SUPPLIER EVALUATION AND SELECTION IN THAILAND'S HARD DISK DRIVE INDUSTRY

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ABSTRACT

Thailand is now the largest hard disk drive (HDD) producer in the world. While HDD companies and their suppliers are located in Thailand, some HDD components still have to be imported from other countries. This thesis attempts to investigate the performance of HDD suppliers in Thailand by comparing suppliers located in Thailand with suppliers located elsewhere.

Before evaluating HDD suppliers, it is important to investigate the linkage between HDD manufacturers and their suppliers. Supplier mapping illustrates information about their location and the components that they supply for the HDD industry in Thailand. This study was designed to determine the criteria for analyze the supplier performance of each country by using the analytical hierarchical process method (AHP) and the weighted-point approach.

The upstream mapping of the HDD industry in Thailand pointed out that there is no supplier in Thailand who can support Wafer and Media. Malaysia, Singapore, China, Japan, and the U.S.A. are all important suppliers to HDD makers. The main criteria, weighted from the HDD makers' responses are cost in the highest rank, while flexibility is in the lowest rank. Cost is the most important because HDD makers focus on the cost competitive advantage due to the high volume intensive nature of the HDD industry. Surprisingly, research and development is considered as a quite low priority.

The results from the HDD makers' weighting were used to calculate the score of each country. Singapore has the highest score in the hi-tech component group, the precision component group, the electrical and electronics component group, and the indirect material group, while Thailand is considered to be more competitive with suppliers' bases in the read/write component group and the other component group. Singapore has good performance in both cost and quality, but the variety and number of suppliers in Singapore is fewer than in Thailand. Singapore is now shifting itself away from its manufacturing base to become a research and development center. Thai suppliers are facing difficulty in entry into the HDD industry. They need to have a large amount of capacity and ability to respond to the HDD makers' needs. The HDD makers in Thailand suggested that there should be a consortium that can represent Thai suppliers. For now, the most lucrative opportunity for Thai suppliers is in indirect materials because the volume of this type of material is not as large as other groups and requires less technology.

KEY WORDS: SUPPLIER EVALUATION / AHP METHOD / HARD DISK DRIVE INDUSTRY

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การประเมินและคัดเลือกผู้ขายปัจจัยการผลิตสำหรับอุตสาหกรรมฮาร์ดดิสก์ไดร์ฟในประเทศไทย
SUPPLIER EVALUATION AND SELECTION IN THAILAND'S HARD DISK DRIVE INDUSTRY

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บทคัดย่อ

ปัจจุบันประเทศไทยเป็นฐานการผลิตฮาร์ดดิกส์ไดร์ฟอันดับหนึ่งของโลก ทำให้มีอุตสาหกรรมต้นน้ำมาตั้งอยู่ในประเทศไทยเป็นจำนวนมาก แต่ทั้งนี้บริษัทประกอบฮาร์ดดิกส์ไดร์ฟก็ยังต้องอาศัยการนำเข้าชิ้นส่วนประกอบจากต่างประเทศอยู่ ดังนั้นวิทยานิพนธ์ฉบับนี้มีจุดประสงค์ที่จะหาเกณฑ์ที่มีความสำคัญต่อการตัดสินใจคัดเลือกผู้ขายปัจจัยการผลิตให้แก่อุตสาหกรรมฮาร์ดดิสก์ไดร์ฟในประเทศไทยและประเมินศักยภาพของผู้ขายปัจจัยการผลิตในแต่ละประเทศ

ทั้งนี้จึงทำการศึกษาแหล่งของอุตสาหกรรมต้นน้ำว่าในแต่ละกลุ่มชิ้นส่วนประกอบอยู่ในประเทศใดบ้าง จากการศึกษาในขั้นนี้พบว่าประเทศไทยยังไม่สามารถป้อนชิ้นส่วนประกอบที่เป็นเวเฟอร์กับมีเดียให้แก่อุตสาหกรรมฮาร์ดดิสก์ไดร์ฟได้ ซึ่งหลังจากการศึกษาแหล่งต้นน้ำแล้ว ก็ได้เอาวิธี analytical hierarchical process method (AHP) และวิธีการถ่วงน้ำหนัก (the weighted-point approach) มาใช้ในการประเมินหาความสำคัญของเกณฑ์และประเมินความสามารถของผู้ขายปัจจัยการผลิตในแต่ละประเทศ ตามลำดับ

ผลจากการศึกษาพบว่าทั้งประเทศไทย มาเลเซีย สิงคโปร์ จีน ญี่ปุ่น และสหรัฐอเมริกาต่างก็เป็นแหล่งต้นน้ำที่สำคัญของอุตสาหกรรมฮาร์ดดิสก์ไดร์ฟ โดยเกณฑ์ที่บริษัทฮาร์ดดิสก์ไดร์ฟในประเทศไทยให้ความสำคัญมากที่สุดในการคัดเลือกผู้ขายปัจจัยการผลิตก็คือราคา ส่วนเกณฑ์ที่ให้ความสำคัญน้อยสุดคือความยืดหยุ่น ทั้งนี้เนื่องจากลักษณะของอุตสาหกรรมฮาร์ดดิกส์ไดร์ฟเป็นการผลิตทีละจำนวนมากและจะแข่งขันกันที่ต้นทุนต่อหน่วย โดยทั้งบริษัทผู้ผลิตฮาร์ดดิกส์ไดร์ฟและผู้ขายปัจจัยการผลิตต่างก็มองการวิจัยและพัฒนาในลำดับความสำคัญที่ค่อนข้างน้อย น้ำหนักที่ได้ในการคำนวณด้วย AHP ก็นำมาทำการประเมินด้วยการคำนวณคะแนนของผู้ขายปัจจัยการผลิตในแต่ละประเทศ ผลที่ได้คือประเทศสิงคโปร์และประเทศไทยเป็นประเทศที่ได้คะแนนสูงสุดในการเป็นต้นน้ำของกลุ่มชิ้นส่วนประกอบในหลากหลายกลุ่ม โดยบริษัทที่ตั้งอยู่ในประเทศไทยส่วนมากเป็นบริษัทต่างชาติ ในขณะที่ผู้ขายปัจจัยการผลิตที่เป็นของบริษัทไทยต้องอาศัยการสนับสนุนจากรัฐบาลในการที่จะเข้าไปอยู่ในอุตสาหกรรรมฮาร์ดดิสก์ได้ อีกทั้งยังต้องพัฒนาในด้านทุนทางปัญญา (Intellectual capital) เพื่อที่จะรักษาความสามารถทางการแข่งขันในระยะยาว

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CHAPTER I
INTRODUCTION

This is the chapter that will give overall details of the background of this thesis and an overview of general principles and methodology that will be used in the thesis. In addition, this introduction chapter will provide the objectives, the scope of work, and expected results from this study is also included.

1.1 Background and Problems statement

In a fully borderless world, globalization of production is spreading all over the world, especially in developing country. Thailand is one of the attractive locations where multinational enterprises (MNEs) are rapidly rising. A significant increase in flow direct investment (FDI) that caused by MNEs has played a major driver of Thailand's economic growth. The manufacturing sector share in net FDI flows increased from an average of 31.4 percent during 1980-1986 to 53 percent in 2007 (Bank of Thailand, 2009). Within the manufacturing sector, the electronics has consistently been a large recipient of FDI amounting to 17.6 percent in 2001.

