SUPPLIER SELECTION BY ANALYTICAL HIERARCHY PROCESS

By

KWANRUDEE APITAIYANON

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

ABAC School of Management
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Project Title	Supplier Selection by Analytical Hierarchy Process
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November 2008

Assumption University
ABAC School of Management
Master of Science in Supply Chain Management

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ABSTRACT

Traditional buyer-supplier relationships emphasize multiple sourcing, competitive bidding and use of short-term contracts; these often-adversarial relationships pit the buyer against the supplier and focus primarily on the purchase price of the product instead of the capabilities of the suppliers and how they can contribute to the long-term competitiveness of the buying organization. Recently, strong competitive pressure forces many companies to provide their products and services faster, with a cheaper price and better quality than their competitors. Many companies have come to realize that they could not do it alone without satisfactory vendors. Therefore procurement has gained importance in supply chain management due to factors such as globalization, and increased value added in the supply chain. Procurement activities involve selection and quantifying suppliers, rating supplier performance, negotiating contracts, comparing price, quality and service, sourcing goods and services, timing purchases etc. A key, and perhaps the most important, process of a procurement function is an efficient supplier selection process because it brings significant competitive benefit to the organization.

In general, the company's supplier selection process is typically a lengthy evaluation process and performed by expert judgment method which does not involve any decision making tool, which results in poor selection and causes end-product customers to get less quality and pay more Therefore, this project examines the Analytical Hierarchy Process (AHP), as applied to the supplier selection process, which involves many intangible factors, but still requires a logical and rational control of decisions, and cross-checks with Expert Choice by using the same alternative and criterion.

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Chapter 1. Introduction

The direction of procurement functions in the present business world has changed radically from those in the past. Today, there is a trend to make a long term relationship between suppliers and customers. One major aspect of the procurement function is vendor selection because the best suppliers become the major factor in delivering the product to meet the needs and satisfaction of the customer. Therefore it is not enough to select the best supplier or vendor based only on price consideration, but comprehensive criteria need to be developed in order to gain shared benefits in a long term cooperation for both supplier and customer sides.

This chapter will discuss the trading company's background, services, products and problem analysis.

1.1 Company Background

The trading company in this case study is a Global Integrated Supplier and Site Services provider of a comprehensive range of high quality, cost competitive products with over 100,000 product items for the manufacturing and services industries. The company also provides cost effective distribution and supply chain management services, including products Sourcing, Procurement, and Distribution services.

The company is head-quartered in Fremont, California, USA. It was incorporated in California on 28 March 1986. The company has wholly owned, direct sales offices in USA, Republic of Ireland, Singapore, Malaysia, Thailand, Philippines, Indonesia, Japan, India and Greater China (Beijing, Suzhou, Shanghai, Shenzhen, Tianjin, Taiwan and Hong Kong) in order to service customers all over the world.

1.1.1 Services

The company helps to connect buyers and sellers within the same or different countries by specializing in sourcing a variety of products all over the world to find the highest quality at the best possible price. These sources build products to meet the company's specifications and ship them as the company instructs.

1.1.2 Products

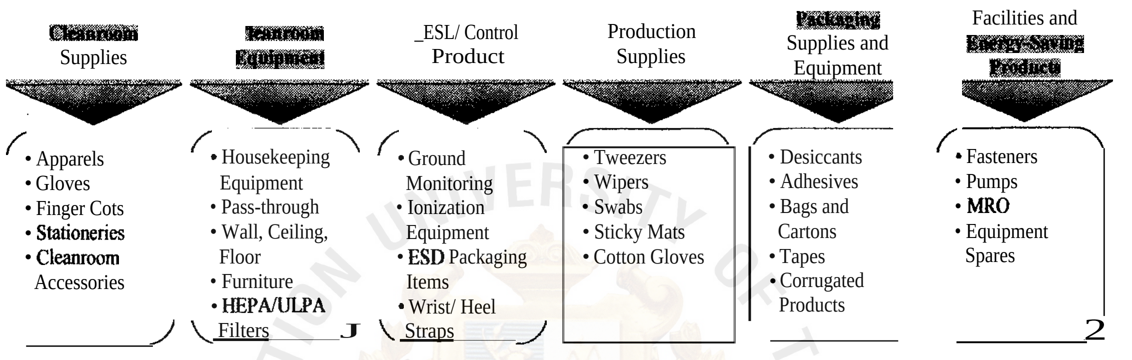

Figure 1.1: Product category

The major product group can be categorized into six groups which is shown in Figure 1.1

1.1.3 Markets

The company's principal customers are major companies dealing in Semiconductors, Electronics, Medical Devices, Bio-medical, Food Products Processing, Pharmaceutical, and Consumer Products Companies, such as Intel, NXP, Colgate-Palmolive, Seiko etc.

1.1.4 Procurement Process for Core Products

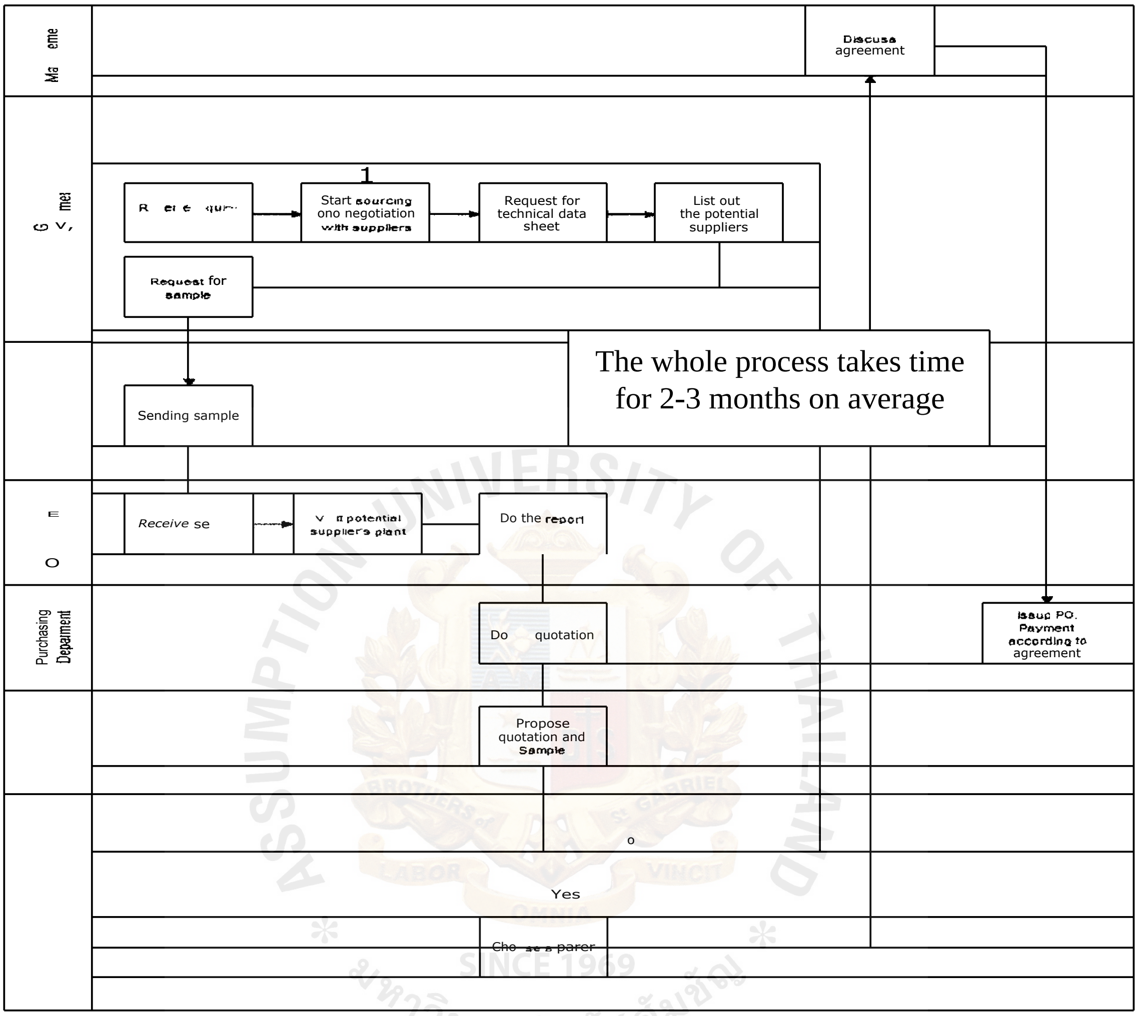

Figure 1.2: Procurement process for core products

As a trading company, the core competency is the procurement process, but it lacks the competitive advantage of responsiveness because it takes a lot of time in order to close an inquiry, normally 2 – 3 months on average. The process starting from global sourcing department (GSO) receives the inquiry from either sales or management, the GSO department needs to source, negotiate and get a quotation and relevant details for the requested item or an equivalent item, at the lowest cost. GSO will then ask for a technical data sheet such as Food and Drug Administration (FDA), Acceptable Quality Level

(AQL), Specification Data Sheet, etc., and record details on a spreadsheet. After that, GSO will screen and select the top 5 potential suppliers based on low price and quality, which is obtained from the technical documents, and asks for samples from those potential suppliers to be sent to the quality assurance department (QA) for evaluation. QA department will make site visits to those suppliers, make a report and inform the result to the purchasing department for making a quotation. Sales department will propose the quotation and sample for customer inspection, testing and evaluation. If the customer is delighted with the product which the company offers, Management will discuss the agreement with the supplier to reach a consensus. Purchasing department will issue a purchase order (PO) and coordinate either with Baltrans as the 3rd party logistic provider or courier and supplier to arrange and ship the product to the location which the company chooses based on the agreed international commercial terms (Incoterm) either through the courier or freight forwarder. On the other hand, if the customer is not satisfied with the proposed quotation, that inquiry will be automatically closed or the company asked to source other suppliers.

1.2 Problem Analysis

Since the company receives more and more complains from the customer about poor product quality, ultimately the customer cancels the order and never again places an order for some core product. This makes the company analyze what really happened between the company and the exiting supplier that caused the customer to cancel and never again place an order.

Referring to Figure 1.3, the company found that external and internal factors of major concern for causing customers to cancel and never again place an order. However, the external factors are uncontrollable variables which are beyond the control of the company whereas the internal factors are the company's internal processes which are controllable factors. The result of internal factors evaluation can greatly affect the external factors. For this reason, this study will analyze the effect of internal factors.

