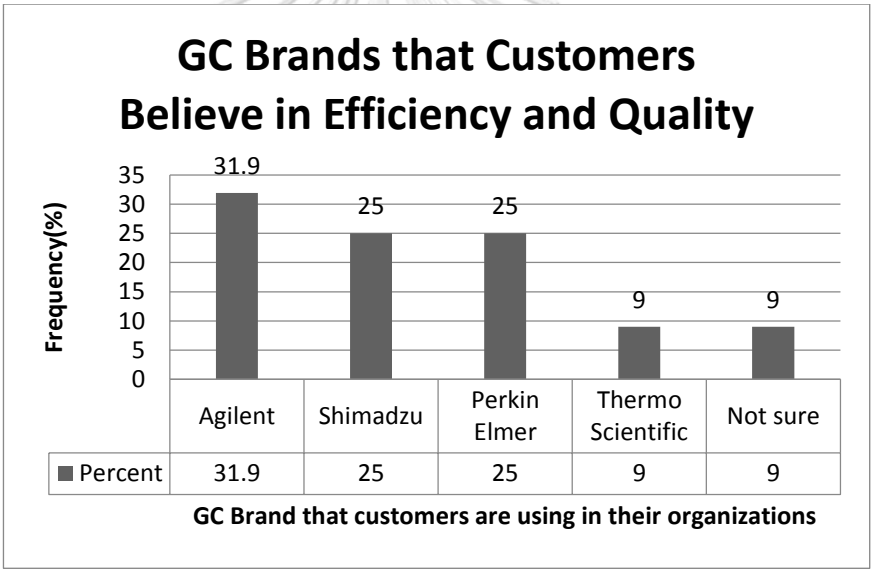

Figure 37 GC Brands that Customers Believe in Efficiency and Quality

After refurbishment, customers trust Agilent the most due to their brand reputation and quality. Although Agilent is the most trusted brand, it can be seen from the chart above that Shimadzu and Perkin Elmer are the second most trustworthy brand after refurbishment. In the case of Thermo, most customers trust only their refurbished GC instruments that are coupled with MSD detectors, and therefore ranked lowest in customer trust (Table 32 and Figure37).

Table 33 Types of Injector that Customers Believe in Efficiency and Quality

Types of Injector that customers believe in efficiency and quality	Frequency	Percent
Auto Sampler	59	36.6%
Manual	57	35.4%
Headspace	17	10.6%
Not sure	13	8.1%
Pyrolysis	8	5%
Gas Sampling	4	2.5%
Thermal Desorption	3	1.9%
Total	161	100%

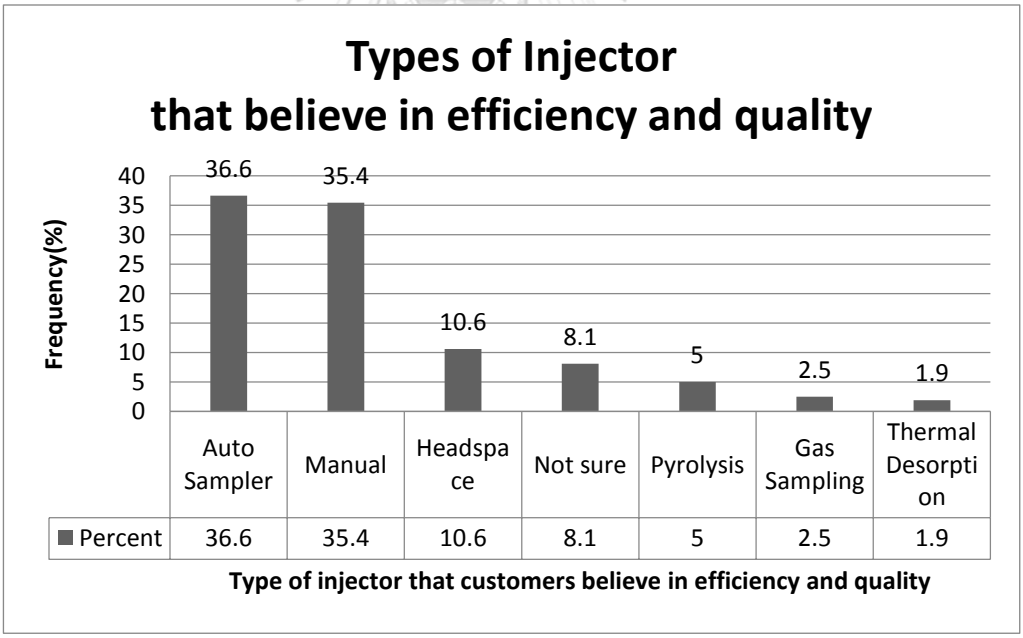

Figure 38 Types of Injector that Customers Believe in Efficiency and Quality

For the types of injectors, auto sampler is the most trusted injector because many customers are usually familiar with the usage methods and the instrument itself. In the case of manual samplers, many customers trust that this will provide them with high quality and efficiency mainly because of its simplicity (simple injection with syringe). (Table 33 and Figure 38)

Table 34 Types of Detector that Customers Believe in Efficiency and Quality

Types of Detector that customers believe in efficiency and quality	Frequency	Percent
FID	74	46%
TCD	28	17.4%
MSD	18	11.2%
FPD	15	9.3%
Not sure	14	8.7%
ECD	6	3.7%
NPD	4	2.5%
PDD	2	1.2%
Total	161	100%

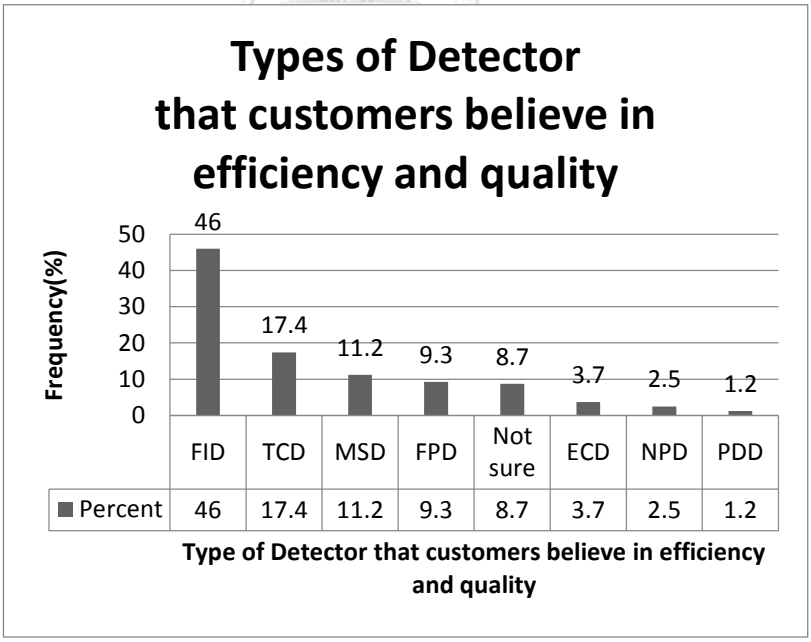

Figure 39 Types of Detector that Customers Believe in Efficiency and Quality

FID detectors are the most trusted type of detector because most of the customers are familiar with it and it is already commonly used. Customers also believed that due to FID not

being an extremely complex detector, it should be able to provide high efficiency when refurbished compared to other detectors. (Table 34 and Figure 39)