As the electronics industry is moving toward shifting manufacturing facilities to Thailand, currently Thailand is the world leader in the production of hard disk drive (HDD). Hard disk drive is the storage device that originally use in computer. Because the HDD usage has been expanded into vehicles and consumer appliances such as cell phones, camcorders, refrigerators and video game consoles, etc., the growth of this industry is still continuing. Moreover, the total export value of HDDs and components is approximately 500 billion baht putting it on par with Thai automotive exports (Board of investment, 2007). Table 1.1 shows that automatic data processing machines and accessories product is the highest exports in 2007 which HDD is categorized in this product group. As a result from an existence of the four world's largest HDD companies (i.e. Seagate, Western digital, Hitachi global storage

technology and Toshiba) in Thailand, many related industries also decided to choose Thailand as the plant locations either, particularly upstream productions. In a contrast, most of downstream companies that involve with computer, electrical, and electronic industries base their production in the country where has a large volume market (e.g. China, USA). The linkage within HDD industry in Thailand is likely to present the relationship between HDD maker and its supplier. Figure 1.1 shows the increasing number of enterprises in HDD industry that located in Thailand.

Table 1.1 The top 10 exports of Thailand in 2007

	Product	**Proportion% (y-o-y)**	**Value (US$ bn)**
1.	Automatic data processing machines and accessories	11.35	17.31
2.	Motor cars, parts and accessories	7.90	12.04
3.	Electronic and integrated circuits	5.28	8.05
4.	Rubber	3.70	5.64
5.	Precious stones and jewelry	3.53	5.38
6.	Polymers of ethylene, propylene, etc.	3.42	5.21
7.	Iron and steel and their products	3.01	4.60
8.	Machinery and parts thereof	2.86	4.37
9.	Refines fuels	2.69	4.10
10.	Chemical products	2.57	3.92

Source: Board of investment (2008)

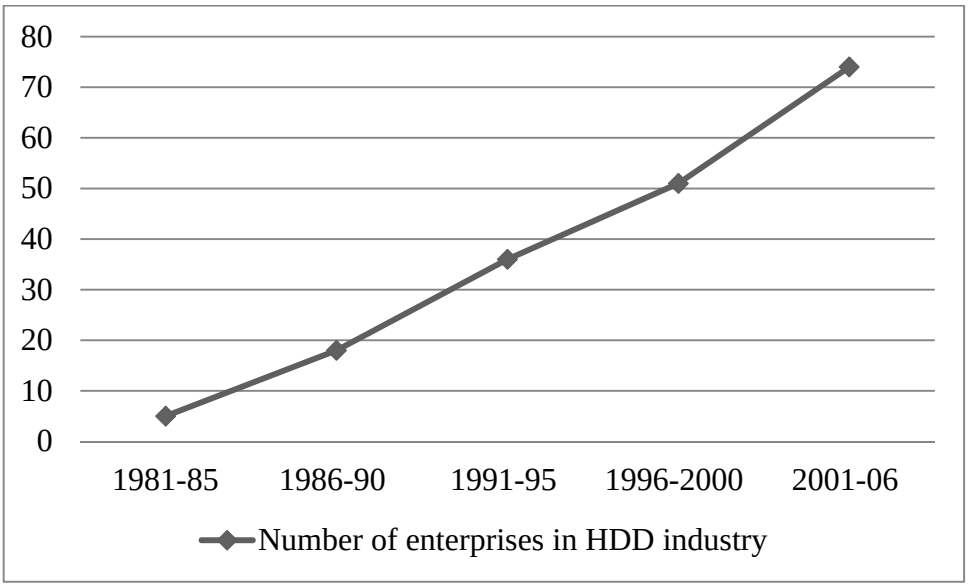

Figure 1.1
The number of enterprises in HDD industry from 1981-2006
Source: Kohpaiboon (2008)

Most of HDD suppliers support material not only for HDD production but also related with other industries (e.g. automotive industry, electronic industry, electrical industry, medical industry, etc.). Not only those industries connected with HDD industry but there are also supporting industry such as material supporter, financial industry, service provider, and related institute, etc. This is a great opportunity for Thailand to create higher economic value from the linkage in supply chain within country. Despite being the bases of the four key global HDD manufacturers, suppliers in Thailand have not been developing as much as they should be. Currently, only 40% of HDD parts are purchased from Thailand. (Nectec, 2007, cited in Piewthongngam and Vijitnopparat, 2009). Thailand has a capability to produce precision parts made from metal, plastic. But it is not clear which HDD parts are supported from suppliers in Thailand and which HDD parts are supported from elsewhere. Thus, the thesis will explore in this issue to understand the HDD upstream. The presence of strong upstream supporting industries is necessary to enhance the competitiveness in HDD industry. The key question here is “how to sustain and expand HDD upstream in Thailand?”

To fulfill this goal, this thesis attempts to investigate the performance of HDD suppliers in Thailand by comparing suppliers that located in Thailand with suppliers that located elsewhere. Before evaluate HDD suppliers, it is important to investigate the linkage between HDD manufacturers and their suppliers. Suppliers mapping will illustrate the information of their location and the components that they supply for HDD industry in Thailand. In order to map suppliers to the components, this thesis will collect data from the procurement department of HDD manufacturers and from literature reviewing. The next step is to define the criteria that affect to the selection of HDD suppliers and evaluate HDD suppliers in each nation. Because the supplier evaluation needs many different points of view and involved with several criteria, this thesis will use indirect process and product evaluation approach. Thus, the questionnaires and face-to-face interviews with HDD manufacturers and their suppliers will be employed to collect the data. After that, the study will determine the criteria by using the analytical hierarchical process method and analyze the supplier performance of each country by using the weighted-point approach.

As mentioned above, the aim of this thesis is try to develop the linkage between HDD manufacturers and their suppliers. As a result, in this thesis, the significant criteria of HDD's supplier selection will be identified from both HDD makers and their suppliers' point of view. In addition, supplier evaluation is approached to assess the performance of suppliers in Thailand and elsewhere.

1.2 Objectives

1.2.1 To generate the suppliers map of Thailand's hard disk drive industry.

1.2.2 To recognize the important criteria that affect on supplier selection in Thailand's hard disk drive industry.

1.2.3 To evaluate the hard disk drive suppliers between Thailand and other countries.

1.3 Scope of Work

1.3.1 The upstream industries that this study will be focused on are the hard disk drive direct and indirect parts manufacturing.

1.3.2 The importance of each supplier selection criterion will be separately summarized from the aspects of hard disk drive makers and their suppliers located in Thailand.

1.3.2 The study on supplier evaluation will be focused on comparing the suppliers between Thailand and elsewhere in each group of parts by employ the questionnaires and interviews with hard disk makers in Thailand only.

CHAPTER II
LITERATURE REVIEW

This chapter will describe the theoretical framework and a review of literature that are related to this thesis. There are five major sections in this chapter. First section reveals the characteristics of supplier selection problem. Second section shows that how to collect data for supplier evaluation. The third section provides the various performance criteria that are considered while evaluating and selecting the suppliers. The next section provides an overview of existing supplier evaluation methods. The existing literature about supplier evaluation and selection and their approaches will be reviewed in the last section.