There are three factors hidden within the internal factors, which are the root cause of the problem. Each factor will be discussed, as follows:

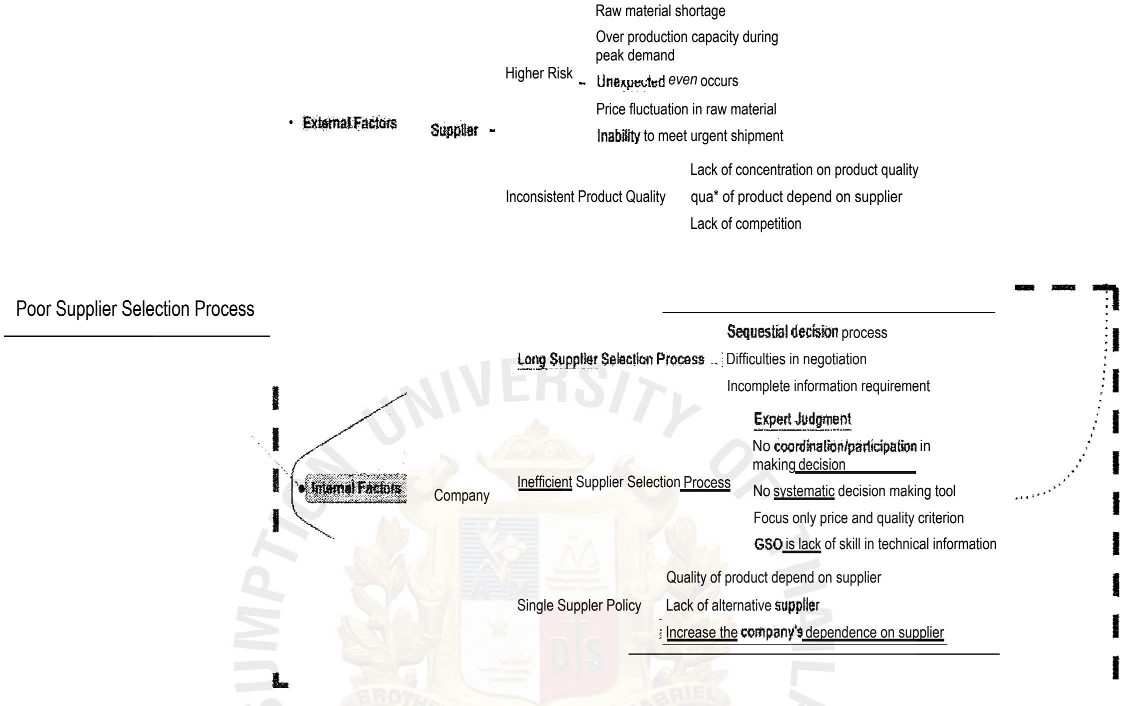

Figure 1.3: Causes of customer to cancel and never again place an order

- Single Supplier Policy

Although a single supplier enables the company to establish a good relationship, with less quality variability, and transportation economies, in reality the company relies solely on a single supplier (one product, one supplier) so the quality of the product depends on the quality which the product supplier provides. By employing a single supplier, the company does not have a second or reserved supplier in case the exiting supplier cannot function properly due to the possibility of unpredicted problems, price fluctuation, raw material shortage or full production capacity during peak demand which means that the supplier could not produce and send the product on time and the company, therefore, also could not deliver the product to the customer as promised, resulting in customer dissatisfaction. Nevertheless, it is due to the fact that as a trading company, the company needs to combine the volume from various customers in order to meet the supplier's minimum order quantity (MOQ) to start production. Referring to Table 1.1, the company notices that the actual order quantity is slightly more than MOQ so it is clearly seen that the company's order quantity is too small to split between multiple suppliers, and the company would like to enjoy a volume discount, to gain bargaining power over the supplier, establishing a tighter relationship with supplier and enjoying transportation economies. Thus, it can be concluded that the company still favors a single supplier policy and it is not a major cause why customers cancel or never again place an order.

Table 1.1: Core products volume to supplier

Month	Description	UOM	MOQ	Order Quantity
Dec	CR, GLOVES,LATEX, CL 100	CTN	1000	1,200
March	CR, GLOVES,LATEX, CL 100	CTN	1000	1,000
July	CR, GLOVES,LATEX, CL 100	CTN	1000	1,300
Oct	CR, GLOVES,LATEX, CL 100	CTN	1000	1,100
Jan	FINGERCOT,WATERWASHED,ANTI-	CTN	300	300
Apr	FINGERCOT,WATERWASHED,ANTI-	CTN	300	300
Jun	FINGERCOT,WATERWASHED,ANTI-	CTN	300	300
Aug	FINGERCOT,WATERWASHED,ANTI-	CTN	300	300
Sep	FINGERCOT,WATERWASHED,ANTI-	CTN	300	300
Nov	FINGERCOT,WATERWASHED,ANTI-	CTN	300	300

- Long Supplier Selection Process

Supplier selection process is quite long, around 2-3 months on average. The long supplier selection leadtime is usually derived from the fact that each department works in a sequential process which adds to the leadtime that causes the supply chain less flexibility and responsiveness to respond to the fast changes of various customer demands. In addition, there is the difficulty in either communication or incomplete information requirement that require the GSO department to ask Sales Department back and forth to get more information to enable GSO to find the right product to meet customer needs and wants which cause even higher administrative costs and a greater delay time to market.

- Inefficient Supplier Selection Process

It is obviously seen that the exiting supplier selection process lacks any systematic decision making tools or coordination between departments. Also, the decision making on supplier selection mostly depends solely on GSO and QA departments to evaluate the performance of suppliers and select them based on only two criteria namely price and quality as primary concerns. This ignores other criteria such as lead-time, payment condition, and capacity of the supplier. Consequently, the value and reliability of the outcome can be diminished, because bias and inaccuracy may occur during judgment, and therefore it is crucial to get involvement from other relevant departments to identify suppliers.

This long and inefficient supplier selection process could lead to selecting a poor supplier. Since the company selects and affects the business with poor suppliers, the company never visits or monitors supplier performance to ensure consistent quality with customer requirements. Not once, but several times customers detect some dust, bad odor, or wrong color, which greatly affects customer satisfaction by failing to meet customer expectation. Finally, the customer might not order that particular items ever again, and will switch to buying from another other supplier or the company's competitors.

Table 1.2: Core products returned from customer

Month	Core Products Delivery (Box)	Return Slip (Box)	Amount of Product Return from Customer
Jan	19,850	1,890	
Feb	22,820	2,450	
Mar	20,350	1,980	
Apr	18,890	1,946	
May	20,090	2,062	
Jun	19,880	1,646	
Jul	24,780	2,253	
Aug	17,750	1,296	

The average of core products return from customer = 9.40%

It is obvious that a long and inefficient process is the factor of the poor supplier selection process which is the main problem why customers cancel or never again order the products. Table 1.2 shows that the average of core products returned by customers during eight months is 9.40%. When compared with the standard performance in reverse logistic for high tech industry as illustrate in Figure 1.6, it is found that the company's product return from customers is higher than the industry standard by around 3.40% (resulting from 9.40% - 6%), so the company has to spend revenue on product returns from customers of around THB 5.08 Million (resulting from 9.40% * Revenue THB 56 Million). Therefore, the total damage of product return from customers accounts for THB 7.98 Million that the company needs to spend on reverse logistics and the opportunity cost of returned products [(resulting from **(8%*54M) + (1-28%)(5.08M)]** as shown in Table 1.3.

Table 1.3: Industry performance in reverse logistics (Gecker 2007)

Industry Sector	% of Products Returned/in 1s Warranty Period	% of Revenues Spent on reverse Logistics Costs	% of Initial Value Recaptured from Returned Products
Consumer Good	11%	10%	31%
High-Tech	6%	8%	28%
Telecom/Utilities	8%	8%	28%
Aerospace & Defense	5%	11%	10%
Medical Device Mfg	11%	15%	22%
Industrial Mfg.	12%	13%	22%

Certainly, the poor supplier selection process not only loses revenue, but also destroys the company image, loyalty, and creditability. Therefore, over time, careful, and effective decision making tools would allow the company to selectively screen-out poor-performing suppliers, gain higher quality products and better delivery, and build successful, trusting relationships with the best potential suppliers. In this case, it can be is foreseen that the importance of the supplier selection process would result in strengthening the competitive advantage in sourcing of the trading company.

1.3 Objectives

- To study decision making tools
- To apply AHP model for the supplier selection problem
- To identify new supplier selection criteria
- To find new suppliers who have high dependability and low cost

1.4 Scope of the project

- To study only one product, which is Cleanroom Latex Glove Class 100 for the semiconductor industry
- Using the "rounding" function with 4 decimal points in the AHP computation process

- This project will compare the exiting supplier selection process with a new supplier selection process, by using the analytical hierarchy process (AI-1P)

1.5 Deliverables

- To creating a systematic decision tool to solve the supplier selection problem
- To shorten the supplier selection lead-time
- Al-IP can be applied in other core products and other areas of business.

Chapter 2. Literature Review

This chapter will begin with a literature review of the definition of the decision making process, structure of decision making and an analysis of each decision making method for vendor selection.

2.1 Definition of the Decision Making Process

Decision making is the study of identifying and choosing alternatives based on the values and preference of the decision maker. Making a decision implies that there are alternative choices to be considered, and not only to identify as many of alternatives as possible but to choose the one that best suits the goals, objectives, desires, values, and so on (Harris 1998).

2.2 Types of Decision Making Environment

The success or failure that an organization makes depends on the decisions that the company makes. What make the difference between a good or bad decision? A good decision is one that is based on logic, considers all available data and possible alternatives, and applies the quantitative approach which is about to be described.

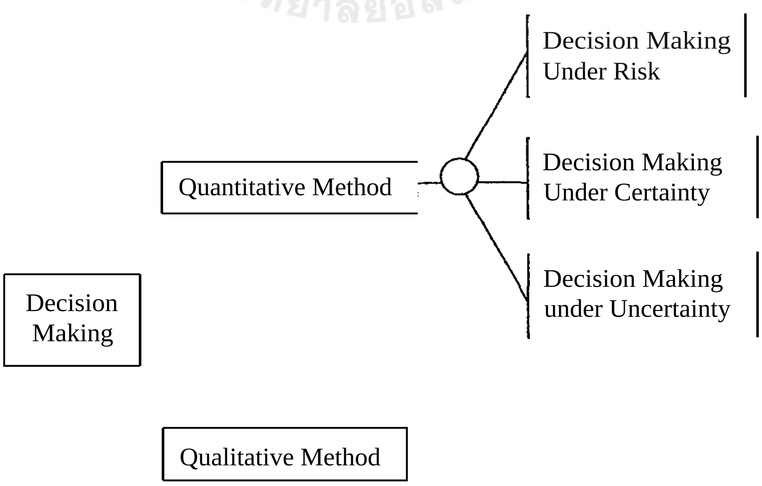

Figure 2.1: The types of decision making (Adapted from Render 1994)

In Figure 2.1, the types of decisions organizations make depend on how much knowledge or information they have about the situation. There are three decision-making environments (Render 1994):

- Type **1:** Decision Making under Certainty

  In decision making under certainty, a decision maker normally knows the deterministic factors and also knows with certainty the consequence of every alternatives. Normally a decision maker will choose the alternative that will result in the best outcome.

- Type 2: Decision Making under Risk

  Decision making under risk is a probabilistic decision situation. Several possible states of nature may occur, each with a given probability. There are several possible outcomes for each alternative, and the decision maker knows the probability of occurrence of each outcome. The decision maker often tries to maximize the expected result.

- Type3: Decision Making under Uncertainty

  In decision making under uncertainty, there are several possible outcomes of each alternative, and the decision maker cannot assess the outcome probability with confidence or does not know the probabilities of various results.