As a sales company, when selling GC instruments to customers, the case study company does have a general idea of which brand is attractive to different staff positions in the customer's company. Chief executive officers usually prefer Agilent because of Agilent's brand positioning (high end) which usually results in a good image for the buyer's organization. Besides, the result shows most users also prefer to use Agilent. Procurement officers prefer Perkin Elmer, due to their long history and durable GC instruments that the brand has been well known to produce. Lecturers prefer Shimadzu mainly because of the price when compared to its quality. This basically means that lecturers believe that Shimadzu provides the best quality to price value for their customers. (Figure 40-43)

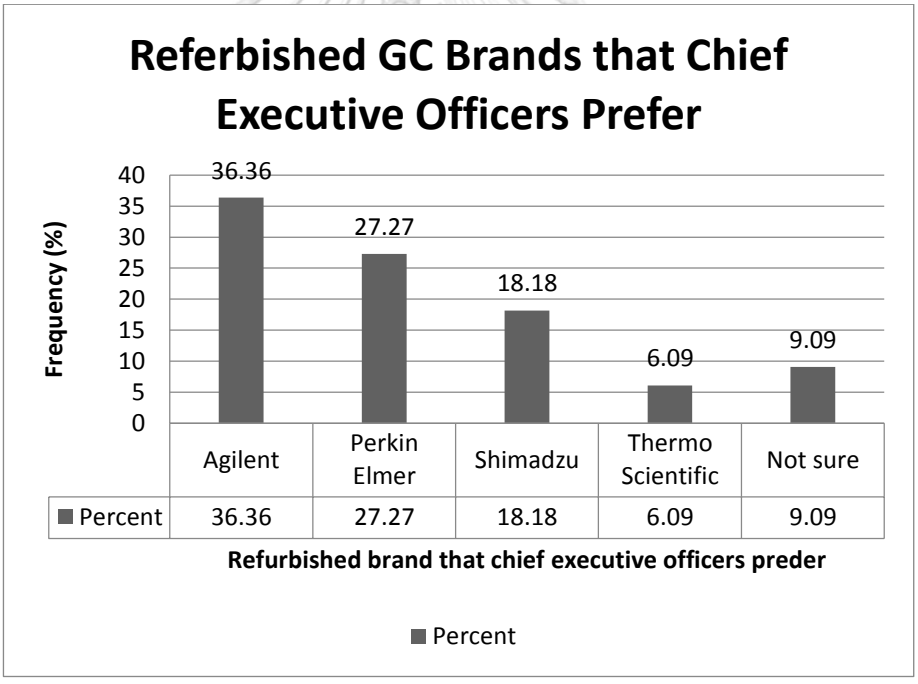

Figure 40 Refurbished GC Brands that Chief executive Officers Prefer

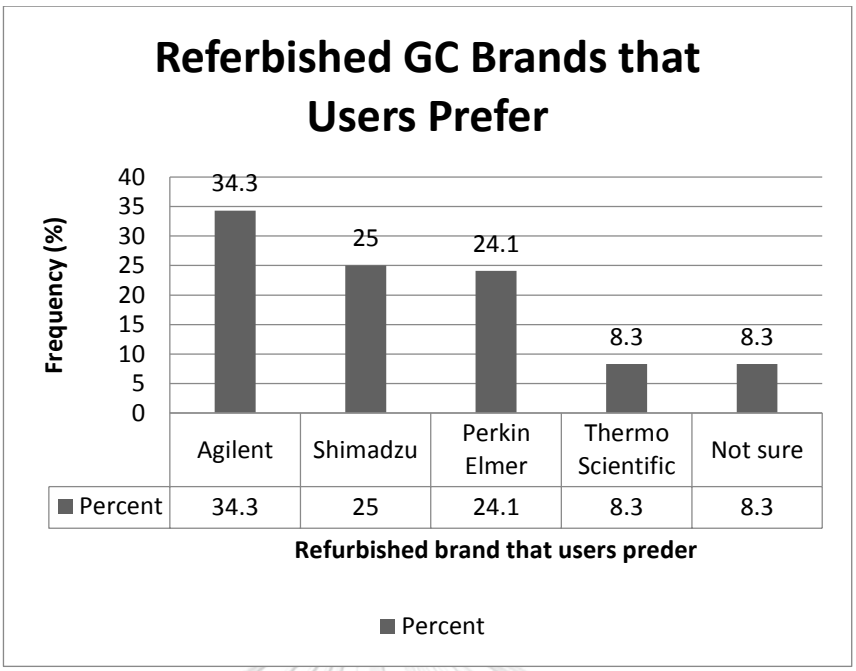

Figure 41 Refurbished GC Brands that Users Prefer

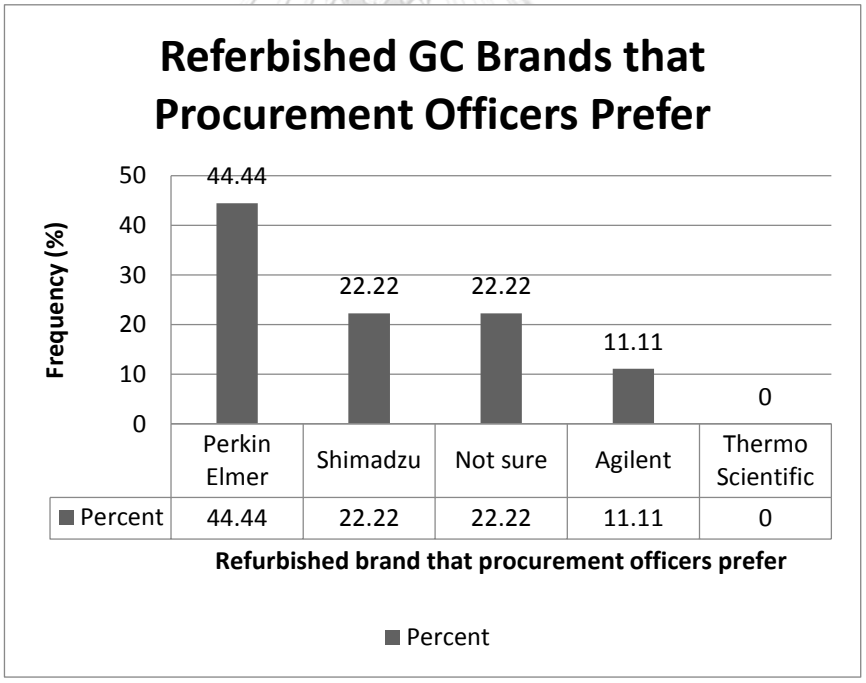

Figure 42 Refurbished GC brands that Procurement Officers Prefer

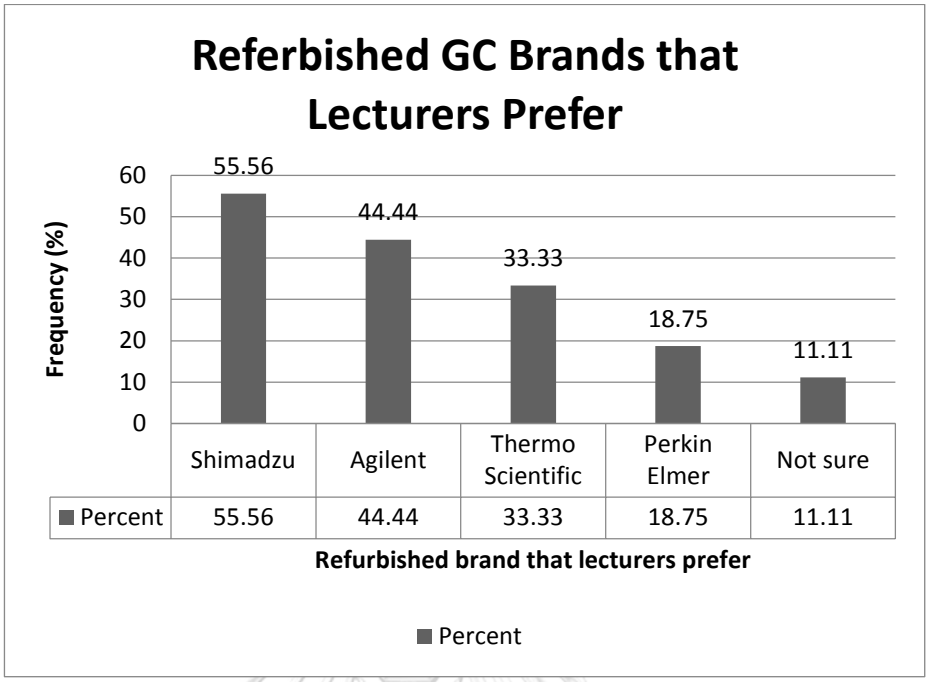

Figure 43 Refurbished GC Brands that Lecturers Prefer

Table 35 Factors to Consider in Purchasing Refurbished GC

Marketing Tools	N	Minimum	Maximum	Mean	Std. Deviation
Strong Service	100	3.00	5.00	4.5700	.47684
Prices of Refurbished GC	100	4.00	5.00	4.5400	.46969
Information About Refurbished GC and Services	100	3.00	5.00	4.5200	.47098
A Competence Salesforce From Salesman	100	3.00	5.00	4.4900	.53172
Product Warranty	100	3.00	5.00	4.4050	.54908
State-of-the-art Technology of Refurbished GC	100	3.00	5.00	4.3750	.59618
Lifetime and New Product Development of Refurbished GC	100	3.00	5.00	4.3333	.52758
Reputation of Distributors	100	3.00	5.00	4.3150	.53492
Completeness of Refurbished GC's Product Line	100	3.00	5.00	4.2900	.57375
Brand and Reputation of Refurbished GC	100	3.00	5.00	4.2467	.49150
Use of Marketing Research and Published in a Paper	100	2.00	5.00	3.9000	.68902
Extensive Advertising About Refurbished GC	100	2.00	5.00	3.6800	.78018

After surveying customers about their criterion which they used to purchase GC instruments to be used in their organizations, there were mainly 4 different reasons on why customers choose to purchase refurbish GC units. These 4 main reasons stem from the 4Ps (marketing mix), with strong service (product) being the main lead for them to finalize their purchasing decisions. Lower prices of refurbished GC instruments (price) are also one of the main factor that droved conversion. Information related to the refurbished GC instruments and aftersales care provided by the company (promotion) was also an important factor to help the customers decide. Last but not least, salesforce and salesperson was also vital as it acted as a sales channel for customers (place), while also helping customers connect at a more understanding level about their relationship with the case study company and its product (Table 35).

Other than the 4 main factors, others also played a minor role in converting the customer to purchase refurbished GC units. Product Warranty provides customers with confidence that the company will take responsibility if the product fails to work as expected, and in case of failure, spare parts and maintenance service must be available for a certain amount of time after purchase. The refurbish GC instruments must also contain state-of-the-art technology, meaning that these units must not contain over dated technical aspects but must be