2.1 Supplier Selection Problem Characteristics

In this section, the various characteristics of the supplier selection problem are summarized. A solution must be able to consider these characteristics.

2.1.1 Strategic decision

Selecting the most appropriate suppliers is one of the most important responsibilities of the purchasing department. Both the difficulty and the importance of supplier selection are being raised by recent business trends. These conditions include the increase in worth of purchased components compared by the total revenue for manufacturing firms, an expansion of global sourcing, and the increased rate of technological change. Thus, the decisions related to the supplier selection problem determine the long-term viability of the firm or the company (Thompson, 1990). These decisions must be in conformity with the strategy that the company decided to achieve its goals.

2.1.2 Multi-actors

The supplier selection decision requires the intervention of the various services of the company (Dyer and Forman, 1992). Definitely, the decisions will be affected on several departments of the firm such as production, transport, storage, purchase, etc. Furthermore, the common evaluation criteria of the problem are subjective. For this reason, it must be decided under the agreement of a group of decision makers with different point of view. A discussion let them know better the interests of the various services of the company.

2.1.3 Multi-criteria

Generally, several criteria must be considered in the supplier selection problem. Moreover, these criteria are frequently conflicting such as the cost of the product and the quality of it, etc. Thus, the best way to select appropriate supplier is selecting the supplier who establishes a better compromise between the criteria.

2.1.4 Subjective criteria

In practical, the majority decision criteria are subjective. The subjective criteria are criteria which we cannot signify in a quantity way. For instance, the decision “desire of business”, “attitude”, and “ethical standards”, expressed by a supplier, are the subjective criteria.

2.1.5 Objective criteria

In addition to subjective criteria, the objective criteria are to be considered. The objective criteria are the criteria which we can represent in a quantitative dimension such as cost etc. In fact, it is not always easy to obtain them. For example, the criterion “price of the product” is an easy criterion to measure, it can be acquired directly. While the “quality” of products and services are difficult criterion because we cannot measure it directly. We should take into account the cost of rejection of the product, the cost of the services after sale, etc.

2.2 Evaluation Information Collection

The evaluation information collection procedures were identified by Purdy and Safayeni (2000). There are four different information collection approaches for supplier evaluation: indirect process evaluation, direct process evaluation, indirect product evaluation, and direct product evaluation. The information that collected from these approaches will be employed in each criterion of supplier evaluation method. This section will examine these approaches included their key advantages and disadvantages.

2.2.1 Indirect Process Evaluation

Indirect process evaluation is based on summarized reports, charts, and data regarding the supplier's production and managerial systems (e.g. capacity, capability, operating controls) supplied by either the supplier or a third-party organization. There are some advantages to using this procedure. It provides the buyer with extensive documentation of processes. Also, it fits the structure and managerial operation of many large, bureaucratic customer organizations. On the other hand, the weaknesses are that it increases potential for receiving distorted information and increases cost of information collection and processing.

2.2.2 Direct Process Evaluation

Direct process evaluation involves direct examination of a supplier's manufacturing and managerial processes by the buyer. The major strength of this strategy is that the buyer physically views the processes. Moreover, it provides a holistic view of the supplier's organization. A third advantage is the opportunity for active supplier development. One main limitation of the direct process evaluation approach is that, generally, there are some physical limitations of direct observation. A second limitation is that most evaluation visits are a snapshot view of the supplier. A third limitation is related to symptom bias. Finally, the direct process evaluation approach requires increased technical and engineering expertise.

2.2.3 Indirect Product Evaluation

Indirect product evaluation is based on summary reports, charts, and data on product performance (e.g. cost, quality, delivery) usually provided to the buyer by the supplier. Another source of indirect product evaluation comes from the market in the form of consumer complaints. The main advantage to this approach is that the buyer has summarized product information from the supplier. The second is that the buyer's expense for product testing minimized. A third advantage is that there is an ability to rely on supplier reputation. There are some disadvantages to using this procedure. That is, the suppliers may have a bias to generate positive information about their products. Moreover, thus, whenever the suppliers undertake product tests, the buyers need to have the appropriate technical and engineering expertise for decoding, evaluating, and determining required actions on the information provided to them.

2.2.4 Direct Product Evaluation

Direct product evaluation is based on the buyer conducting a direct examination of a supplier's final product or subassembly. There are several advantages to using this approach. First, the information is more reliable because the buyer carries out the testing. Second, the buyer will get learning on their part. As a result of gaining new information, the buyer may recognize implications for product design improvements. Third, it is an additional level of product quality control of buyer's company. In contrast, there are some limitations to doing direct product evaluation. First, the buyer needs to be increased technical and engineering expertise. Moreover, the time and costs for correction increase with the use of this approach.

2.3 Criteria in Supplier Selection

Supplier selection decisions are complicated by the fact that various criteria must be considered in decision making process. The analysis of criteria for measuring and selection the performance of suppliers has been the focus of many scientists and researchers since the 1960's.

An interesting work, which is a reference for the majority of papers dealing with supplier selection problem, was carried out by Dickson (Dickson, 1966, cited in Weber, Current, and Benton, 1991). His study surveyed buyers in order to identify factors they considered in awarding contracts to suppliers. Out of the 23 criteria considered, at that time (1966), the most significant criteria were the quality, on-time delivery, the performance history, and the warranty policy.

Another research was presented by Weber et al. (1991). The paper showed a classification of all the articles published since 1966 according to the treated criteria. Based on 74 papers, the authors summarized that price was the most often treated in the literature, followed by delivery and quality.

The 23 criteria presented by Dickson still cover the majority of the criteria presented in the literature until today. On the other hand, the evolution of the industrial environment modified the relative importance of these criteria. After Weber's work, most researchers focused on supplier selection criteria in either specific industries or specific countries. Table 2.1 summarizes some of these criteria which have emerged in literature since 1966.

Table 2.1 Various evaluation criteria that have appeared in literature

Selection Criteria	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Net price	●	●		●		●	●	●	●	●	●	●
Quality	●	●	●	●	●	●	●	●	●	●	●	●
Delivery	●	●	●	●	●	●	●	●	●	●	●	●
Production Facilities and Capacity	●	●		●		●		●	●	●		
Geographical Location	●					●		●	●			●
Technical Capability	●			●		●	●	●		●		
Management and Organization	●	●				●	●					
Reputation and Position in Industry	●					●	●	●				
Financial Position	●		●			●	●	●			●	
Performance History	●							●		●		●
Repair Service	●						●					
Attitude	●	●										
Packaging Ability	●	●			●							
Operating Controls	●							●				
Training Aids	●									●		
Procedural Compliance	●											
Labor Relations Record	●											
Communication System	●	●	●		●	●	●		●			
Reciprocal Arrangements	●					●						
Impression	●								●			
Desire for Business	●						●					
Amount of Past Business	●											●
Warranties & Claims Policies	●						●		●			
Technical Support		●					●		●	●		
Response to customer request		●		●	●	●				●	●	
E-commerce Capability									●			
JIT Capability						●						
Ease-of-Use		●										
Maintainability		●										
Environmental friendly products										●		
Ethical standards						●						●
Continuous improvement			●			●			●	●		
R&D							●			●		●

A, Weber et al. (1991); B, Dröge et al. (1991); C, Purdy et al. (1994); D, Handfield (1994); E, Schmitz and Platts (2003); F, Kannan and Tan (2003); G, Shahadat (2003); H, Barla (2003); I, Teng and Jaramillo (2005); J, Phusavat and Kanchana (2007); K, Ting and Cho (2008); L, Oke et al. (2009).