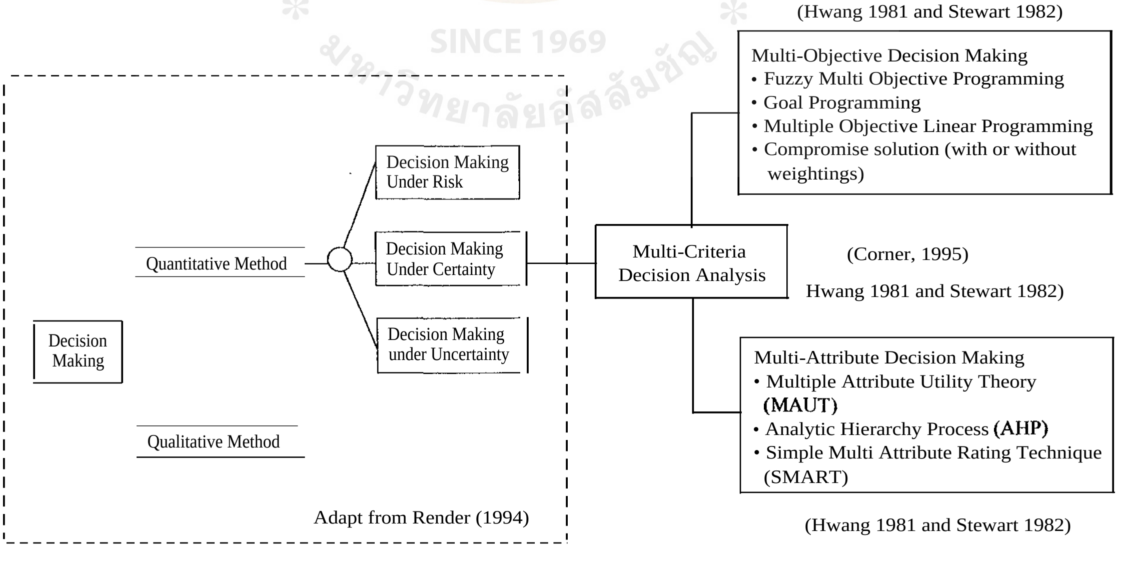

Figure 2.2: Decision making under certainty with multi-criteria decision analysis

In Figure 2.2, (Corner 1995) describes an experiment in decision making under certainty with Multi Criteria Decision Analysis. Moreover, (Hwang 1981), and (Stewart 1992) also state that there are many different ways to classify the Multi Criteria Decision Analysis. One common classification is to divide into:

- Multi-Objective Decision Making (MODM), which involves making preference decisions over the available alternatives that are characterized by multiple or an indefinite number of alternatives.
- Multi-Attribute Decision Making (MADM), which refers to methods suitable for solving multi-criteria problems where the objectives are explicitly defined and discrete.

This paper will concentrate on discrete problems and only on Multi-Attribute Decision Making (MADM) methods.

2.3 Comparing Decision Making Tools

Table 2.1: Summary and Limitations of AHP, MAUT, and SMART

Author	Application	Summary	Limitation
(Boonkanit 2007)	AHP: Selecting Products at Conceptual Design Phase	This study uses AHP as the methodology for selecting green product at the conceptual design, It can be used to help designers evaluate and select the best designed based on consumer requirement and other important design criteria such as environment friendly. This method guarantees that the designed product will match market demand. Some conclusions drawn are: • The quality and cost of product can be evaluated during design process • The quality of the product is deployed	• It is hard to reach consensus in the pairwise comparison required in AHP. That means decision makers need to clearly state the preferences on criteria by criteria basis and translate that preferences into a numeric scale • Different people have their own conceptions. Each of these can affect the capability of reaching consensus and converting judgments into numeric scale in order to describe the pairwise comparisons of objectives and alternatives required in the AHP

Author	Application	Summary	Limitation
		based on customer need • **AHP** can evaluate the priority vector for design alternatives and increase decision making efficiency • The design uncertainties can be reduced and may alternatives can be developed	
(Ta 2000)	**AHP:** Bank Selection Decision	In the study, nine criteria for bank selection at five banks are identified, and the decision problem is structured into a three-level hierarchy using the Analytic Hierarchy Process **(AHP).** The findings show that undergraduates highly concentrate on the pricing and product dimensions of bank services. The results are of interest to bank managers because they provide information on the importance of the selection criteria as well as areas of strength and weakness of banks	• A lack of information about the criteria being compared or a lack of concentration during the judgment process can also cause inconsistency • Comparison lacking consistency may indicate that the respondents did not understand the differences in choices presented or unable to assess accurately the relative importance of the elements compared
(Lagoudis 2006)	**MAUT:** Ocean Transportation	In this research, **MAUT** has been used to measure and compare the value of different processes of four sectors of ocean transportation which are **:** liner, dry bulk, liquid bulk and specialized The result suggests that the industry strongly emphases quality. Service and cost are differentiating attributed between sectors. Time factors are ranked as the least appreciated ones.	In case of there is no historical performance for comparison. The complexity is mainly derived from the decision makers who have to consider the various involved factors simultaneously, some of which are qualitative factors that make the comparison among the difference of ocean transportation companies less straightforward and ambiguous

Amuthor	Application	Summary	Limitation
(Sanayei 2008)	MAUT and LP: Supplier Selection	For supplier selection problem, an integrated MAUT and LP model is a well suited to deal with such decision problem. MAUT determines supplier's utility from the decision maker's opinions. The LP model is then used to determine the order quantities to be purchased from each supplier to maximize the quantity purchased from the most desired suppliers	• The greater the number of attributes taken into consideration, the more difficult and time consuming is the completion and identification of the performance, measures, criteria and importance weights.
(Kuhn 2000)	SMART: National Microbial Water Quality Program	Due to the rapid demographic change, water use pattern resulting in the microbial water quality problem which has a severe impact on human health. SMART is used in the conceptual design of the National Microbial Water Quality Program (NMMP) to identify the priority area in South Africa	• Due to SMART requires no judgment of preference therefore, purely judgment is difficult to score on 0-100 utility scale as the range is wide

Table 2.2: Comparison of the advantages and disadvantages between AHP, MAUT and SMART

Author	Method	Advantages	Disadvantages
(Yap 1992)	SMART	• Simple method • SMART could be done manually without the aid of computer • The tasks are more comprehensible • More content with the decision process • Easily adapted where decision making is performed by a group	• Requires no judgments of preference • Unreliable and unrepresentative of real preferences • Bore untutored decision makers into rejection of the process • Wide range score 0-100

Author	Method	Advantages	Disadvantages
(Espen 2007)	**AHP**	• Handle both tangible and intangible • Better clarify problem • Better in eliciting goals and preferences • More content in the result • Software package	• The number of computation requires Substantially complicated the method • Require more time consuming
	MAUT	• Ratings are given as expected total utility • Handles both qualitative and quantitative • Can be applied in uncertainty or risk situation	• Complexity and difficulty in preference elicitation procedure • Expected total utilities (0-1 scale) don't have any direct physical meaning • Question in **MAUT** seem to be ambiguous • Expected total utilities might seem complex and fuzzy for decision maker
	AHP	• Most widely used • Encourage participation and brainstorming • Reduce bias • **Pairwise** Comparison • Consistency ratio • **Eigenvalue** analysis • Easier to understand than MAUI • Incorporate both quantitative and qualitative judgment • Give much greater difference in the rating than **MAUT** • Software package	• Time consuming when the number of alternatives is large • The conversion from verbal to numerical judgment tends to overestimate preference differences

Table 2.3: Comparison of the Three Methods of Assessing the Characteristics

Characteristics	**ARP**	**MAUT**	**SMART**
Evoking response	**Pairwise** Comparison	Direct rating	Direct rating
Preference judgment	Present	N/A	N/A
Scale ranking	1-9	0-1	0-100

Characteristics	AHP	MAUT	SMART
Quantitative and qualitative involved	Present	Present	Present
Consistency measure	Present	N/A	N/A
Software Package	Yes	N/A	N/A
Comparison of importance	Comparative Judgment	Swing Weighting*	Swing Weighting

* Swing Weighting is an approach which requires decision maker to compare individual attributes directly by imaging hypothetical outcomes (Bichler 2001).

In conclusion, AHP seems to be a useful technique for applying in supplier selection when there are multiple criteria since most people cannot deal with more than seven decision considerations at a time (Miller 1956). AHP is suitable for decisions with qualitative and quantitative criteria. It puts them in the same decision context by depending on relative comparisons instead of attempting to define absolutes. It facilitates discussion of the importance of criteria and the ability of each alternative to meet the criteria. Its strength is the analytical hierarchy that provides a structured model of the problem by imitating the way people normally approach complex problem and also provide pairwise comparison based on a nine- point scale with has its own physical direct meaning in each point on the scale to determine the relative performance score of the decision table for each alternatives on each criteria. AHP also provides a measure of consistency ratio to ensure that the decision maker's answer is consistent and reasonably acceptable.

2.4 The Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a pairwise comparison method developed by Thomas L. Saaty, designed to solve complex problems involving multi-criteria. The process requires the decision maker to convert the subjective assessments of relative importance to a set of overall scores or weights. A property of AHP is that both weights and component scores are quantitative which mean decision makers must states how much better is alternative *a* when compared to alternative *b?*

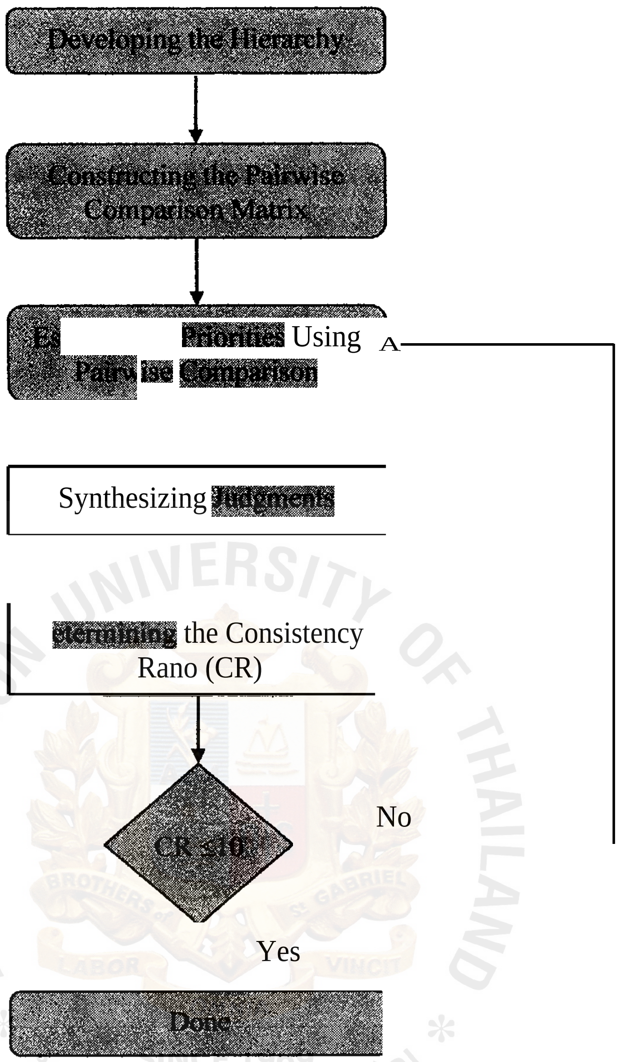

Figure 2.3: The Analytical Hierarchy Process (Anderson 1941)

From Figure 2.3, the process starts by laying out the overall hierarchy of the decision. This hierarchy reveals the factors to be considered as well as the various alternatives in the decision. It organizes the basis rationally by breaking down a problem into smaller and smaller constituent parts and then guides the decision maker through a series of pairwise comparisons to express which of the two the alternative decision makers preferred and how much importance they find in this alternative compared to the other. A ratio scale called the Fundamental Scale (Table 2.4) is used in pairwise comparison. The number in the scale shows how many times the larger scale of the two elements dominates the smaller (ratios).