comparable to the new GC instruments. The refurbished unit must also still be able to support analytical standards required by the user. In the lifetime and product developmental aspect, the refurbished unit must look as similar as possible to the new GC units. Distributors must have a good reputation, selling quality products to customers and are experienced in refurbished unit sales. These GC product lines must also be complete to a certain extent, which means that the refurbish GC units must be compatible with various other new technologies (computers, spare parts, other lab equipment, etc.). An example would be that the refurbished GC units should be able to use with the inlet liners sold currently in the market. The refurbished GC instruments must also be a reputable brand (Agilent, Shimadzu). The last two factors, although contributing only a small percentage towards customer's purchasing decisions, also should be considered. These include the refurbished GC unit brand marketing research and publication history in scientific papers and the extensiveness of their advertisements (online ads, TV ads, billboard ads, etc.). (Table 35)

4.3 STEP 3 Assessing Supply Markets

In order to analyze the supply market after discussing with team members, the tool used was brainstorming. The results obtained from brainstorming were used to perform SWOT analysis and Porter's five forces. The results are shown in Table 36 and the Porter's five force list below:

4.3.1 SWOT Analysis

Table 36 SWOT Analysis for the Case Study Company's GC Procuement

Strengths	Weaknesses
▪ Long experience in chromatography , especially gas chromatography ▪ Professional technical support team ▪ Good reputation ▪ Good financial habit ▪ Positive cash ▪ Good relationship with suppliers ▪ Closed, long relationship and established customer base ▪ Skilled sales team ▪ Fast and good service ▪ Reliable after-sales service ▪ The ability to quick respond and make decision ▪ Efficient operation and administration ▪ Good location, near airport, and not far from customer location ▪ Quickly support spare parts	▪ A few experts ▪ Ineffective website ▪ High staff turnover ▪ High cost of freight ▪ Inefficient purchasing process ▪ Low ability to cover all market ▪ Small business size ▪ All of the instruments and equipment have to import from overseas ▪ Unable to find domestic supply source
Opportunity	**Threats**
▪ A number of low budget customer in Thailand ▪ FDA regulations that require some factories to analyse their products by using GC such as food and pharmaceutical factories ▪ A Policy of many companies in Europe that requires to change GC instrument every five years ▪ Customer demands for turn-key product e.g. fat determination system	▪ Political instability in Thailand ▪ Slow economic growth ▪ A lack of support in R&D from the government ▪ A lack of confidence from foreign investors due to instable political situation ▪ Instable macroeconomic environment

4.3.2 Porter's Five Forces

1. Competitive Rivalry (LOW)

- A few rivals in the market
- Very small size of competitors due to no rival who operate in a form of a company
- The global industry is growing but nobody knows the exact growth rate of this product in Thailand
- Low diversity of rivals
- Low differentiation in term of function of the GC, but high differentiation in term of condition of GC's physical appearance
- Easy to exit the industry
- High switching cost

Conclusion: It is low competitive rivalry because there is no official seller who sells refurbished GC in Thailand.