2.4 Supplier Evaluation Methods

Supplier evaluation methods are the models that commonly use in supplier selection process. In order to select the most qualified supplier, it is necessary to employ the appropriate method (or a combination of difference methods). Each method has advantages and disadvantages, thus understanding supplier evaluation methods are important. In the past twenty years, there are many literature related in supplier selection and evaluation models. Most of methods have to set supplier performance criteria which discussed in previous section.

2.4.1 Linear weighting models

Some researchers evaluate supplier by using linear weighting models. This type of models measures suppliers by rating their performance in many criteria and calculating into single score. The methods that are categorized as linear weighting models are the categorical method, the weighted-point method and the analytical hierarchical process. This section will examine these methods' structure and formulation included their strengths and weaknesses.

Categorical method is a basic method for supplier evaluation. The process involved in this method is simple, intuitive, and has restricted applications (Youssef, Zairi, and Mohanty, 1996). According to this approach, it separates the suppliers' performance into different categories such as cost, quality, on-time delivery, etc. The buyers who are people in the purchasing, production, quality, and sales departments all express their opinions about the suppliers' performance on these criteria. They classify either a satisfactory, unsatisfactory, or neutral rating for each of performance attributes for all competing suppliers. The method can be exemplified by matrix below (Table 2.2).

Table 2.2 Evaluating criteria for categorical method

Supplier	Performance criteria			Total
	Cost	Quality	Delivery	
1	-	-	0	- -
2	+	-	+	+
3	+	+	+	+ + +
4	0	0	0	0
5	0	+	+	+ +
N	-	+	-	-

Key:

+ = Satisfactory

- = Unsatisfactory

0 = Neutral

Based on this approach, supplier which has more satisfactory rating (+) is preferred to supplier with less rating. The primary advantage of the categorical method is that it helps assemble the evaluation process in a logical way. It is very simple, easiest and can be implemented with least cost. However, it requires very experienced buyers with good memory and individual verdict. The major negative aspect of this method is that the attributes are equally important. As a result, it rarely leads to supplier performance improvement. Otherwise, the method can be more useful if weights are assigned to each identified attribute (Youssef et al., 1996). The categorical method which modified with weights assignment represents the basis for the weight-point method discussed later.

The weight-point method is another most basic of all supplier analysis methods (Teng and Jaramillo, 2005). It considers criteria that are weighted by the buyer. The weight for each criterion is then multiplied by the performance score that assigned by the buyer. Finally, these are totaled to define a final rating for each supplier (Timmerman, 1986). Normally, the weight-point method is formulated as follows:

$$S_j = \sum_{i=1}^{n} a_i b_{ij}$$

Where:

S_j = Summarized score signifying the total performance anticipated from supplier (j).

a_i = Importance weight attached to evaluative criterion (i).

b_{ij} = Performance rating on evaluative criterion (i) for supplier (j).

n = Number of evaluative criteria.

In this model, the supplier with the highest score is represented as the best performance (Lee, Yen, and Tsai, 2008). Typically the weight-point method is proposed to employ quantitative measurement. The advantages of this approach contain that the firm can be adapted to virtually any type of purchase decision by define appropriate evaluation factors and assign them weights according to the buyer's requirements (Youssef et al., 1996).. This method is more costly than the categorical method but tends to be more objective (Tahriri, Odman, Ali, and Yusuff, 2008). The weight-point method is by far the most commonly used technique (Thomson, 1991, cited in Lee et al., 2008). It is popular due to its simplicity, flexible, effectiveness, and easy to implement. The mathematics underlying weighted-point method is simple but it is fairy efficient in optimal decision making. Nevertheless, weighted-point method also has some limitations. One major drawback of this method is that it is not easy to effectively take qualitative evaluation criteria into consideration.

The key for successful application of the weight-point method includes sufficient estimation of weights in performance criteria and a fine understanding of common performance levels in the industry. While using this method, the input for estimating the weights should come from the associates of cross functional teams, not just from the purchasing department (Teng and Jaramillo, 2005). The sample application of weight-point method is Cormican and Cunningham (2007).

A review of the supplier selection literature shows that the analytical hierarchical process (AHP) is one of the most commonly applied methods in practice. The AHP method was originally developed by Thomas Saaty in 1971 (Saaty, 1980, cited in Ting and Cho, 2008). It is an ideal decision-making method for ranking

alternatives when multiple criteria and sub-criteria are presented in the decision-making process (Tahriri et al., 2008). It allows the decision maker to structure complex problems in the form of a hierarchy. AHP is a simple and robust method that considers hierarchical relationships among factors (Teng and Jaramillo, 2005). This approach incorporates qualitative and quantitative criteria (Tahriri et al., 2008).

AHP is frequently considered as a supplier selection method because it allows decision maker to rank suppliers based on the relative importance of the criteria and the suitability of the suppliers (Saaty, 1980, cited in Tahriri et al., 2008). Normally, the hierarchy has at least three levels: the goal, the criteria, and the alternatives. For the supplier selection problem, the goal is to select the overall supplier. The criteria can be price, quality, delivery, flexibility, reliability, etc. The alternatives are the different supplied by the suppliers. The problem hierarchy lends itself to an analysis based on the impact of a given level on the next higher level.

The AHP method, as applied to the supplier selection problem, consists of the following five steps (Nydick and Hill, 1992, cited in Tahriri et al., 2008):

1. Specify the set of criteria for evaluating the supplier's proposals.
2. Obtain the pair-wise comparisons of the relative importance of the criteria in achieving the goal, and compute the priorities or weights of the criteria based on this information.
3. Obtain measures that describe the extent to which each supplier achieves the criteria.
4. Using the information in step 3, obtain the pair-wise comparisons of the relative importance of the suppliers with respect to the criteria, and compute the corresponding priorities.
5. Using the results of steps 2 and 4, compute the priorities of each supplier in achieving the goal of the hierarchy.

The use of the AHP method offers a number of benefits. The strength of this approach lies in its ability to structure a complex, multi person, multi attribute, and multi period problem hierarchically (Saaty, 1980, cited in Tahriri et al., 2008). AHP avoids the main drawback of the traditional linear weighting models, which assign weights and scores arbitrarily. Moreover, it can make trade-off between the quantitative and qualitative criteria. One important advantage is its simplicity (Liu and

Hai, 2005, cited in Tahriri et al., 2008). Moreover, it provides the buyer with an overview of criteria, their function at the lower levels, and goals as at the higher level (Tahriri et al., 2008). Thus, the buyer is able to get a good picture of the supplier's performance. Nonetheless, AHP also has some weaknesses. One of these is that if more than one person is working on this method, different opinions about the weights of each criterion can complicate matters. AHP also requires information based on experience, knowledge, and judgment which are subjective for each decision maker (Tahriri et al., 2008). The some applications of AHP are Rangone (1996), Teng and Jaramillo (2005), Phusavat and Kanchana (2007), and Ting and Cho (2008).