Table 2.4: The pair-wise comparison is made using a nine —point scale (Saaty 1980):

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment slightly strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values adjacent scale values	When compromise is needed
Reciprocals of above nonzero	If activity *i* has one of the above nonzero number assigned to it when compared with activity *j*, then] has the reciprocal value when compared with	A reasonable assumption
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix

The results from comparisons are put into matrices wherein each alternative is compared against the others, such as if alternative A receives a score of 2 relative to alternative B, the alternative B should receive a score of '/2 when compared with alternative A. Hence, for each comparative score given, the reciprocal is awarded to the opposite relationship.

The priority vector is calculated for each criterion using the geometric mean of each row in the matrix divided by the sum of the geometric mean of all the criteria (Synthesization). This process is repeated for the alternatives comparing them one to another determine their relative importance for each criteria. To identify the most preferred alternative multiply each normalized alternative score by the corresponding normalized criterion weight, and sum the result for all alternative criteria. The most preferred alternative will have the highest total score.

Moreover, AHP also provides a measure of the consistency of pairwise comparison judgments which is called consistency ratio. The consistency ratio is obtained by comparing the C.I. with the appropriate one of the set of RI numbers shown in Table 2.3.

$$CI = \frac{max - n}{n-1} \qquad \text{Eq. (2.1)}$$

Where CI = the sum of consistency vector

λ_{max} = the largest or principal eigenvalue of Matrix

n = total number of alternatives

Therefore,

$$CR = \frac{CI}{RI} \qquad \text{Eq. (2.2)}$$

Where RI = the random index is a direct function of the number of alternatives.

Table 2.5: Table of Random Inconsistency for Different Size Matrix.

	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

In general, If CR 5 0.10, the decision makers' answers are relatively consistent.

If CR 0.10, the decision makers should seriously consider reevaluating their response during the pairwise comparisons that were used to obtain the original matrix of pairwise comparison.

2.5 Change Management

AHP implementation requires a company to reengineer the company procurement process in a fundamental way, modify old ways of conducting business and restructure job area responsibilities and roles. During times of significant change to an organization, employees can experience high levels of stress which will lead to resistance to change.

Organizational change is a complex process that is not always successful due to a variety of reasons. When change is implemented it often results in individuals taking on and performing new tasks needing development new skills and new ways of working, thus a greater degree of stress that often drives resistance to change. Resistance to change is an inability or an unwillingness to discuss or to accept the organizational changes that are perceived as in some way damaging or threatening to the individual or group (Huczynski 2001)

To cope with resistance, change has to be managed and conducted in a rational and right direction. Change Management Strategic Framework, a six-step process can be applied to transitioning individuals, teams, and organizations from a current state to a desired future state (Chahal 2006).

2.5.1 Preparing the Organization

This is the first and most critical phase. It enables the company to assess the nature and direction of the change and requires establishment of the need to change, raise awareness and change belief, listening to the workforce to demonstrate respect, and is a powerful tool to build self-esteem during a potentially turbulent time. This process helps move them into a sense of control and engagement to honor the past, recognize the need to engage employee throughout the change process using their ideas on how to make it happen successfully and to avoid the feeling of mistrust for change, which are the fundamental ingredients of resistance.

2.5.2 Developing the Vision and Implementation Plan

Analyzing the feedback from previous step will give a change manager a feeling of the nature and the possible direction of change. This feedback will probably have many great ideas and solutions floating around. Link these concepts to an overall vision and a change plan that everyone can grasp easily and remember. The vision should say something that helps the company to clarify the direction the company is heading towards, how the future will be different from the past, and how the company can make that future a reality. The change plan will describe details of the role and responsibility of individuals responsible for the change, instructions for the employee about the change and how it has been designed and will be implemented.

2.5.3 Checking

Step three provides employees along with management the opportunity to review all the documents and plans before actual implementation. All advantages and disadvantages can be evaluated by being taken into consideration

2.5.4 Communication and Workforce Engagement

To implement change effectively, communication must be established and kept open to avoid isolating sections of the workforce: everyone should have access to discuss their concerns. A high degree of workforce consultation and participation should start as early as possible and continue through the implementation and evaluation phases. Employee involvement is essential for two reasons. First, it helps to develop a process that is useful to the people that have to execute this process. Second, involvement increases the acceptance of the developed process and reduces the amount of resistance encountered during the implementation phase.

2.5.5 Implementation

When implemented in an organization, where the changes to the current state were small and incremental, people were more willing to apply the new practice than in the organizations that tried to make a large change. Implementation for small change usually entails some form of training, which officially introduces the new or revised processes. This training includes overviews of the process, individual process descriptions and tutorials in any newly introduced techniques or tools. During the implementation, it is crucial to recognize that conflict and resistance to change are unavoidable. It is essential to listen to concerns raised during the implementation phase as many of these will be genuinely taken into account

2.5.6 Evaluation

There is no hard and fast rule for when to schedule, but it is recommended to evaluate how effective the changes has been. The method of evaluation needs to be agreed and the format should follow the original goals and objectives of the change. The review of a new process is an acceptable method of evaluation along with process inspection and audit. Once the evaluation process has been undertaken, it is possible to identify areas needing improvement and adjustment to the process which may be need to be made

Chapter 3. Methodology

This chapter describes the method used to fulfill the purpose of the project. It consists of research strategy, research approach, and limitation and constraints.

3.1 Research Strategy

This paper uses a case study methodology. The case study focuses on a vendor selection problem in a trading company by using the Analytical Hierarchy Process (AHP) technique. Four main criteria to be considered, such as competitive price, good quality, short lead-time, and long credit term. The criteria and sub-criteria can be obtained by interviewing and discussing corresponding persons in QA, Global Sourcing and Purchasing Departments. Alternatives are then evaluated and compared under both quantitative and qualitative factors to find a new supplier who has high dependability and low cost.

3.2 Research Approach

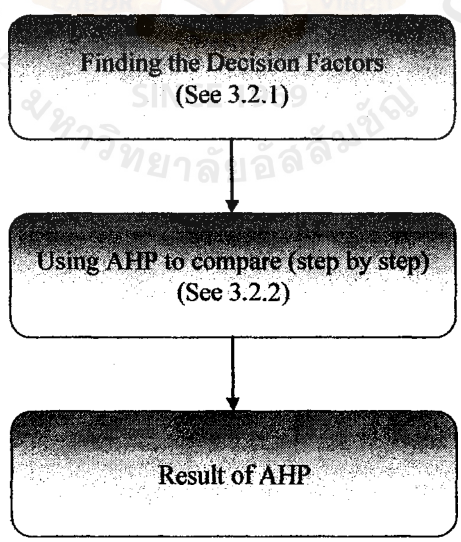

Figure 3.1 Methodology research approach (ref. Chapter 2)

3.2.1 Finding the Decision Factors

The first step in the research approach is to identify goals and the relevant criteria. Form a cross-functional group interview and discussion between QA, Global Sourcing and Purchasing Departments to identify the goal and to make sure that everybody agrees and reach the consensus to use the set of criteria and sub-criteria to be applied in AHP. The following main criteria and sub-criteria for selection of a vendor could be summarized as follows:

- The competitive price criteria can be easily determined since there is direct information of the cost of products supplied by the supplier
- Good quality is a technical criterion of the supplier. This will give a very important insight into the technical capability of supplying high quality Cleanroom Latex Glove. Therefore, it is essential to discuss with QA department the necessary criteria about quality. QA department provides the following factors as four sub- criteria of the quality criterion, as summarized in Table 3.1.

Table 3.1: Cleanroom Latex Glove Quality Criteria

Type	Particle Count/ cm	Ionics µg/ cm^2	FTIR	NVR mg/ cm^2
Class 100	< 800	CL < 0.3 NO_3 < 0.3	N/A	Max 35
Class **10**	< 500	CL < 0.2 NO_3 < 0.2	N/A	Max 30

* Particle count is used to test and classify a cleanroom to ensure its performance is up to a specific cleanroom classification standard.

* CL is derived from Chlorination which is difficult to remove during the washing process.

* No_3 is a Nitrate ion

* FTIR refers to Fourier transform infrared spectroscopy

* NVR refers to Non-Volatile Residue. It is tested by using a weighing scale. Soak the glove in the Deionised water and stir it for a certain time. Then remove the glove and test only the water.

- Short Lead-time is an advantage for both customers and the company. If the company can deliver the product ahead of the competition, it stands a better chance of receiving future orders so the company must retain a realistic short lead-time

- The nature of the company normally gives a long credit term to the customer. Hence, to pay the supplier on time, the company prefers a long credit term.

3.2.2 Using AHP to compare (Step by Step)

As AHP computation takes many steps and is relatively complicated, to make it easy to understand, it is necessary to create and take a process approach to diagramming, as shown in Figure 3.2 to gain a better understanding what is happening in each process and accurately reflect an insight into the following AHP computation process.

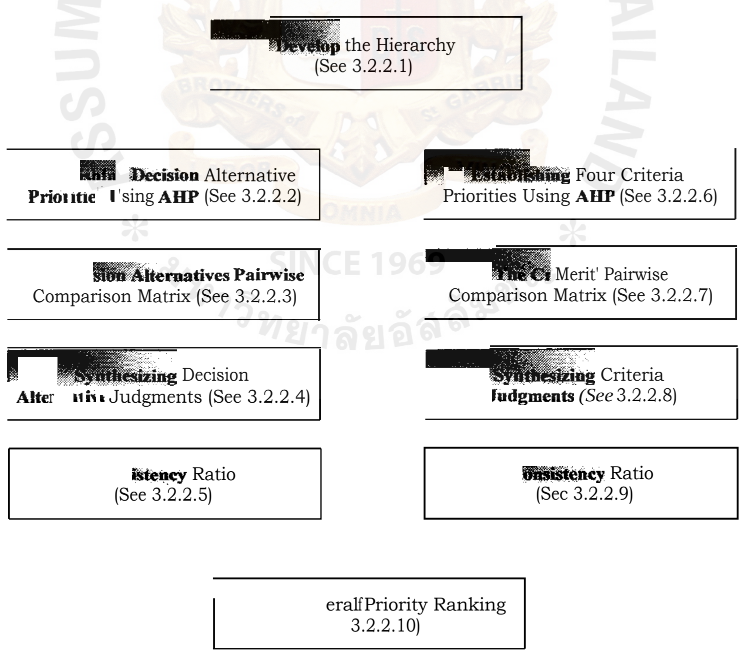

Figure 3.2: AHP computation step

3.2.2.1 Developing the Hierarchy

Developing a graphical representation of the problem in terms of the overall goal, criteria, and decision alternatives. Such a graph reveals the hierarchy for the problem. The first level of the hierarchy shows the overall goal. The second level reveals the main criteria which will contribute to the achievement of the overall goal. The third level consists of the sub-criteria of quality. Finally, at the fourth level, each decision alternative contributes to each criterion in a unique way, which is shown in Figure 3.3.