2. Threat of New Entrants (LOW)

- Low capital requirement
- Hard to find skilled workers
- New entrants are hard to achieve economic of scale
- Require knowledge of market and customer base
- Long product life cycle
- Require trust in the company from customers
- High customer loyalty
- Low risk of switching

Conclusion: It's difficult for new entrants to join in this industry because it requires high skilled technician and customer base.

3. Threat of Substitutes (HIGH)

- Relative performance of substitutes is high
- Substitute has higher price
- Perceived values of substitutes are high
- Easy to switch to substitute
- Buyer prefer substitutes, if the price is low

Conclusion: The substitute product is brand new GC. It's easy for customer to switch to buy a new GC. If the price of new GC is affordable, the customer will prefer to buy a new one.

4. Bargaining Power of Suppliers (LOW)

- Diverse supplier base
- Anyone can supply second-hand GC
- Brand of supplier does not concern
- Significant orders to supplier, if it is a small company
- Don't have ability to pass on price increase
- Cannot switch cost

Conclusion: Suppliers have limit bargaining power since there are a lot of supply base which anyone who has used GC instrument can become a supplier.

5. Bargaining power of Buyers (HIGH)

- Buyers can switch to buy substitute product (brand-new GC)
- High price sensitivity
- High impact on quality and performance
- After-sale service is necessary
- Little product differences
- Buy low volume

Conclusion: Buyers have higher bargaining power because price and quality are very sensitive. Basically, the buyers prefer to buy brand-new GC, if they are affordable.

4.4 STEP4: Formulating Purchase Strategy

After analyzing the previous 3 steps, a purchase strategy was developed, which includes the topics mission, vision, objective, action plan, and KPI. These topics are explained in the following section below:

4.4.1 Vision

To be a trusted gas chromatography with our suppliers and customers

4.4.2 Mission

To provide quality refurbished gas chromatography with affordable price through effective activities and initiatives that enhances company's competitive advantages

4.4.3 Objective

1. To purchase second-hand GC competitively
2. To develop effective and reliable supply sources
3. To simplify and standardize company's purchasing process
4. To avoid interruption of material flow and service
5. To keep up-to-date the GC market trend
6. To reduce inventory risks and loss

4.4.4 Action Plan

Table 37 Action Plan

	Objective	Action	Target date	Responsibility
1	To purchase second-hand GC competitively	Apply Leagile purchasing portfolio model	May 2018	Procurement officer, Procurement Department
2	To develop effective and reliable supply sources	Develop selecting qualifies suppliers guidance	April 2018	Procurement officer, Procurement Department
3	To simplify and standardize company's purchasing process	Develop sourcing template and guidance	April 2018	Procurement officer, Procurement Department
4	to avoid interruption of material flow and service	Implement "assemble-to-order" customer order decoupling point	May 2018	Procurement officer, Procurement Department
5	To keep up and update the GC market trend	Survey and interview customer demand	March 2018	Sales and Marketing Department
6	To reduce inventory risks and loss	Implement stock control and develop stock card	May 2018	Stock keeper

4.4.5 Key Performance Indicator (KPI)

- The case study company can reduce the total cost of refurbished GC instrument 10%
- At least two second-hand GC suppliers are qualified

4.5 STEP 5 Executing and Refining Strategy

In the final step, strategies placed in step 4 were implemented on the case study company which is composed mainly of 6 actions as specified in the action plan. These actions are shown below:

4.5.1 ACTION1: Apply Leagile Purchasing Portfolio Model

As the Refurbished GC instruments are the combination of functional and innovative product as shown in Table 38, Leagile purchasing portfolio model is applied.

Table 38 Product Type of Refurbished GC Instrument

	Functional Product	Innovative Product	Refurbished GC Instrument
Demand Aspect	Stable/Predictable Demand	Unstable/Unpredictable demand	Stable/Predictable Demand
Product Life Cycle	Long (More than 2 years)	Short (3 months to 1 year)	Long (More than 10 years)
Variety	Low (10-20 variants/categories)	High (millions of variants/categories)	High
Volume	High	Low	Low
Manufacturing Strategy	Make to Stock	Make to Order	Make to Assemble
Lead Time Required for Make to Order	6 months to 1 year	1 day to 2 weeks	4 to 6 months
Purchasing Strategy	Lean	Agile	Leagile

Table 39 Dimensions of Leagile Components Model

Factors Influencing Lean strategy	Factors Influencing Agile Strategy
Quality	Time
Cost	Flexibility

In order to enhance competitiveness of purchasing, Leagile strategy was applied to the consideration of purchasing second-hand GC instruments. Leagile strategy comes from combination of Lean and Agile strategy. Leanness principally concern about quality and cost, while Agility mainly focus on flexibility and time.

- Quality

As the GC instruments were entirely bought online and import from overseas, it is a lack of touch-feel-try creating concern over the quality. The company has to buy the GC instruments without actual seeing. The electronic image of the product may be misleading due to the electronic and real image may not match. In term of quality, the procurement should primary check as list below:

1. Brand of GC instruments: Agilent, Shimadzu, and Thermo scientific
2. Configuration of the instrument:

- Flow control: Type of flow control
- Sample inlet and sampling devices (injector): Type and number of injector
- Controlled temperature zones (oven)
- Detector: type of detector
- Display function and key board

3. Physical appearance: colors, scratches, and dents
4. Function: Errors checking shows on display

- Cost

The price of second-hand instrument is quite diverse, which depends on brand, components, physical appearance, and condition. According to STEP1 analyzing spend data and STEP 2 determining customer requirements; STEP1 implies that the cheaper cost of second-hand instrument, the higher margin will be gained. The cost of second-hand instrument approximately cost 80,000 baht, it will be 30% of the total cost. STEP2 shows that most of the customers accept the price of refurbished GC instrument around 500,000 baht or not more than 50% of the brand new GC. Therefore, the procurement should buy the second-hand instrument not exceed 130,000 baht in order to keep cost lower than 40% of the total cost and provide some benefit to the company.

- Time

After discuss with the director of the case study company, the lead-time of second-hand instrument should be 2-3 weeks. Then, the company will refurbished and prepare for installation at customers site within 6 weeks.

- Flexibility

The procurement should consider flexibility of both GC instrument and supplier.

Flexibility of GC instrument

Workstation flexibility: It is the ability to work with new vision of software and computer.