2.4.2 Total cost models

Another set of methods is classified as total cost approach. The idea of this approach is mainly interested in all costs which are related to the selection of a supplier. This type of model includes the cost ratio method and the total cost of ownership (TCO) method.

The cost ratio method (Timmerman, 1986, cited in Tahriri et al., 2008) is based on cost analysis that considers cost ratios for product quality, delivery, customer service, and price. This method measures the cost of each criterion as a percentage of total purchase for the supplier. The higher rating applied to the supplier comes from the lower ratio of costs to value. The numbers of costs in the evaluation depend on the products engaged. The costs related to quality include the costs of visits to a supplier's plants, sample approval costs, inspection costs of incoming shipments, and the costs associated with defective products such as unusual inspection procedures, reject parts, and manufacturing losses due to defective goods. Quality costs can be determined and documented by the quality control department with the assist of other departments such as receiving and production. The costs associated with delivery contain communications, settlements, and emergency transport costs etc.

Generally, the cost ratio method has several advantages. For example, it reveals the actual total cost of doing business and utilizes quantitative evaluation criteria. The most significant advantage of quality cost is to translate quality problems into the language of top management, who are normally concerned with financial

performance (Wasserman and Lindland (1996), cited in Lee et al., 2008). Because of the flexibility of this approach, any company in any market can adopt it. The disadvantage of the cost ratio method is its complexity and requirement for a developed cost accounting system of the firm. This approach is expensive to implement due to its complexity and requires more time (Tahriri et al., 2008). Furthermore, it is very difficult to estimate hidden costs thus this method is hard to use with first time supplier evaluation and selection. Finally, cost-based supplier evaluation models do not provide useful information for continuous improvement to suppliers (Lee et al., 2008).

Total cost of ownership (Ellram, 1990, cited in Tahriri et al., 2008) is a methodology and philosophy, which looks beyond the price of a purchase to include many other purchase-related costs (Bhutta and Huq, 2002). In addition to the price, other costs also considered including the costs associated with quality shortcomings, a supplier's unreliable delivery service, transport costs, ordering costs, reception costs, and inspection costs. The first step of the total cost of ownership method is defining all the activities related to external purchasing. It should be expressed through the activity analysis. The next step is to define factors which raise the cost of a given activity. The final step is to identify which activities are generated in the purchasing organization by each individual supplier. This approach's advantages are saving the costs and allowing various purchasing policies to be compared with one another. It improves the purchaser's understanding of supplier performance issue and cost structure and provides excellent data for negotiation and improvement (Garfamy, 2009). The disadvantage of this method is its complexity.

2.4.3 Mathematical programming models

Last type of supplier evaluation model is mathematical programming model. The purpose of this type of model is to select several suppliers while optimizing objective function which subject to supplier and buyer constraints. This type consists of two methods: the neural network (NN) and the data envelopment analysis (DEA). This section will examine these methods' principle included their advantages and disadvantages.

The neural network (Wei, 1997) is another method for supplier selection problem. This method system includes two functions. First, the function for measure and evaluate performance of purchasing and store the evaluation in a database to provide data sources to neural network. The second function is the function using neural network to select suppliers. The advantage of this method is that saves money and time of system development. The weakness of this approach is that requires software and the experts on this subject.

Data envelopment analysis is a mathematical programming method for assessing the comparative efficiencies of decision-making units where the presence of multiple inputs and outputs makes comparison difficult. DEA is a non-parametric method that allows efficiency to be measured without having to specify either the form of the production function or the weights for the different inputs and outputs. See Garfamy (2006), Ha and Krishnan (2008) for more details. The disadvantage of this approach is that knowledge of advanced statistical method is required.

2.5 Literature Review

In this section, the literature will be reviewed on supplier evaluation criteria to frame an understanding.

The following researches are the investigation of how the criteria might be applicable in a global context, especially involving with sourcing from developing countries' suppliers. A recent study, Oke, Maltz, and Christiansen (2009) investigated the criteria that the firms in developed countries use to choose suppliers in developing countries including countries in Eastern Europe, Asia, Mexico and Africa. The sourcing purposes as well as the complexities involved in decisions were interested in this study. They centered on how and why companies change their sourcing locations and what makes suppliers of developing countries more or less attractive than another. They adopted a multiple case study method to find out their questions. The sample in this study consisted of three lead manufacturers or buyers, an intermediary supplier,

and two primarily suppliers. These companies were in the industrial machinery, electronic equipment and component, metal and FMCG industries. The authors used semi-structured interview protocol by interviewed multiple personnel in the selected companies. The interview questions were customized based on companies' position in the supply chain. The study resulted that cost remains a primary criterion for choosing amongst suppliers in developing countries because the buying firms need to be competitive. Next, geographic, cultural proximity and political factors were also the important criteria. Finally, quality and reliability were key differentiators for selecting amongst prospective suppliers in a chosen developing country.

Similar to Shahadat (2003), the paper examined the criteria for selecting suppliers of executing agencies in developing countries. Executing agencies are the statutory organizations that procure goods and services by using the aid-funds in order to implement developmental projects in developing countries. The author aimed to identify the supplier choice criteria and the importance of each criterion. He used 7-point Likert scale questionnaires and personal structured interviews with selected respondents from three different organizations: the executing agencies, the supplying organizations, and the aid providing organizations. Data was analyzed using statistical measures such as rankings, percentage of frequency and measures of central tendency. The result revealed that, similar to Oke et al. (2009), the price in procurement of goods and services was the most important criteria because the respondents believed that the funds were insufficient and it was easy to quantify and compare an offer with other competing offers. Next, the "timely delivery" criterion was the second most important factor because this was one of the major causes of delay in the completion of the projects. These two criteria were core requirements with a mean of more than 5 as perceived by the respondents.

The following are the literatures that studied the important supplier evaluation criteria in each region or country. Kannan and Tan (2003) revealed that the managers in both American and Europe firms considered that the subjective criteria such as supplier commitment had a greater impact on firm performance than the objective criteria such as cost and price. They selected to compare supplier selection in USA and Europe because of these two markets' size. In addition, the USA and Europe

represented two of the largest economic markets. The authors developed a survey instrument to gather data to address the research questions. They listed the number of criteria in the questionnaires and used a five-point Likert scale to measure how important of each criterion. They had a total of 527 usable surveys. This study resulted that, unlike Oke et al. (2009), the most important criteria for supplier selection were due date performance, commitment to quality, and capability, moreover, in particular geographic and cultural proximity were the least important items.

Another survey was developed by Hanffield (1994). He investigated an overall assessment of global sourcing practices raised by US managers. The respondents were American managers included those using domestic sources and those using global sources. In conclusion, similar to Kannan and Tan (2003), the number one criterion used to evaluate both domestic and foreign suppliers was quality. Besides, the result showed that US firms using domestic sources were concerned with delivery performance and developing partnerships with local suppliers while placing less emphasis on cost. In international supplier selection, trust played a significant role. The author stated that the managers using an international source need to consider the total costs of doing business, including customs, tariffs, currency fluctuations, transport, inventory, and the cost of unreliable delivery.