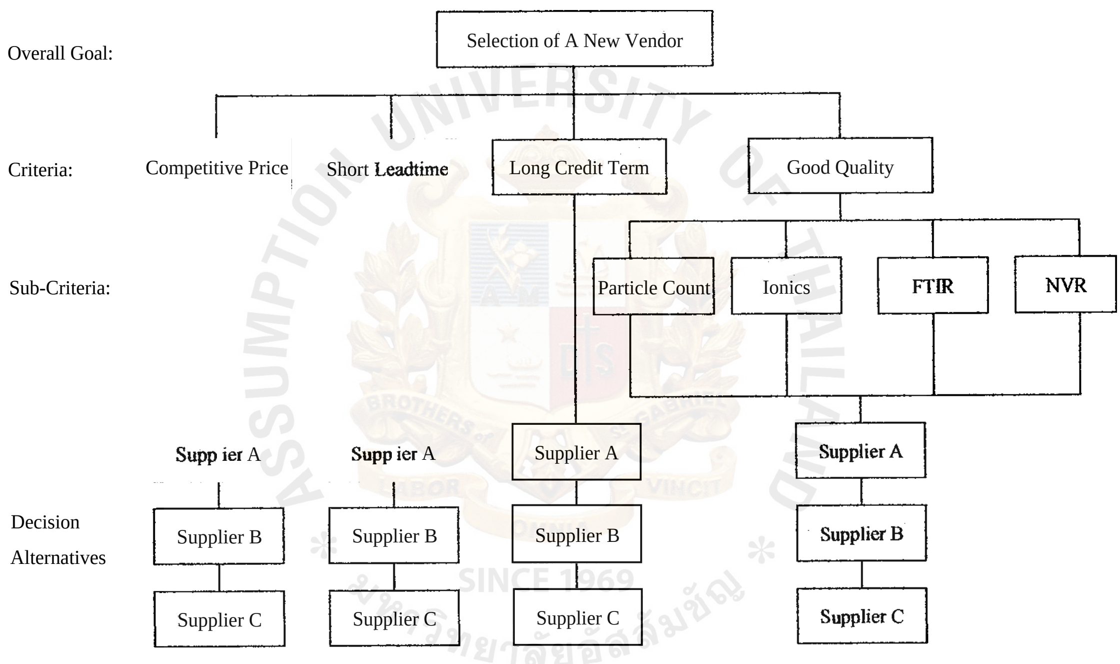

Figure 3.3: Hierarchical level of decision making for using AHP

3.2.2.2 Establishing Decision Alternative Priorities Using AHP

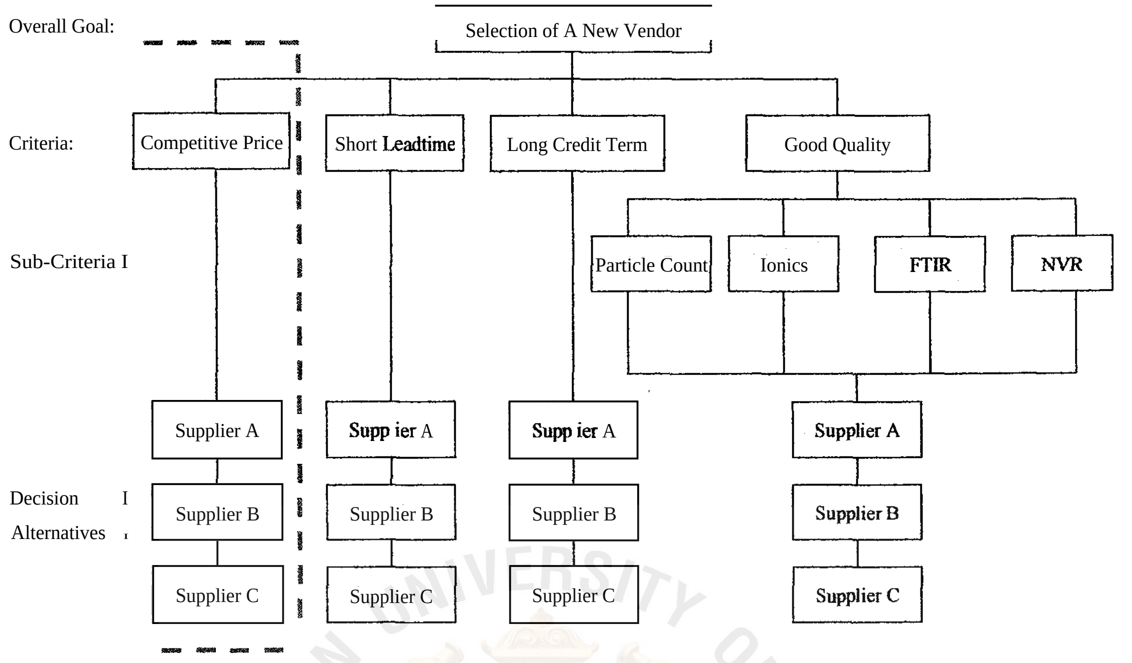

Figure 3.4: Prioritize suppliers under price criteria

Based on Figure 3.4, price criteria and supplier alternatives will be used as an example in the computation of a decision alternatives pairwise comparison matrix, synthesizing decision alternative judgments until the computation of the consistency ratio. They are scored using a pair-wise comparison method and mathematics to establish priority measures for both criteria and the decision alternatives. AHP uses an underlying scale with the value 1-9 as a reasonable basis to rate the relative preferences for two items.

3.2.2.3 The Decision Alternatives Pairwise Comparison Matrix

Table 3.2: Supplier alternatives pairwise comparison matrix with respect to competitive price criteria

Competitive Price	Supplier A	Supplier B	Supplier C
Supplier A		3	3
Supplier B	1/3		1/2
Supplier C	1/3	2	

Referring to Table 3.1, to prioritize suppliers, matrices are developed wherein each supplier alternative is compared against other. If supplier A is moderately important compared to supplier B (i.e. a value of "3"), then supplier B has a value of 1/3 compared to supplier A. Thus, for each comparative score given, the reciprocal is awarded to the opposite relationship. In general, for any pairwise comparison matrix, 1 s will be placed down the diagonal from the upper left corner to the lower right corner.

3.2.2.4 Synthesizing Decision Alternatives Judgments

Step 1 Sum the value in each column of the pairwise comparison matrix

Competitive Price	Supplier A	Supplier B	Supplier C
Supplier A	1.0000	3.0000	3.0000
Supplier B	0.3333	1.0000	0.5000
Supplier C	0.3333	2.0000	1.0000
Total	1.6666	6.0000	4.5000

Step 2 Divide each element in the pairwise comparison matrix by its column total; the resulting matrix is referred to as the normalized pairwise comparison matrix.

Competitive. Price	Supplier A	Supplier B	Supplier C
Supplier A	0.6000	0.5000	0.6667
Supplier B	0.2000	0.1667	0.1111
Supplier C	0.2000	0.3333	0.2222
Total	1.0000	1.0000	1.0000

Step 3 The normalized principal Eigen vector can be obtained by computing the average of the elements in each row of the normalized matrix; these averages provide an estimate of the relative priorities of the elements being compared. The preferred alternative will have the highest total score.

Competitive Price	Supplier A	Supplier B	Supplier C	Row Average
Supplier A	0.6000	0.5000	0.6667	0.5889
Supplier B	0.2000	0.1667	0.1111	0.1593
Supplier C	0.2000	0.3333	0.2222	0.2518
Total	1	1	1	1

The normalized principal Eigen Vector is also called the "priority vector". Since it is normalized, the sum of all elements in priority vector is 1. The priority vector shows relative weights among the things that are compared.

Therefore, considering competitive price criteria, the most preferred vendor is supplier A (58.89%). Supplier C (25.18%) is second, followed by supplier B (15.93%). The priority vector showing the relative priorities of supplier A, supplier B, and supplier C with respect to competitive price criterion is

$$\begin{vmatrix} 0.5889 \\ 0.1593 \\ 0.2518 \end{vmatrix}$$

3.2.2.5 Consistency Ratio for Decision Alternatives

Aside from the relative weight, a key step in AHP is the establishment of priorities through the use of the pairwise comparison procedure just described. Perfect consistency is difficult to achieve and some lack of consistency is expected to exist in almost any set of pairwise comparisons. To handle the consistency question, AHP provides a method for measuring the degree of consistency among the pairwise judgments provided by the decision maker. If the degree of consistency is acceptable, the decision process can continue. However, if the degree of consistency is unacceptable, the decision maker should reconsider and possibly revise the pairwise comparison before proceeding with the analysis.

The step in estimating the consistency ratio are as follows:

Step 1 Multiply each value in the first column of the pairwise comparison matrix by the relative priority of the first item considered; multiply each value in the second column of the matrix by the relative priority of the second item considered; multiply each value in the third column of the matrix by the relative priority of the third item considered. Sum the values across the rows to obtain a vector of values labeled "weighted sum"

$$0.5889\begin{vmatrix}1.0000\\0.3333\\0.3333\end{vmatrix} + 0.1593\begin{vmatrix}3.0000\\1.0000\\2.0000\end{vmatrix} + 0.2518\begin{vmatrix}3.0000\\0.5000\\1.0000\end{vmatrix}$$

$$= \begin{vmatrix}0.5889\\0.1963\\0.1963\end{vmatrix} \quad \begin{vmatrix}0.4779\\0.1593\\0.3186\end{vmatrix} \quad \begin{vmatrix}0.7554\\0.1259\\0.2518\end{vmatrix} \quad \begin{vmatrix}1.8222\\0.4815\\0.7667\end{vmatrix}$$

Step 2 Divide the elements of the vector of the weighted sums obtained in step 1 by the corresponding priority value.

$$\left[\frac{1.8222}{0.5889}\right] = 3.0942$$

$$\left[\frac{0.4815}{0.1593}\right] = 3.0226$$

$$\left[\frac{0.7667}{0.2518}\right] = 3.0449$$

Step 3 Compute the average of the values found in step 2; this average is denoted λ_{max}.

$$\lambda_{max} = \frac{3.0942 + 3.0226 + 3.0449}{3} = 3.0539$$

Step 4 Compute the consistency index (CI), which is defined as

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad \text{Eq. (3.1)}$$

Where

n = the number of items being compared

For the new supplier selection problem with $n = 3$

$$CI = \frac{3.0539 - 3}{2} = 0.0270$$

Step 5 Compute the consistency ratio (CR), which is defined as

$$CR = \frac{CI}{RI} \qquad \text{Eq. (3.2)}$$

Where RI, the random index, is the consistency index of a randomly generated pairwise comparison matrix, the RI, which depends on the number of elements being compared, takes on the following values:

2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Thus, for a new supplier selection problem with $n = 3$ and RI = 0.58, the consistency ratio will be:

$$CR = \frac{0.0270}{0.58} = 0.0466$$

As mentioned previously in Chapter 2, a consistency ratio of 0.10 or less is considered acceptable. In contrast, the ratio is designed in such a way that values of the ratio exceeding 0.10 are indicative of inconsistent judgment. The problem studied here shows a consistency ratio of 0.0466, therefore the degree of consistency exhibited in the pairwise comparison matrix for price criteria is acceptable.

Continue with AHP analysis of a new supplier selection problem by using the pairwise comparison procedure to determine the priorities of the three suppliers with respect to short lead-time, long credit term and good quality criteria and following the same synthesis and consistency ratio procedure that was used for the competitive price criterion.