Modification flexibility: It is the ability to modify the second-hand instrument or exchange some parts with other second-hand instrument. In case, it must be change some part of the instrument when customer require or the company can exchange the broken part with another instrument.

Components accessibility: Difficulty to access spare parts and accessories

Flexibility of suppliers

Volume flexibility: the minimum order that the supplier require per order

Shipping flexibility: the shipping company that the supplier provides the shipping and the destination of shipping must be Thailand.

4.5.2 ACTION2: Develop Selecting Qualified Suppliers Guidance

1. List the potential suppliers that supply second-hand GC instruments
2. Search the information about the suppliers
   - Duration the supplier supply the GC instrument
   - Company history
   - Contact information
   - Products they are offering
   - Supplier's financial stability
   - References e.g. primary customers
   - Interested in doing business with the case study company
   - Selling history e.g. pervious customers, customer satisfaction rate, customer's comment, and distribution channel
   - Discount offer
   - Contract
3. Narrow the suppliers to 2-3 suppliers and asked for bid on the second-hand GC instrument

4. Select suppliers by asking Request for Quotation (RFQ). The REQ should contain specifications and details of the products, quantity requirement, payment terms, and delivery requirement

Table 40 Qualifies Suppliers Form

	Supplier Name	Contact Person	E-mail	Telephone	Country	Ability to offer required specification	Ability to offer required quantity	AveragePrice per unit	Lead-time (weeks)
1	GC Supplier001	N/A	N/A	N/A	N/A	✓	✓	60,000	2
2	GC Supplier002	N/A	N/A	N/A	N/A	✓	✓	60,000	2-3
3	GC Supplier003	N/A	N/A	N/A	N/A	✓	✓	60,000	3
4	GC Supplier004	N/A	N/A	N/A	N/A	✓	✓	65,000	2-3
5	GC Supplier005	N/A	N/A	N/A	N/A	✓		80,000	2
6	GC Supplier006	N/A	N/A	N/A	N/A	✓		65,000	2-3
7	GC Supplier007	N/A	N/A	N/A	N/A		✓	54,000	6
8	GC Supplier008	N/A	N/A	N/A	N/A		✓	60,000	4
9	GC Supplier009	N/A	N/A	N/A	N/A	✓		70,000	2-3

4.5.3 ACTION3: Develop Sourcing Template and Guidance

In the third implemented action, procurement officers brought the template shown in Figure 44 to be used as a checklist in order to help them decide whether the used GC instrument matches the specification required by the case study company and also to help them select suppliers.

Second-hand GC Sourcing Template

Company…….GCSupplierX……
Brand: ☑ Agilent ☐Shimadzu ☐ Thermo scientific ☐ Other……
Model: ……5890……..
Configuration check list:

	Configuration	Detail	Amount
✓	Flow control	-	1
✓	Injector	Manual and Auto Sampler	2
✓	Oven	-	1
✓	Detector	FID	1
✓	Display Function	-	1
✓	Keyboard	-	1

Physical appearance:
Colors……Ivory…White……
Scratches: ☑Do not have ☐ Have (Specify……)
Dents: ☑ Do not have ☐ Have (Specify……)
Function: ☑ Work ☐ Errors
Price: ……59,222…baht…(1,800 US dollar)….per unit ☐ Negotiable
Warrant: ☑ Do not have ☐ Have
Minimum order: ……1……unit
Lead time……2…….week
Shipping company……UPS……

Approval:
☑ Approve ☐ Not Approve

Authorized Signature:

……

Figure 44 Second-hand GC Sourcing Template

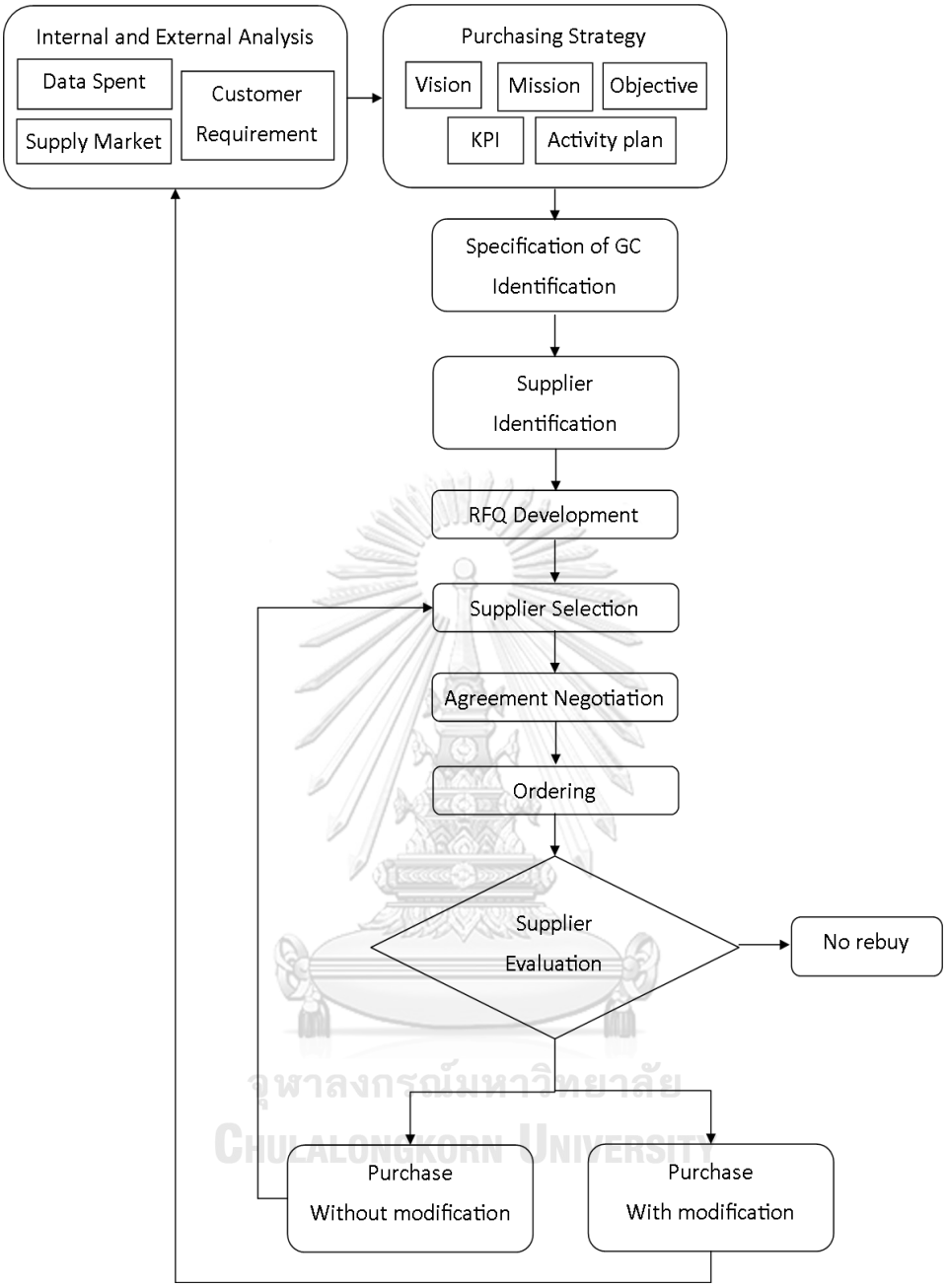

Figure 45 Refurbished GC Purchasing Process

The flowchart shows the standard process when purchasing used GC units. (Figure45)