Phusavat and Kanchana (2007) attempted to identify competitive priorities derived from manufacturing firms and evaluate their implications on industrial development. This paper employed a survey method that collected data from top executives' opinions of ten firms belonging to the Federation of Thai Industry (FTI). In this study, there were six criteria (i.e. quality, cost, delivery, customer focus, flexibility, and know-how) included in the survey to help reflected competitive priorities. AHP was used to in-depth analyze the surveys' responses. The paper revealed the criteria's relative importance and compared Thailand's result with other countries (i.e. Taiwan, China). Similar to Hanffield (1994), Kannan and Tan (2003), the overall finding showed that the top three competitive priorities were quality, customer-focus, and delivery, respectively. The comparison's results showed that quality was the most important criterion for companies in Thailand and Taiwan. On the other hand, delivery was thought to be the most important criterion for Chinese firms. The authors commented that it was interesting that the know-how or

innovativeness was perceived to be the second most important competitive priority by Taiwanese firms. Unfortunately, this was not the case for the firms in Thailand. As a result, this paper suggested that Thai manufacturers needed to become more innovative to continue quality improvement.

Phusavat and Kanchana (2008a) also examined Thai service providers' perspectives about competitive priorities. They used the similar methods as same as Phusavat and Kanchana (2007). The study revealed that the quality and service provision criteria were recognized as critical competitive priorities for service providers in Thailand. Another paper of the authors, Phusavat and Kanchana (2008b), also compared competitive priorities between manufacturers and service providers and showed the trends of their competitiveness in the future.

Another type of researches, the following papers are the researches that studied about supplier evaluation in specific industry (i.e. automotive industry, textile and apparel industry). Schmitz and Platts (2003) studied in the automotive industry about roles of supplier performance measurement. They employed questionnaires and structured interviews with five major vehicle manufacturers. Interviews were partially transcribed and analyzed using inductive coding techniques in order to identify and categorize concepts for roles of supplier performance measurement and compare them between the five companies. The notice from this study was that four of the five vehicle manufacturers in this study used weighted scoring method for their supplier evaluations. This paper concluded that the major roles of supplier performance measurement as identified in the case studies were to provide information on supply base for logistics management first and to communicate performance dissatisfaction to suppliers second.

Purdy, Astad, and Safayeni (1994) also focused in the automotive supplier as same as Schmitz and Platts (2003). The authors studied the supplier evaluation process of a North American vehicle manufacturer using semi-structured interviews. Unlike Schmitz and Platts (2003), this paper considered the suppliers' perspective, not the buyers, on the evaluation process. Moreover, the research investigated the perceived effectiveness of the supplier evaluation process for automotive supply organizations. One of the concluding comments from this paper was that more than 60

percent of the suppliers interviewed argued that the evaluation did not accurately reflect their effectiveness.

Another interesting global industry was studied. Teng and Jaramillo (2005) developed a model for evaluation and selection of suppliers in US textile and apparel industries. They developed the simple, flexibility, and easy to use evaluation model by using the adoption of AHP and multiple attribute utility theory approach. The model considered five main clusters to reflect the performance: cost, delivery, quality, reliability, and flexibility. Each main cluster has own criteria which appropriate with textile and apparel industries. This paper also presented the case study using this model. The authors commented that the textile/apparel companies can use this model to find capable suppliers in the supply chain. Furthermore, with minor modifications, the model also can help companies in most industries. The issues raised in this paper pointed out that pricing was not one and only criterion in supplier selection and evaluation.

CHAPTER III
METHODOLOGY

In chapter three, the content will give the explanations of methodology. We have to choose the appropriate method that is suitable with this industry. There are five steps of research methodology which will be described in this chapter.

3.1 Research methodology

The research methodology adopted in this thesis consists of the following steps:

3.1.1 Preliminary study

The first step is to investigate through literature that relevant with supplier evaluation and selection. The theory of supplier evaluation and the reviews of those papers will be documented in the literature review chapter. It is also important to study the overview of the HDD components and the location of each supplier in HDD industry. Hence, we can understand the basic information of the relationship between the HDD assembly firm and its supplier to choose the suitable methodology.

We have to identify the components and the countries that we will evaluate. As shown in table 3.1, we divided the components of HDD into six groups. First group is hi-tech component which require high technology manufacturing. The component parts in this group are a high value part. Second group is a physical component that use for transform platter's magnetic field into electrical current and transform electrical current into magnetic field (read/write). Third group is a component from high precision machinery. Electrical and electronics component is a fourth group. The other direct components of HDD that cannot categorize in the above groups are in the fifth group. Last group is an indirect material which is not a direct component but will be used in the HDD industry such as mask, smock, packaging, etc.

Table 3.1 The list of component parts in each group

Part group	Part name
1. Hi-Tech Component	Wafer
	Media
2. Read/Write Component	Slider Fabrication
	HGA
	HSA
3. Precision Component	Suspension
	Pivot
	Actuator
	Top Cover
	Ramp
	Screw
	Connector
	Clamp
	Latch
	Disk Spacer
4. Electrical & Electronic Component	PCBA
	Semiconductor(IC)
	VCM
	FPC
	Motor Base
5. Other Component	Seal
	Filter
	Label
6. Indirect Material	Package
	Clothing
	ESD Related Material
	Equipment / Tooling
	Chemical

The countries that will be focused on are selected from the preliminary study. These countries are the key important location of Thailand's HDD suppliers which are Thailand, Malaysia, Singapore, China, Japan, and United States of America.

3.1.2 Development of Questionnaire

This thesis aims to map the linkage between the HDD manufacturers and their suppliers, identify the important criteria that affect to the supplier selection and the performance of their sources. We have to collect data from HDD manufacturers and secondary data from previous studies for develop the questionnaire. As a result, the completed questionnaires will be used to collect data from HDD manufacturers and their suppliers located in Thailand.

The questionnaires and semi-structured interviews with HDD makers will be employed to collect the data for suppler evaluation analysis. For this study, the questionnaire developed by Teng and Jaramillo (2005) was modified to suit with hard disk drive firms. It is important to note that the selection of this questionnaire was made after reviews with the practitioners in HDD industry and the experts from academic institutions on its comprehensive and applicability. It contains five main criteria: delivery, quality, cost, reliability, and flexibility. There are twenty two sub-criteria used to explain the details on these five main criteria. Another part of questionnaire will ask general questions about the supplier evaluation and supplier related issues, etc. (Appendix A).

3.1.3 Collecting data

After questionnaire design and validation were completed, four major HDD manufacturers, first group of sample, will be studied using questionnaires as well as semi-structured interviews. We will use questionnaires and interview with multiple personnel (e.g. logistics director, purchasing manager, etc.) in the selected companies. We will seek information about the criteria that they use to source from and select suppliers. Moreover, we can obtain the supplier evaluation data of Thailand and elsewhere in each group of parts from the questionnaires for using in next analytical step. Another section of interview will ask general questions about the evaluation process, the use of the evaluations, the procurement issues, and supplier

related issues, etc. For the second group of sample, HDD suppliers in Thailand, a mail-out will be conducted. We wish to get the data about the significant criteria or their competitive priorities from the suppliers' aspects. Furthermore, it is possible to identify suppliers which are willing to co-operate and be interviewed that we can collect for more details from them further. Table 3.2 shows the summary of the data collection method.