3.2.2.6 Establishing Four Criteria Priorities Using AHP

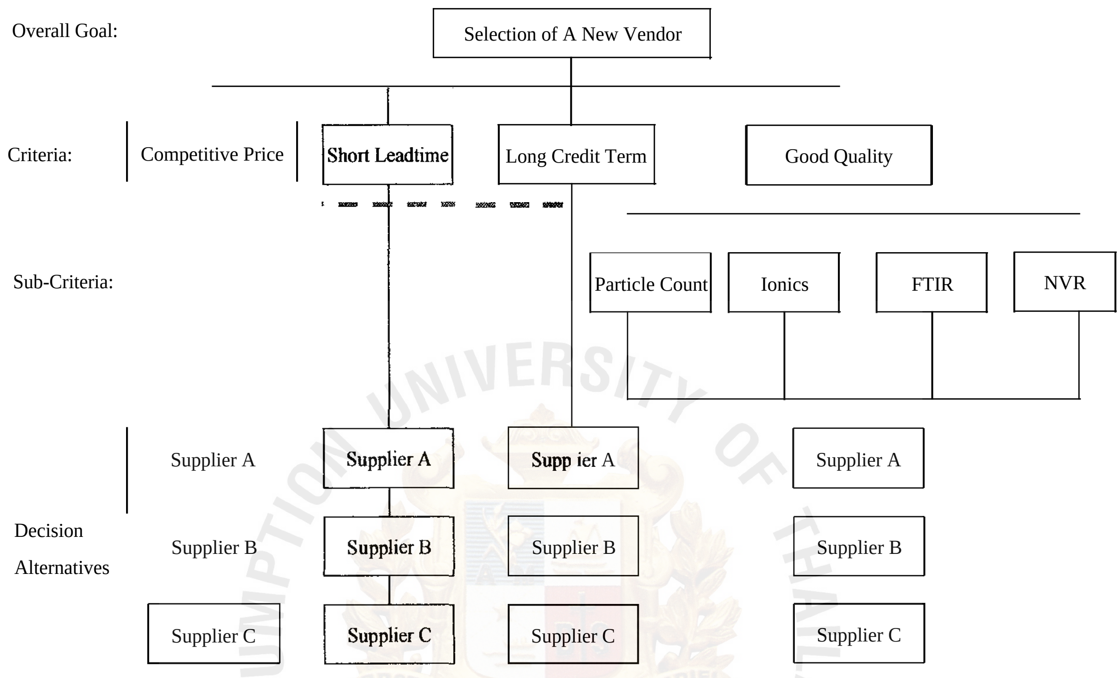

Figure 3.5: Prioritize competitive price, short leadtime, long credit term and good quality

In addition to the pairwise comparison, synthesization and consistency ratio of the decision alternative, continuing the same pairwise comparison procedure needs to be set and uses the same synthesization process and consistency ratio procedure as described earlier to covert the pairwise comparison information to priorities for all four criterion in terms of importance of competitive price, short lead-time, long credit term and good quality criteria in contributing toward the overall goal of selecting the best supplier.

3.2.2.7 The Criteria Pairwise Comparison Matrix

Table 3.3: Criteria Pairwise Comparison Matrix

Criteria	Competitive Price	Short Leadtime	Long Credit Term	Good Quality
Competitive Price	1	4	5	1
Short Leadtime	1/4	1	2	1/9
Long Credit Term	1/5		1	1/5
Good Quality	1	9	5	1

3.2.2.8 Synthesizing Criteria Judgments

Step 1 Sum the value in each column of the pairwise comparison matrix

Criteria	Competitive Price	Short Leadtime	Long Credit Term	Good Quality
Competitive Price	1.0000	4.0000	5.0000	1.0000
Short Leadtime	0.2500	1.0000	2.0000	0.1111
Long Credit Term	0.2000	0.5000	1.0000	0.2000
Good Quality	1.0000	9.0000	5.0000	1.0000
Total	2.4500	14.5000	13.0000	2.3111

Step 2 Divide each element in the pairwise comparison matrix by its column total; the resulting matrix is referred to as the normalized pairwise comparison matrix.

Criteria	Competitive Price	Short Leadtime	Long Credit Term	Good Quality
Competitive Price	0.4082	0.2759	0.3846	0.4327
Short Leadtime	0.1020	0.0690	0.1538	0.0481
Long Credit Term	0.0816	0.0345	0.0769	0.0865
Good Quality	0.4082	0.6207	0.3846	0.4327
Total	1.0000	1.0000	1.0000	1.0000

Step 3 The normalized principal Eigen vector can be obtained by computing the average of the elements in each row of the normalized matrix; these averages provide an

estimate of the relative priorities of the elements being compared. The preferred alternative will have the highest total score

Criteria	competitive Price	Short Leadtime	Long Credit Term	Good Quality	Row Average
Competitive Price	0.4082	0.2759	0.3846	0.4327	0.3754
Short Leadtime	0.1020	0.0690	0.1538	0.0481	0.0932
Long Credit Term	0.0816	0.0345	0.0769	0.0865	0.0699
Good Quality	0.4082	0.6207	0.3846	0.4327	0.4616
Total	1.0000	1.0000	1.0000	1.0000	1.0000

After determining the preferred criteria, good quality (46.16%) is the highest-priority, or most important, criteria in a new supplier selection decision. Competitive price (37.54%) is ranked next in importance. Short lead-time (9.32%) is moderately important, whereas long credit term (6.99%) is a relatively unimportant criterion in terms of the overall goal of selecting the best supplier. This can be written in the priority vector as

$$\begin{vmatrix} 0.3754 \\ 0.0932 \\ 0.0699 \\ 0.4616 \end{vmatrix}$$

3.2.2.9 Consistency Ratio for Criteria

The step in estimating the consistency ratio is as follows:

Step 1 Multiply each value in the first column of the pairwise comparison matrix by the relative priority of the first item considered; multiply each value in the second column of the matrix by the relative priority of the second item considered; multiply each value in the third column of the matrix by relative priority of the third item considered. Sum the values across the rows to obtain a vector of values labeled "weighted sum"

$$0.3754\begin{bmatrix}1.0000\\0.2500\\0.2000\\1.0000\end{bmatrix}+0.0932\begin{bmatrix}4.0000\\1.0000\\0.5000\\9.0000\end{bmatrix}+0.0699\begin{bmatrix}5.0000\\2.0000\\1.0000\\5.0000\end{bmatrix}+0.4616\begin{bmatrix}1.0000\\0.1111\\0.2000\\1.0000\end{bmatrix}$$

$$\begin{bmatrix}0.3754\\0.0939\\0.0751\\0.3754\end{bmatrix}+\begin{bmatrix}0.3728\\0.0932\\0.0466\\0.8388\end{bmatrix}+\begin{bmatrix}0.3495\\0.1398\\0.0699\\0.3495\end{bmatrix}+\begin{bmatrix}0.4616\\0.0513\\0.0923\\0.4616\end{bmatrix}$$

$$\begin{bmatrix}1.5593\\0.3782\\0.2839\\2.0253\end{bmatrix}$$

Step 2 Divide the elements of the vector of the weighted sums obtained in step 1 by the corresponding priority value.

$$\left[\frac{1.5593}{0.3754}\right] = 4.1537$$

$$\left[\frac{0.3782}{0.0932}\right] = 4.0579$$

$$\left[\frac{0.2839}{0.0699}\right] = 4.0615$$

$$\left[\frac{2.0253}{0.4616}\right] = 4.3876$$

Step 3 Compute the average of the values found in step 2; this average is denoted λ_{max}.

$$\lambda_{max} = \frac{4.1537 + 4.0579 + 4.0615 + 4.3876}{4} = 4.1652$$

Step 4 Compute the consistency index (CI), which is defined as

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad \text{--- Eq. (3.3)}$$

Where

n = the number of items being compared

For the new supplier selection problem with $n = 4$

$$CI = \frac{4.1652 - 4}{3} = 0.0551$$

Step 5 Compute the consistency ratio (CR), which is defined as

$$CR = \frac{CI}{RI} \qquad \text{--- Eq. (3.4)}$$

Where RI, the random index, is the consistency index of a randomly generated pairwise comparison matrix, the RI, which depends on the number of elements being compared, takes on the following values:

2	0.00
3	0.58
4	0.90

5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Thus, for a new supplier selection problem with $n = 4$ and RI = 0.90, the consistency ratio will be:

$$CR = \frac{0.0551}{0.90} = 0.0612$$

As the result of consistency ratio is 0.0612, which is less than 0.10, therefore the degree of consistency exhibited in the pairwise comparison matrix for four criteria is acceptable.

3.2.2.10 Develop Overall Priority Ranking

The preceding sections demonstrated how to use a pairwise comparison matrix to develop a prioritized ranking of the items being compared. Now this topic will show how to combine the priorities of each decision alternative and criterion priorities to each criterion to develop an overall priority ranking of the decision alternatives, as shown in Figure 3.6.

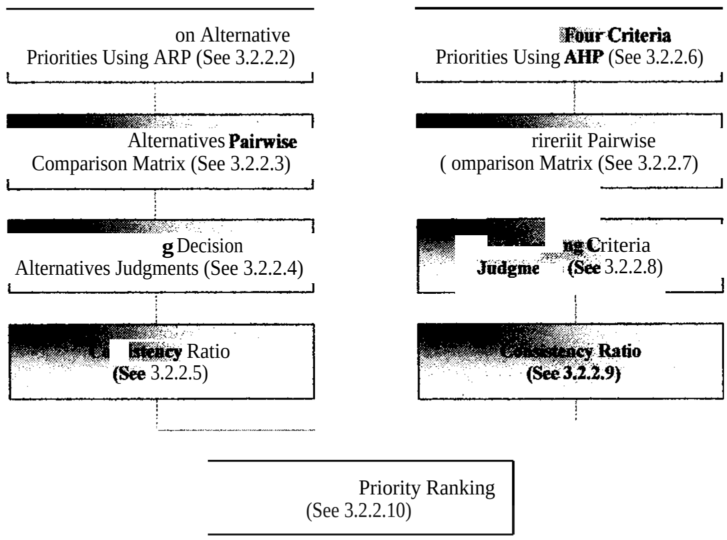

Figure 3.6: Overall priority computation step (ref. figure 3.2)

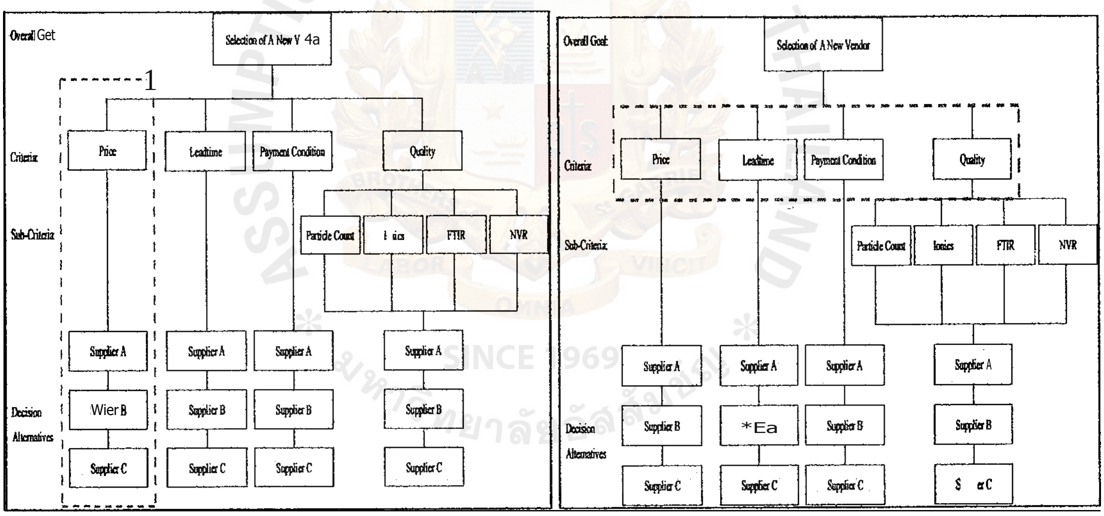

Figure 3.7: The product of the decision alternative priority and criteria priority (ref. Figure 3.4 and Figure 3.5 respectively)

Referring to Figure 3.7, the overall priority for each decision alternative is obtained by summing the products of the criterion priority times the priority of its decision alternative.