4.5.4 ACTION4: Implement "Assemble-to-order" Customer Order Decoupling Point

In order to avoid interruption of material flow and service, the customer order decoupling point is taken into account. Assemble-to-order is applied to the purchasing process. The second-hand GC instrument is order from the supplier followed the demand that the company has survey the customer need and keep as an inventory. The instrument will be refurbished and assembled again when there is an order from the customer. The Lean supply chain will be applied to upstream of the customer order decoupling point, which is associated with cost and quality leadership. However, Agile supply chain is applied to downstream of the customer order decoupling point, which is associated with differentiation and flexibility strategy. Moreover, the market information flows from downstream forward further to upstream to provide advance purchasing planning. (Figure46)

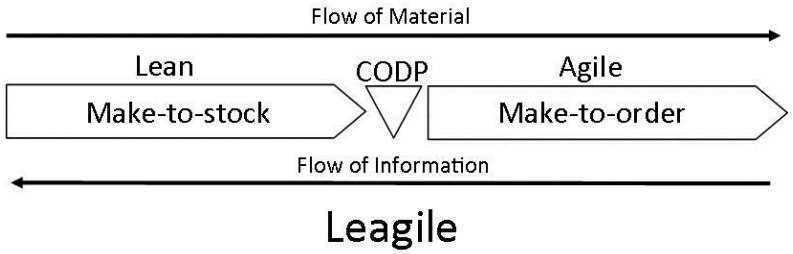

Figure 46 Assemble-to-order for Refurbished GC Instrument

4.5.5 ACTION5: Survey and interview customer demand

The results of survey and interview customer demand are conducted and can be referred to in STEP 2 (Determine customer requirements) to keep up-to-date with the GC market trend.

Figure 47 Before and After Refurbished GC Instrument

4.5.6 ACTION6: Implement Stock Control and Develop Stock Card

In order to control inventory, recording the inventory is important to manage stocks. A good inventory control system must be able to gather purchase information and the purchase amount. This study has designed a stock card that was used to control and show the case study company's inventory (Figure47).

STOCK CARD

Item……GC…Instrument……

Date	References	Model	Location	By Brand			Total		
				IN	OUT	BALANCE	IN	OUT	BALANCE
25/3/2018		Agilent 5890	Room 2 Bench1						
		Agilent 5890	Room 2 Bench2						
		Agilent 5890	Room 2 Bench3						
		Agilent 5890	Room 2 Bench4						
		Agilent 5890	Room 2 Bench5						
		Agilent 5890	Room 2 Bench6						
		Agilent 5890	Room 2 Bench7						
		Agilent 5890	Room 2 Bench8						
		Agilent 5890	Room 2 Bench9						
		Agilent 5890	Room 2 Bench10						
		Agilent 5890	Room 2 Bench11			11			11
25/3/2018	INV20180410	Agilent 5890	Room 2 Bench1		1	10		1	10
10/4/2018	B40118	Shimadzu 9A	Room 2 Bench12						
		Shimadzu 14A	Room 2 Bench13						
		Shimadzu 14A	Room 2 Bench14						
		Shimadzu 17-A	Room 2 Bench14	4		4	4		14
		Thermo	Room 2 Bench1	1		1	1		15
17/4/2018	INV20180417	Agilent 5890	Room 2 Bench2		1	9		1	14
30/4/2018	INV20180728	Shimadzu 9A	Room 2 Bench12		1	3		1	13
24/5/2018	INV20180524	Shimadzu 17-A	Room 2 Bench14		1	2		1	12
1/6/2018	XY18002	Shimadzu 9A	Room 2 Bench12						
		Shimadzu 14A	Room 2 Bench14						
		Shimadzu 17-A	Room 1 Bench1						
		Shimadzu 17-A	Room 1 Bench2						
		Shimadzu 9A	Room 1 Bench3	5		7	5		17

Figure 48 Stock Card

4.6.1 Cost Saving

Table 41 shows the parallel results obtained from the KPI that was made for the case study company.

Table 41 Cost Saving Result

Item	Average Price (per unit)		Cost Saving (per unit)	
	Before implement purchasing strategy	After implement purchasing strategy	Baht	% (E)
Second-hand GC instrument	80,000	60,000	20,000	25
Airfreight	20,000	12,000	8,000	40
Refurbished GC instrument cost	270,283	242,283	28,000	10.35

After implementation, the company was able to purchase approximately 5 units per procurement (compared to purchasing 1 unit every time per procurement in the past), which resulted in a cheaper price of the used GC units. The price decreased from about 80,000 baht to 60,000 baht per unit after implementation. The air freight price was also lowered from 20,000 baht to 12,000 baht. This is due to the packing nature of the GC units delivered. The total cost of the refurbished GC instruments after implementation decreased by 10.35%, which created a higher profit margin for the case study company. This achieved the goal according to the first KPI set in STEP 4.

4.6.2 Qualified Suppliers

From our second KPI, the case study company was able to locate 3 different suppliers shown in Table 40, which are all qualified suppliers according to the guidance provided in ACTION 2 above.