Table 3.2 The summary of the data collection method

Population group	HDD manufacturer	HDD supplier
Population size	4 companies (Western digital, Seagate, Hitachi global storage technology, Toshiba)	112 companies
Data collection tool	Questionnaire	Questionnaire
Data collection method	Face-to-face interview	Opened P.O. box and Send out questionnaire by using postal service
Questionnaire objective		
1. Collect the location of suppliers in the HDD industry	✓	-
2. Supplier evaluation	✓	-
3. The important of HDD supplier selection criteria	✓	✓

3.1.4 Supplier evaluation analysis

The next task involves an in-depth analysis on the surveys' responses. The applied weighted-point and analytical hierarchy process (AHP) was chosen as the main analysis method. See Teng and Jaramillo (2005) for more details. The analysis primarily includes the tasks on normalize criteria weight from the aspects of HDD makers and their suppliers, using AHP and statistics such as mean score, etc. and

determining each criterion's importance. The next task, measuring suppliers in each country by summarizes its performance rating in many criteria and calculates into the scores of each country by group of parts. Then, the following task is to compare the performance of suppliers in Thailand with other countries in each group of parts.

3.1.5 Conclusion

As a result from this thesis, we will map the upstream of Thailand HDD supply chain, also conclude the supplier selection criteria that HDD manufacturers give the attention and the performance of HDD suppliers in each country. From this overall information and the data from literature, interviews, and discussion, the recommendations will be made to suggest the way to strengthen HDD suppliers and the upstream in Thailand.

CHAPTER IV
SUPPLIER EVALUATION MODEL DEVELOPMENT

This chapter will illustrate the details of the development of supplier evaluation model and the questionnaire that is used in this thesis.

4.1 The Development of the supplier evaluation model

The model developed in this study is the adoption of the weight-point method and AHP. It reflects the HDD supply chain conditions and proposes the companies a simple, flexible, and effective tool for evaluation of their suppliers. The model is designed according to a hierarchical structure with two levels. The first level of the hierarchy is for the most critical area in sourcing for the HDD supply chain. This level contains five main criteria group. The main criteria include delivery, quality, cost, reliability, and flexibility. Each main criterion will have a weight, which is assigned by HDD makers according to their needs. A second level of the hierarchy consists of sub-criteria that have significant effect on each main criterion. HDD makers must assign appropriate weights to each criterion according to specific situations or needs.

The index used in this model to determine a supplier's performance in each country is the total supplier score. This score consists of five main criteria score: delivery score, quality score, cost score, reliability score, and flexibility score. The following equation shows the supplier evaluation model:

Total supplier score = delivery score + quality score + cost score + reliability score + flexibility score (1)

The five scores that determine the total supplier score are from the five key supplier performance criteria. To determine these main criteria scores, we need to

determine the main criteria weights (*C*), the sub-criteria weights (*K*) that influence the main criteria, and a value *(V)* that is the HDD maker provided score. In this model, the supplier with the highest total score is represented as the best performance.

4.1.1 The main criteria for evaluating supplier

There are five main criteria under in this model. Figure 4.1 shows the structure of the decision-making matrix in the proposed approach for evaluating supplier performance and selecting HDD suppliers. The sub-criteria affecting the five main criteria's performance are selected based on the most common and significant issues in the HDD industry. Thus, they are selected after reviews with the practitioners in the HDD industry. In each criterion, a buyer needs to define the description or the ranges of each score (1 to 5) that appropriates for the firm.

4.1.1.1 Delivery Criterion

The delivery criterion consists of four sub-criteria that include geographic location, freight terms, trade restrictions, and order lead time. Geographic location *(K_{gl})* represents the proximity to customer and is determinant to supplier selection from the logistics point of view. Scores on this criterion are according to the following five scales include very close proximity with suppliers located in Thailand (score = 5), close proximity with suppliers located in Southeast Asia (score = 4), far with suppliers located in East Asia (score = 3), far with suppliers located in the rest of Asia (score = 2), and very far with suppliers not located in Asia (score = 1).

The second sub-criterion of the delivery criterion is the freight terms *(K_{ft})*. This sub-criterion refers to the expedience of shipping conditions from the supply chain point of view. There are five scores assigned to this sub-criterion that include Excellent (score = 5), Good (score = 4), Fair (score = 3), Poor (score = 2), and Very Poor (score = 1).

The next sub-criterion under the delivery is the trade restrictions *(K_{tr})*. This sub-criterion normally associated with the tariffs, custom duties, and government regulations for the products in both side of the supply chain. Scores on this sub-criterion are according to the level of trade restrictions that include free-trade agreements between countries (FTA) (score = 5), low trade restrictions (score = 4),

moderate trade restrictions (score = 3), high trade restrictions (score = 2), and very high trade restrictions (score = 1).

The last sub-criterion is the order lead time *(K_{lt}).* The order lead time is the time from the moment the buyer places an order to the moment it is received by the buyer. Because it is difficult to establish specific targets for this sub-criterion, a buyer may define the ranges for evaluation. For example, Excellent with order lead time from 1 to 7 days (score = 5), Good with order lead time from 8 to 15 days (score = 4), Fair with a period from 16 to 30 days (score = 3), Poor with a period from 31 to 45 days (score = 2), and Very Poor with a time beyond 45 days (score = 1).

The delivery score calculated in equation (2) is according to all sub-criteria in the delivery:

$$\text{Delivery score} = C_D[(K_{gl}*V_{gl}) + (K_{ft}*V_{ft}) + (K_{tr}*V_{tr}) + (K_{lt}*V_{lt})] \quad (2)$$

Where:

C_D = Weight of the delivery main criterion.

K_{gl}, K_{ft}, K_{tr}, K_{lt} = Weight of each sub-criterion.

V_{gl}, V_{ft}, V_{tr}, V_{lt} = Values obtained for each sub-criterion.

4.1.1.2 Quality Criterion

The quality criterion includes five sub-criteria that consist of quality of product, percentage of on-time deliveries, response to customer's request and feedback, certifications, and research and development (R&D) programs. Quality of product *(K_{qp})* could be defined as the percentage of the yield of good product that received from the supplier. The scales must be defined by the buyer. A buyer may define the ranges for evaluation. For example, Very High with good products yield beyond 99.5 percent (score = 5), High with good products yield from 98 to 99.5 percent (score = 4), Acceptable with good products yield from 97 to 98 percent (score = 3), Low with good products yield from 96 to 97 percent (score = 2), and Very Low with good products yield lower than 96 percent (score = 1).

The second sub-criterion, percentage of on-time shipment *(K_{ot})*, is one of the key criteria in supplier quality because some obstacles may affect on-time shipments. This category may be evaluated as follows: Very High with more than 97 percent of on-time shipments (score = 5), High with 95 to 97 percent of on-time shipments (score = 4), Moderate with 90 to 95 percent of on-time shipments (score = 3), Low with 85 to 90 percent of on-time shipments (score = 2), and Very Low with less than 85 percent of on-time shipments (score = 1).