Therefore,

Overall supplier A priority

= 0.3754(0.5889) + 0.0932 *(Supplier A with respect to Short Lead-time)* + 0.0699 *(Supplier A with respect to Long Credit Term)* + 0.4616 *(Supplier A with respect to Good Quality)*

Overall supplier B priority

= 0.3754(0.1593) + 0.0932 *(Supplier B with respect to Short Lead-itme)* + 0.0699 *(Supplier B with respect to Long Credit Term)* + 0.4616*(Supplier B with respect to Good Quality)*

Overall supplier C priority

= 0.3754(0.2518) + 0.0932 *(Supplier C with respect to Short Lead-time)* + 0.0699 *(Supplier C with respect to Long Credit Term)* + 0.4616*(Supplier C with respect to Good Quality)*

The highest overall priority ranking values is the best alternative based on AHP analysis.

Chapter 4. Result and Analysis

This chapter will identify which supplier will be the most potential supplier, analyze what is / are the criteria which affect supplier selection decision making and which supplier should be selected if some criteria change.

4.1 Result and Analysis Approach

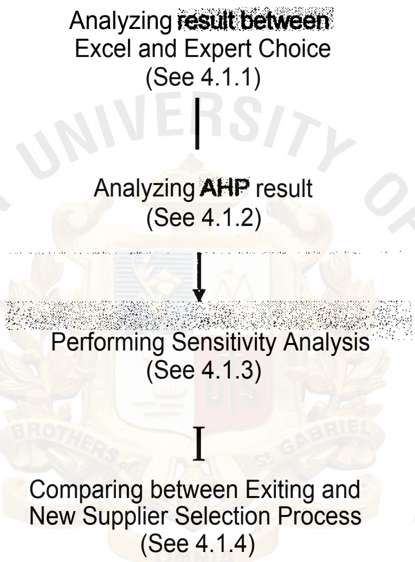

Figure 4.1: Result and Analysis Procedure

4.1.1 Analyzing result between Excel and Expert Choice

The previous chapter 3 demonstrates how Excel can be used for the AHP calculation. AHP software which is called "Expert Choice (EC)" can be used to solve the issue and can lead to a decision in a few hours. The result between Excel and EC show slightly different results as an example of overall priority of each supplier and criteria priority is show in Table 4.1 and Table 4.2 respectively.

Table 4.1: Summary of the results of overall priority for each supplier

Overall Priority	Supplier A	Supplier B	Supplier C
Excel	0.3302	0.2501	41
Expert Choicer	0.326	0.248	[illegible]

4 Slightly different result between Excel and EC

Table 4.2: Summary of the result of criteria priority

Criteria Priority	Competitive price	Short Leadtime	Lang Credit Term	Good Quality_
Excel	0.3754	0.0932	0.0699	16
Expert Choice	0.369	0.089	0.067	4

To verify the results obtained from Excel, Expert Choice is used to calculate the exact solution. The priorities computed by Expert Choice (EC) differ slightly from those obtained in Excel at the second decimal point. The reason is that the Expert Choice has the computation of eigenvalue in the synthesization procedure which is not available in Excel. The computation of eigenvalue increases the accuracy (Booz) so it can be concluded that Expert Choice gives a more precise result than Excel. This chapter will therefore illustrate the application of the AHP using Expert Choice software, presenting the findings and insights, and performing sensitivity analysis. However, both of them suggest the same answer, that supplier C is voted as the most appropriate supplier and is followed by supplier A and B with scores of 0.426, 0.326, and 0.248 respectively based on good quality criteria as the most important criteria for the cleanroom latex glove product with a score of 0.475.

4.1.2 Analyzing AHP results

Moreover, according to Tables 4.3, 4.4, 4.5 and 4.6, the details of the result of supplier selection under each criterion, are shown:.

Table 4.3: Summary the result of supplier selection under competitive price

Competitive Price	Supplier A	Supplier B	Supplier G
Excel	0.5889	0.1593	0.2518
Expert Choice	0.594	0.157	0.249

Table 4.4: Summary the result of supplier selection under short lead-time criterion

Short Leadtime	Supplier A	Supplier B	Supplier C
Excel	0.0903		0.3537
Expert Choice	0.089	0.559	0.352

Table 4.5: Summary the result of supplier selection under long credit term criterion

Long Credit Term	Supplier A	Supplier B	Supplier C
Excel	0_6334	0.1061	0.2605
Expert Choice	Q.637	0.105	0.258

Table 4.6: Summary the result of supplier selection under good quality criterion

Good Quality	Supplier A	Supplier B	Supplier C
Excel	0.1468	0.2899	0.5634
Expert Choice	0.119	0.281	0.6

From the result of supplier selection under each criterion, since all suppliers meet the quality criteria, it can imply that the company should begin and develop cooperation with the new supplier C as the key supplier or supply base, which is superior in terms of quality In addition, by purchasing from supplier C, the company not only gains a better product quality, but also there will be a better prospect of a long term partnership, which is the trend of the current management practices to enable a firm's coordination with its supplier that results in a potentially successful trading industry and keeps customers satisfied or coming back. Although Supplier C outranks the others, it is still inferior in the area of high price, long lead-time and short credit term. Some or all the inferior points can be improved. This can be done by negotiation, coordinating or integrating a number of product-related activities by building trust, sharing information on things like capacity changes; new marketing strategies; purchasing plans; delivery date and anything else impacting the company's purchasing. Improvement can also include supplier C's production and distribution plans in order to reduce costs and delivery cycle time, leading to improvements in the terms and conditions of the purchase.

4.1.3 Sensitivity Analysis

The next step in this study is to demonstrate a what-if analysis. The Expert Choice result will be used to perform sensitivity analysis. Figure 4.2, shows that good quality is more important than competitive price by around 10.6% (resulting from good quality score: 0.475 minus competitive price score: 0.369 = 0.106).

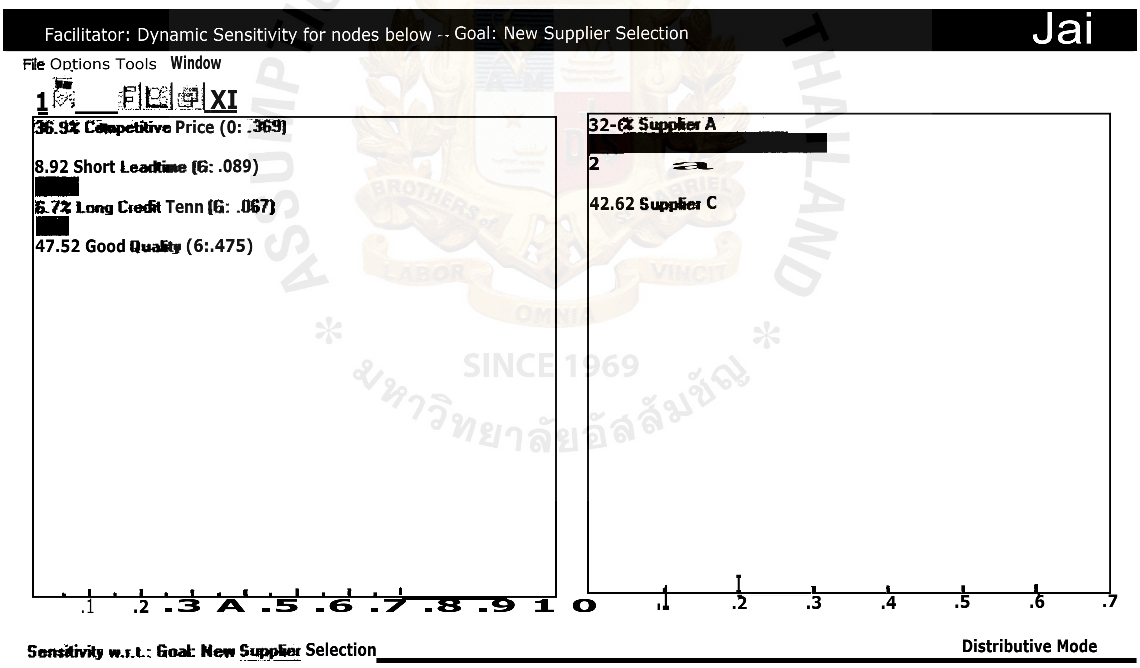

Figure 4.2: Dynamic Sensitivity of overall priority when focusing only on good quality criteria

To prove the impact on supplier alternatives by dragging the competitive price criteria (as the second important criteria) back and forth in figure 4.2, the priorities of the alternative will instantly change in the left column, which is exhibited in Figure 4.3.

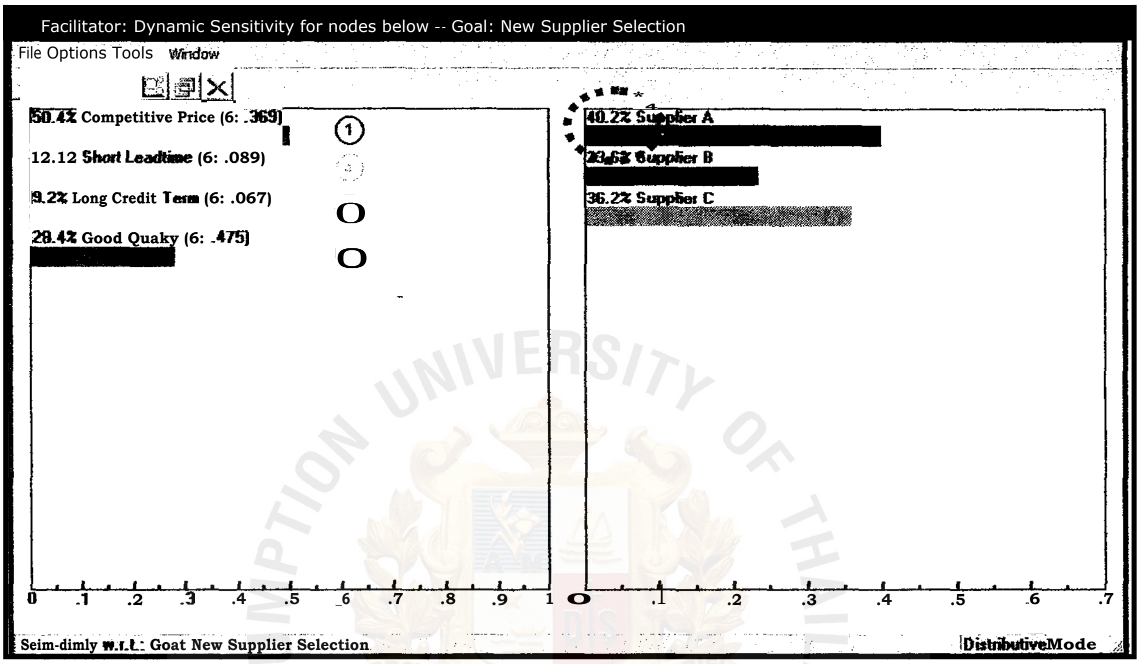

Figure 4.3: Dynamic Sensitivity of overall priority after changing the focus on competitive price criteria

After changing the criteria from good quality to competitive price criteria, the result absolutely changes, and supplier A (with a score of 0.402) appears superior to supplier C (with a score of 0.362). The sensitivity analysis result indicates that the company might consider supplier A as the second supplier who offers the most competitive price and long credit term at an acceptable quality. In case supplier C is faced with material shortage, stock-outs, full production capacity or even unpredictable circumstance such as the political situation, the company might purchase from supplier A in order to increase customer satisfaction, and improve service levels through product availability at the cheaper price and acceptable quality. Supplier A also has an opportunity to be developed as the first supplier or to replace supplier C, but the company needs to work closely with supplier A to assist in enhancing product quality performance by tracking supplier performance over time to examine a supplier's lower quality problem and then providing suggestions for improvement. Another way could be that the, company might fully work with a supplier from sourcing raw material, the production process until the quality assurance process, to analyze the root causes of the lower quality, preparing a corrective action plan, and verify the outcome of the plan as part of the supplier's continuous improvement effort.