4.6.3 Developed Purchasing Process for Refurbished GC Instruments

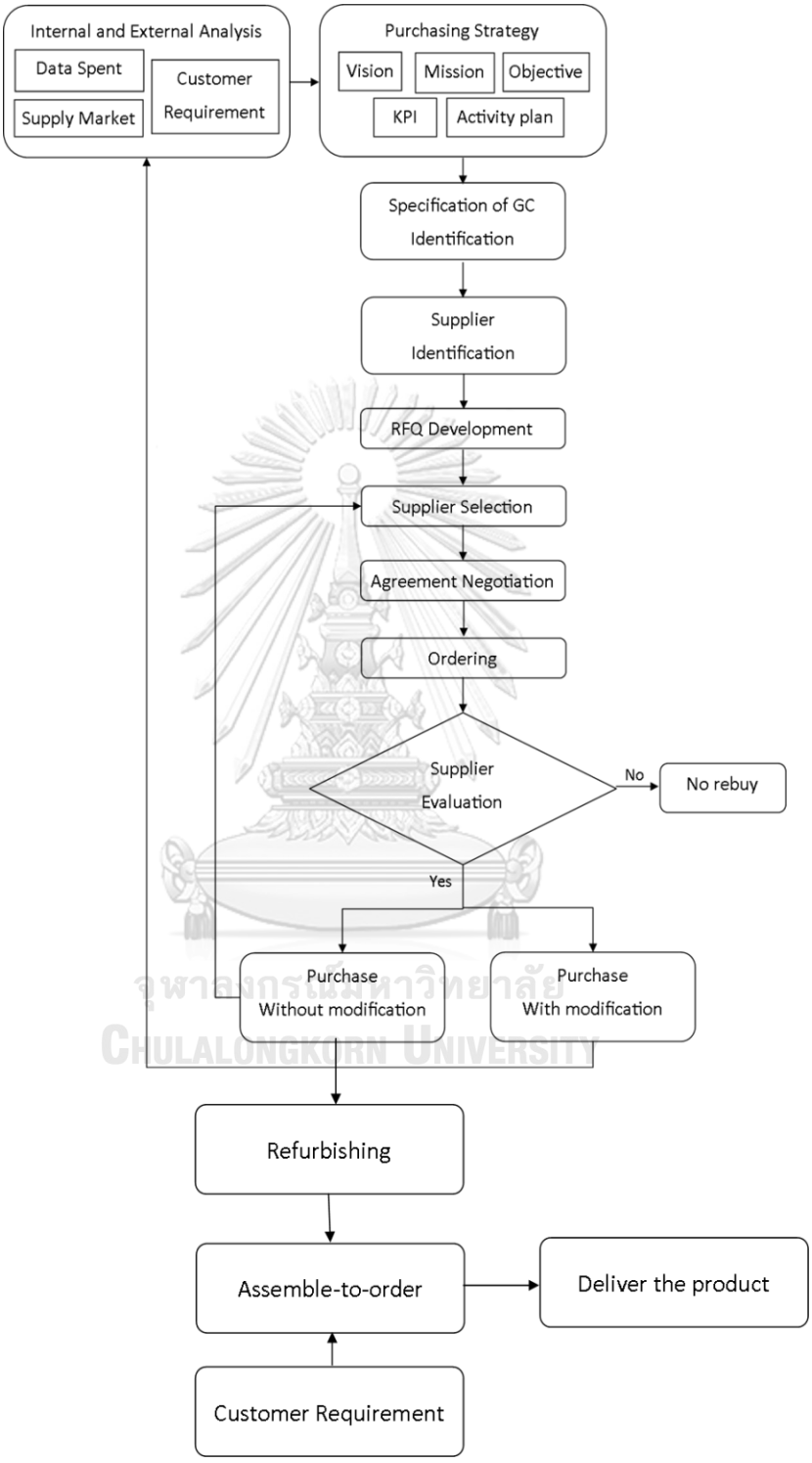

Figure 49 Refurbished GC Instrument Purchasing Process

Chapter 5
Conclusion and
Recommendation

This chapter concludes what this study has discovered and accomplished, as well as some recommendations for the case study company.

5.1 Conclusion

The efficiency purchasing process is a very important activity that helps provide companies with a high quality working process which will enable these organizations to increase efficiency, decrease cost, and improve delivery. Companies should develop purchasing strategies based on their objectives and goals. The steps in developing these purchasing strategies consist of the 5 steps:

STEP 1: Analyzing spending data – to improve spending by differentiating the negative points to positive points. From analyzing the spending data, it was found out that there were three major spending that should be focused on, which are the purchase of second-hand GC instruments, GC software, and gas & regulator. These three items impact the case study company, and therefore when focused upon, can help decrease major costs. Out of these three major items, the case study should focus highly on the GC instruments, due to it being a leverage item that can be supported by many suppliers. The company should take advantage of its status as a leverage item to negotiate better price deals for these used units.

STEP 2: Determining customer requirements – to get to know the market and obtain training on using currently up to date GC instruments. From the survey, the most popular brands of GC units used in Thai organizations are Shimadzu and Agilent. In the case of the injectors, auto injectors are most popular due to them being the most convenient to use and their precision, while manual injectors (also popular) are preferred in simpler settings where complexity is not required and cost is an issue. FID detectors are preferred due to them being simple to use, large sample detection range, and low-medium pricing. However, after refurbishing, customers prefer Agilent more than Shimadzu due to it being made at a higher quality and the brand is more trustworthy, which when compared with new Agilent GC units, the pricing is highly different. In the case of Shimadzu, people who purchase these second-hand units are used to using the brand because they might have used it before in their organization. For refurbish injectors and detectors, customers still want what they are used to

in their organization, which are auto sampler and manual sampler for injectors and FID for detectors. Factors that affect if a customer will purchase a refurbished unit are guarantees from the seller that they will provide services for the used GC units and also the pricing of these GC units.

STEP 3: Supply market – From SWOT analysis, the strength of the case study company is their professional support team. The case study company is highly experienced in selling chromatography instruments. Their weakness is that the company is a small family business and still lack sophisticated purchase methodology. When viewing future opportunities, due to Thai customers have a need to use GC instruments but are not highly funded, they seek for cheaper alternatives that purchasing new GC units, which is good for the case study company. Future threats include political issues and economic issues. Governmental support is close to zero and therefore there is not a lot of sponsorship to push these small companies forward. From Porter's five forces, low competitive rivalry because there are no competitors in the market selling refurbished GC units. There is also a low threat of new entrances, because there is a barrier in the technical side, which requires highly skilled technician. A high customer base is also necessary. There is also a low bargaining power for supplier because there are a lot of suppliers suggesting to sell used GC instruments, which is opposite in the case for bargaining power of buyer because of the price sensitivity. For threat of substitutes, the risks are also high because people could switch to buy new GC units more.

STEP 4: Formulating purchase strategy – the development of purchasing strategy is composed of vision, mission, objectives, action plans, and KPIs.

STEP 5: Executing and refining strategies – bringing the objectives in STEP 4 and implementing them into action plans (ACTION 1 – ACTION 6), where ACTION 1 is to apply Leagile purchasing portfolio model which is a focus on the 4 factors which are quality, cost, time, and flexibility. ACTION 2 is the development of selected qualified supplier guidance which helped the case study company narrows the amount of suppliers to 3 main ones. ACTION 3 is the development of sourcing templates and guidance, where a template will be obtained for considering when selecting suppliers. In this action, a standard purchasing template which is obtained from all the information the company has obtained will then be developed. ACTION 4 is then the implementation of the 'assemble-to-order' customer order decoupling point which is the addition of the Lean, Agile, and Leagile strategies into the decoupling point. ACTION 5 is the survey and interview of customer demands which was already described in STEP 2. ACTION 6, or the last action is the implementation of stock control and development of the stock card.

From these 5 steps, cost saving of refurbished GC instrument cost was increased by 10.35% and the case study company was able to qualify 3 main suppliers. Lastly, the case study company has been able to now create a standard purchasing process which can be used for future procurement that can help their business to create competitive advantages.

5.2 Recommendations

- Supplier relationship management is recommended for the case study company to develop more productive and deeper relationship with its suppliers. The case study company may build a program and apply to its supply chain in order to manage and reduce complexity of supply. Maintaining a long relationship and the continuance of an improving collaboration enables the case study company to gain more competitiveness. Since the case study company knows the requirement and demand from the end-customer, making transparent supply chain can reduce the Bullwhip effect and increase its capability to source the right product, the right quality, the right quantity, the right place, and the right time.
- Shimadzu is one of the most popular GC brands that customers prefer to use in laboratory. The product is originally produced in Japan, therefore the company may find supply source for used GC instrument in Japan in order to reduce cost of goods and transportation.
- One of the valuable assets in any company is effective customer relationship management since it helps the case study company to have better customer services and enhancing customer's loyalty and satisfaction.
- GC software and gas & regulator are strategic items that provide high impact on supply risk and profitability. These items have single supplier contributing to very high supply risk. Therefore, the case study company should find more suppliers in order to lower risks.
- The purchasing should align with the company's goals and objective. However, the case study company should keep updating and improving purchasing strategy in order to cope with changing demand and supply.
- In order to support specific customer demand and expand the market, the case study company may sell refurbished GC instrument as a turnkey instrument such as offering a biofuel analysis instrument, which provide suitable gases, injector, column, detector, and method for qualitative and quantitative samples.

Appendices

Appendix A: Questionnaire for Determining Customer Requirements

Behavior and Satisfaction in Purchasing Refurbished Gas Chromatography (GC)
CUSE, Chulalongkorn University
and the University of Warwick, UK

Part 1 Interviewer Information

1.1 Gender
☐ Female ☐ Male

1.2 Position
☐ Chief executive officers ☐ User ☐ Procurement Officer ☐ Lecturer

1.3 Type of your business
☐ Food/Feed ☐ Petroleum/Petro chemical ☐ Pharmaceutic ☐ Environment
☐ Forensic Science and Toxicology ☐ University ☐ Laboratory and testing Service
☐ Other……

1.4 Size of your organization
☐ Big Size Enterprises
☐ Medium Size Enterprises
☐ Small Size Enterprises

1.5 Your experience in using GC
☐ 0-1Years ☐ 1-5 Years ☐ 6-10Years ☐ 10+Years

Part 2 Behavior and Information on Using the Current GC

2.1 What brand of GC you are currently using?
☐ Agilent ☐ Thermo Scientific ☐ Perkin Elmer ☐ Shimadzu
☐ Dani ☐ Scion (Bruker/ Varian) ☐ Other……

2.2 What injector you are currently using?
☐ Manual ☐ Auto Sampler ☐ Headspace
☐ Pyrolysis ☐ Thermal Desorption ☐ Gas Sampling Valve

2.3 What detector you are currently using?
☐ MSD (Mass spectrometry Detector)
☐ FID (Flame Ionization Detector)
☐ TCD (Thermal Conductivity Detector)
☐ ECD (Electron Capture Detector)
☐ NPD (Nitrogen Phosphorous Detector)
☐ FPD (Flame Photometric Detector)
☐ PDD (Pulsed Discharge Detector)

2.4 How many GC do you have in your organization?
☐ 1-5 Instruments ☐ 6-10 Instruments ☐ 10+ Instruments

2.5 How long does your GC last?
☐ 0-1Year ☐ 1-5 Years ☐ 6-10Years ☐ 10+Years

2.6 How often do you use GC?
☐ Sometime ☐ 1-5 times/month ☐ 6-10 times/month ☐ 10+ times/month

2.7 Do you have enough GC for using in your organization?
☐ Enough ☐ Not enough

2.8 Do you use external laboratories and testing service?
☐ Yes ☐ No

2.9 Are you satisfied with the GC that you are currently using?
☐ Yes ☐ No

2.10 Are you satisfied with the service that you receive from your GC distributor?
☐ Yes ☐ No

Part 3 Attitude and Interest in Refurbished GC

3.1 Do you think refurbished GC has ability to work well as new GC instrument?
☐ Yes ☐ No ☐ Not sure

3.2 What brand of refurbished GC that you are believe in efficiency and quality?
☐ Agilent/HP ☐ Shimadzu ☐ Thermo Scientific
☐ PerkinElmer ☐ Other ☐ Not sure

3.3 What injector of refurbished GC that you are believe in efficiency and quality?
☐ Manual ☐ Auto Sampler ☐ Head space ☐ Pyrolysis
☐ Thermal Desorption ☐ Gas Sampling Valve ☐ Not sure

3.4 What detector of refurbished GC that you are believe in efficiency and quality?
☐ MSD (Mass spectrometry Detector)
☐ FID (Flame Ionization Detector)
☐ TCD (Thermal Conductivity Detector)
☐ ECD (Electron Capture Detector)
☐ NPD (Nitrogen Phosphorous Detector)
☐ FPD (Flame Photometric Detector)
☐ PDD (Pulsed Discharge Detector)
☐ Not sure

3.7 If a new GC is priced 1,000,000 baht, How much the refurbished GC should cost?
☐ Less than 500,000 baht ☐ 500,000 baht
☐ 600,000 baht ☐ 700,000 baht ☐ More than 700,000 baht

Factors to Consider in Purchasing Refurbished GC					
Aspects	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Brand and Reputation of Refurbished GC					
Brand and Reputation of Refurbished GC have an influence on purchasing decision					
Brand of GC that you are currently using have an influence on purchasing decision					
Brand of refurbished GC that you are going to purchase has to be recommended by influential person					
Lifetime and New Product Development of refurbished GC					
Refurbished GC has to look like new condition					
Refurbished GC has to be new product development and still sell in the market					
Spare parts of refurbished GC are still available in the market					
A competence Salesforce from Salesman					
Salesman has to express enthusiasm in working and providing information					
Salesman has to be polite and provide good service					
State-of-the-art Technology of Refurbished GC					
Technology of refurbished GC has to be up-to-date like new GC					
Interpretation of refurbished GC is able to support analytical standard					
Strong Service Distributors					
Distributor enables to support after sale service and maintenance					
Distributor enables to support spare parts					
Reputation of Distributors					
Distributor has to have good reputation in providing quality products and services					
Distributor has to have experience in GC and chromatography					
Completeness of Refurbished GC's Product line					
Refurbished GC is able to compile with consumable products selling in the market					
Refurbished GC is able to compile your software or new software					
Strong Protection and Warranty					
Distributor has to provide warranty					
Distributor has to guarantee that the company is able to provide spare part					

Use of Marketing Research and Publish Paper					
GC has to take market research that meet customer's expectation					
GC is cited by any scientific publish paper					
Prices of Refurbished GC					
Refurbished GC's price has to be much cheaper than new GC					
Refurbished GC's price has to meet your budget					
Information about Refurbished GC and Services					
Information about efficiency of Refurbished GC have an influence on purchasing decision					
Distributor gives information and ensure that the company is able to provide after sale service					
Extensive Advertising about Refurbished GC					
Online advertisements have influence on purchasing decision e.g. website and Facebook					
Catalog and brochure can enhance interest of refurbished GC					

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