4.1.4 Comparing the Existing Supplier Selection Process and New Supplier Selection Process by AHP

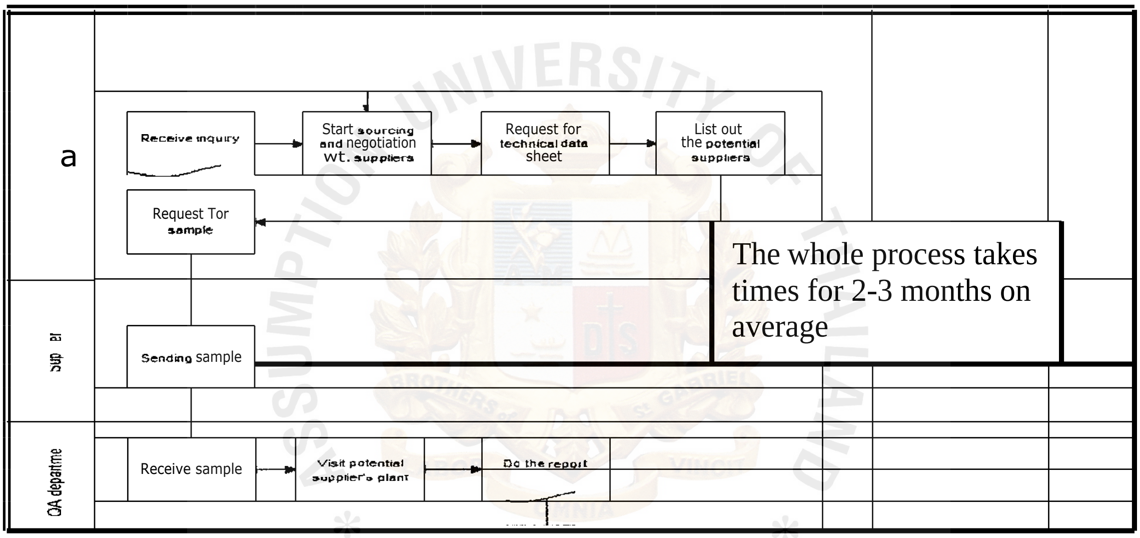

Figure 4.4: As-is business process for core products

Figure 4.4 illustrates each department's current work and makes the decision from their perspective without any collaboration between departments to reach the same objective which is finding the new supplier. For example, the Global Sourcing Department (GSO) lists out the potential suppliers based on only the competitive price, while the Quality Assurance Department (QA) reviews those potential suppliers from technical data sheets and overlooks other criteria, so there might be individual biases taking place which could negatively impact the effectiveness of the decision making and lead to poor supplier selection . Moreover, the existing decision making shows a lack of responsiveness because the current decision making process is not simultaneous, but sequential. For example, if GSO has not yet finished listing the potential suppliers, QA could not start in evaluating those potential suppliers, so it is very time-consuming which is around 2-3 months on average to close a project or inquiry.

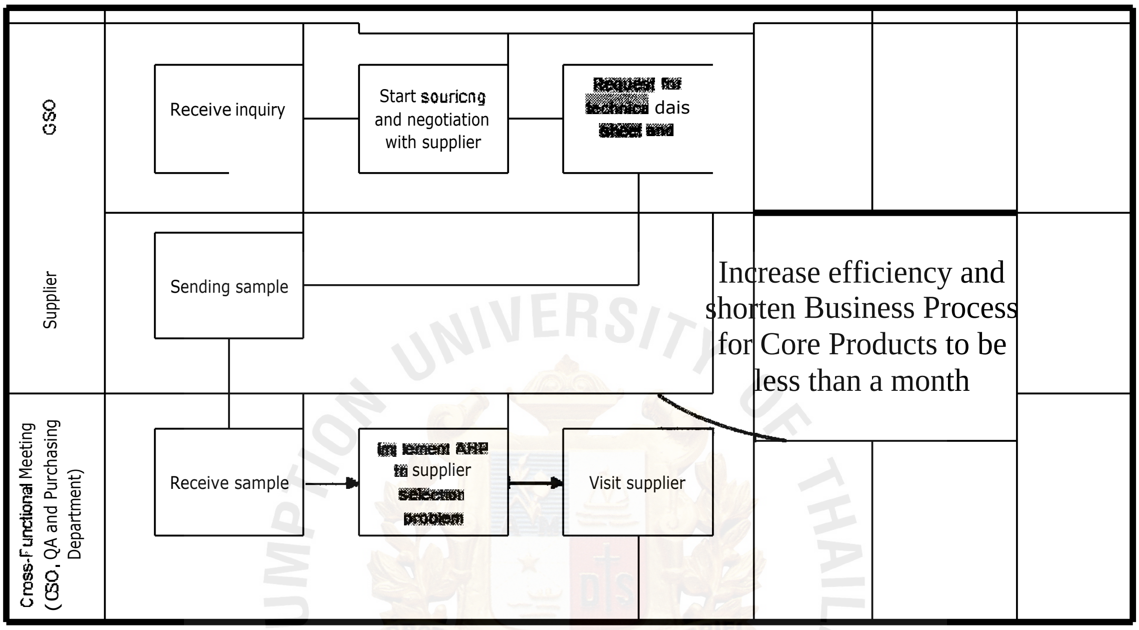

Figure 4.5: To- be business process for core product improvement

By a full implementation, AHP encourage participation and brainstorming from a cross-functional team who can assist each other in sharpening their judgments to provide the judgments in their area of expertise, thus complementing each other and reaching a consensus. AHP not only enables the company to improve efficiency and effectiveness, and standardize the whole process of supplier selection, but also leads to significant time saving of the whole business process, which is obviously reduced from 2 – 3 months on an average to be less than a month (approximately), it does this by grouping and cutting some functions out of the process such as listing the potential suppliers and doing the report function that enables the company to make a better decision in a systematic way, as shown in Figure 5.2. It could also increase flexibility through reduced supplier selection process lead-time. Moreover, AHP is flexible to re-run the result when there is a change in criteria, and can also advise the reserve supplier whom the company should begin the relationship to supply the product and to hedge against some unexpected circumstance that makes the first supplier unable to provide the products. Moreover, the company can apply MP to other aspects of the business such as identifying third party logistic providers or other type of core products, in an efficient way.

Finally, by running both Excel and Expert Choice, it was found that Expert Choice gives a simpler and more accurate way to be used for the supplier selection problem, performs sensitivity analysis and provides decision results faster. Excel calculations could introduce human error, be time consuming in performing sensitivity analysis and in recalculating to reach consistency. Increased accuracy can be found in the Excel computation by discussing the findings and include the relevant criterion which is considered as a direct factor that mostly affect with result of a new supplier selection problem in the calculation. So it can be concluded that Excel could be used when Exert Choice is unavailable because Excel gives similar answers to Expert Choice.

Chapter 5. Conclusion and Recommendation

5.1 Conclusion

When the company is confronted with choosing the best supplier to provide the product, the decision can often quite complex, but it is one of the most important processes of the purchasing function because it brings significant benefits to the company. This research presented the objective of this case study, which are divided into 3 sections: to study decision making tools, to apply AHP to the supplier selection problem, to identify new supplier selection criteria and to find a new supplier who has high dependability and low cost.

The first section was to study 3 decision-making tools, AHP, MAUT and SMART, to be selected as the decision making tool for the supplier selection problem by comparing the characteristics, limitations, and also pros and cons of each decision tool. AHP is proposed to select the best potential supplier for the trading company. AHP is a simple and flexible decision-making process to help the company set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered which rely on the supposition that people are more capable of making relative judgments than absolute direct rating Moreover, ARP uses a scale of 1-9 which is easy to understand and identify and also provides the computation of a consistency ratio to check for the consistency with the answers, which is unavailable in both MAUT and SMART.

Second, by applying AHP to the supplier selection problem, group decision making and spreadsheet Microsoft Excel is developed for calculating the AHP model. After that, the relevant criterion (competitive price, short lead-time, long credit term and good quality) are obtained by cross-functional discussion. Then they are decomposed into a graphical hierarchy to represent goal, criteria, sub-criteria and alternatives. Once the hierarchy has been constructed, the prioritization should be developed to determine the relative importance of the element in each level. Prioritization involves eliciting judgments in response to questions about the dominance of one elements over another with respect to each criteria based on a scale of 1-9. Finally all comparisons are synthesized to rank the supplier alternatives. The output of AHP is a prioritized ranking of the supplier alternatives based on the overall preferences expressed by the company.

Third, Tables 4.1 and 4.2 advise the same answer, that supplier C should be developed as the first supplier or supply base and to establish a long term partnership for supplying cleanroom latex gloves. This is because supplier C is voted higher than supplier A and B based on good quality criteria which is considered as the most important criteria, followed by competitive price, short lead-time and long credit term in the problem of finding a new supplier.

5.2 Limitations

1. Only one core product was studied which is cleanroom latex glove class 100 for the semiconductor industry.
2. The Company rely on a single supplier (one core product, one supplier)
3. Criterion and sub-criterion and voting score are performed by interviewing and discussion between QA, Global Sourcing and Purchasing Departments.
4. Using "round" function with 4 decimal points in AHP computation by Excel.
5. Excel does not contain the computation of synthesization which involves the computation of eigenvalue tables
6. There is no risk or uncertainty involved in this case study.

53 Recommendations

Referring to the limitations, this case study does not include the computation of eigenvalue in Excel. Therefore, by adding eigenvalue in the computation, this case study could gain more precision and accuracy when compared to Expert Choice. Therefore the suggestion for future research is to prove that eigenvalue can increase the precision and accuracy of Excel.

Another suggested recommendation for future research is that if there are changes which reflect on direct factors in the future, e.g. adding more sub-criteria such as ESD properties, the decision making result might change: therefore this project topic should be re-studied again in order to confirm this assumption.

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