The third sub-criterion is response to customer's request and feedback *(K_{rc})*. This sub-criterion refers to the actions of the supplier that response to buyer's request and feedback. It is defined by the buyer's experience. This sub-criterion has five ratings: Excellent (score = 5), Good (score = 4), Fair (score = 3), Poor (score = 2), and Very Poor (score = 1).

The next sub-criterion is the certifications *(K_{ct})*. It is for the recognition of the supplier's quality level. This sub-criterion is evaluated as follows: Very High with ISO certifications and other international supplier certifications (score = 5), High with ISO certifications and other domestic supplier certifications (score = 4), Acceptable with ISO certifications (score = 3), Poor with domestic supplier certifications (score = 2), and Very Poor that the supplier does not have any certification (score = 1).

The last quality sub-criterion is research and development (R&D) programs *(K_{rd})*. This sub-criterion normally associated with the capability to search for and invent new products or technologies. This criterion has four ratings: Excellent (score = 5), Good (score = 4), Fair (score = 3), Poor (score = 2), and Very Poor (score = 1).

With these five sub-criteria, the quality score is calculated in equation (3) and the coefficient C_Q is the weight of the quality main criteria:

$$\text{Quality score} = C_Q[(K_{qp}*V_{qp}) + (K_{ot}*V_{ot}) + (K_{rc}*V_{rc}) + (K_{ct}*V_{ct}) + (K_{rd}*V_{rd})] \quad (3)$$

4.1.1.3 Cost Criterion

Generally, this criterion has great influence on the supplier selection process. There are three sub-criteria considered in the evaluation of this cluster including supplier's selling price, internal cost, and the cost for ordering and invoicing. Supplier's selling price *(K_{sp})* is evaluated according to the following five scales: Very Low Prices (score = 5), Low Prices (score = 4), Acceptable Prices (score = 3), High Prices (score = 2), and Very High Prices (score = 1).

The internal cost *(K_{ic})* sub-criterion evaluates the total cost of each purchase. In addition to the product price that a buyer has to pay for, other costs related with transportation and quality must also be considered. This sub-criterion is evaluated according to the following scales: Very Low Internal Costs (score = 5), Low Internal Costs (score = 4), Acceptable Internal Costs (score = 3), High Internal Costs (score = 2), and Very High Internal Costs (score = 1).

The last cost sub-criterion is the ordering and invoicing *(K_{oi}).* It relates to the ease of order placing. The implementation of EDI technologies has contributed to the advancements in this area. This criterion has five ratings: Excellent (score = 5), Good (score = 4), Fair (score = 3), Poor (score = 2), and Very Poor (score = 1).

The cost score is calculated in equation (4) with C_C being the weight of the cost main criteria:

$$\text{Cost score} = C_C[(K_{sp}*V_{sp}) + (K_{ic}*V_{ic}) + (K_{oi}*V_{oi})] \quad (4)$$

4.1.1.4 Reliability Criterion

Five sub-criteria, the feeling of trust, the financial position, country's political situation, the currency exchange situation, and the warranty policies influence the reliability of a supplier. The feeling of trust *(K_t)* is the first sub-criterion. It is evaluated according to the buyer's perception of a given supplier. It is determined by an on-going partnership between supply chain partners and supplier evaluations over the years. A supplier's reputation can influence the evaluation result in this sub-criterion. The evaluation of this sub-criterion has the following five levels: Very High

(score = 5), High (score = 4), Moderate (score = 3), Low (score = 2), and Very Low (score = 1).

The second sub-criterion is the financial position *(K_{fp}).* It is evaluated according to the financial status of each supplier. This sub-criterion has five ratings: Excellent (score = 5), Good (score = 4), Fair (score = 3), Poor (score = 2), and Very Poor (score = 1).

The third sub-criterion is country's political situation *(K_{ps}).* The proposed evaluation criteria for this factor include five ratings: Excellent (score = 5), Good (score = 4), Fair (score = 3), Poor (score = 2), and Very Poor (score = 1). The Excellent rating shows that the supplier's country of origin exhibits good short and long-term stability and there are absolutely no concerns of distracting supply chain operations due to the country's political situation. In contrast, the Poor rating shows that the supplier's country of origin exhibits serious concerns regarding political stability and disruptive events in supply chain activities.

The forth sub-criterion under reliability main criterion is the currency exchange situation *(K_{ce}).* Buyers may have preference for suppliers located in the countries where the currency exchange situation favors their companies in different planning horizons. The evaluation of this category is from a buyer's perspective. The buyer determines the degree of favorability according to the following five scales: Very Favorable (score = 5), Favorable (score = 4), Neutral (score = 3), Poorly Favorable (score = 2), and Non Favorable (score = 1).

Warranty policies (K_{wp}) sub-criterion, the fifth under reliability, is about the responsibility on non-conformities. The evaluation of this category is similar to the previous sub-criterion. The Very Favorable (score = 5) rating means that the supplier takes full responsibility on non-conformities and offers rebated on them. On the other hand, For Non Favorable (score = 1), the supplier does not take any responsibility on non-conformities.

Equation (5) shows the computation for the reliability score. In the equation, C_R is the weight of the reliability main criterion:

$$\text{Reliability score} = C_R[(K_t*V_t) + (K_{fp}*V_{fp}) + (K_{ps}*V_{ps}) + (K_{ce}*V_{ce}) + (K_{wp}*V_{wp})] \quad (5)$$

4.1.1.5 Flexibility Criterion

Our approach in evaluating supplier's flexibility is according to five sub-criteria including capacity, technical capability, information sharing, negotiability, and customization. The first sub-criterion, capacity *(K_c)*, is defined by the buyer's knowledge or experience. This score must show the order quantities that a supplier can deal with. Scores on this sub-criterion are according to the following five scales: Very High (score = 5), High (score = 4), Acceptable (score = 3), Low (score = 2), and Very Low (score = 1).

The second sub-criterion is the technological capability *(K_{tc})*. The scores must be determined by the buyer's knowledge or information obtained from the source itself. This score display the supplier's level of technology in production. Scales on this category are the same as those of the previous criterion.

The third sub-criterion, information sharing *(K_{is})*, refers to the level of information shared between the supplier and the buyer. The scales on this sub-criterion include Very High with real time updates and compatible electronic data interchange (EDI) technologies (score = 5), High with weekly updates and compatible EDI technologies (score = 4), Acceptable with updates within one to three weeks and with low compatibility in EDI technologies (score = 3), Low with monthly updates and with low compatibility EDI technologies (score = 2), and Very Low with monthly updates and with no compatibility EDI technologies (score = 1).

The forth flexibility sub-criterion is negotiability *(K_n)*. Negotiability is associated with the mutual trust existed between the supplier and the buyer. This sub-criterion is evaluated according to the scales of Very High (score = 5), High (score = 4), Acceptable (score = 3), Low (score = 2), and Very Low (score = 1).

The last sub-criterion, the customization *(K_{cu})*, proposes to evaluate the supplier's ability to take orders with unusual requests from the buyer. Scores on this sub-criterion are the same as the scales for the previous criterion.

The flexibility score is computed in equation (6) with C_F as the weight of the flexibility main criterion:

$$\text{Flexibility score} = C_F[(K_c*V_c) + (K_{tc}*V_{tc}) + (K_{is}*V_{is}) + (K_n*V_n) + (K_{cu}*V_{cu})] \quad (6)$$

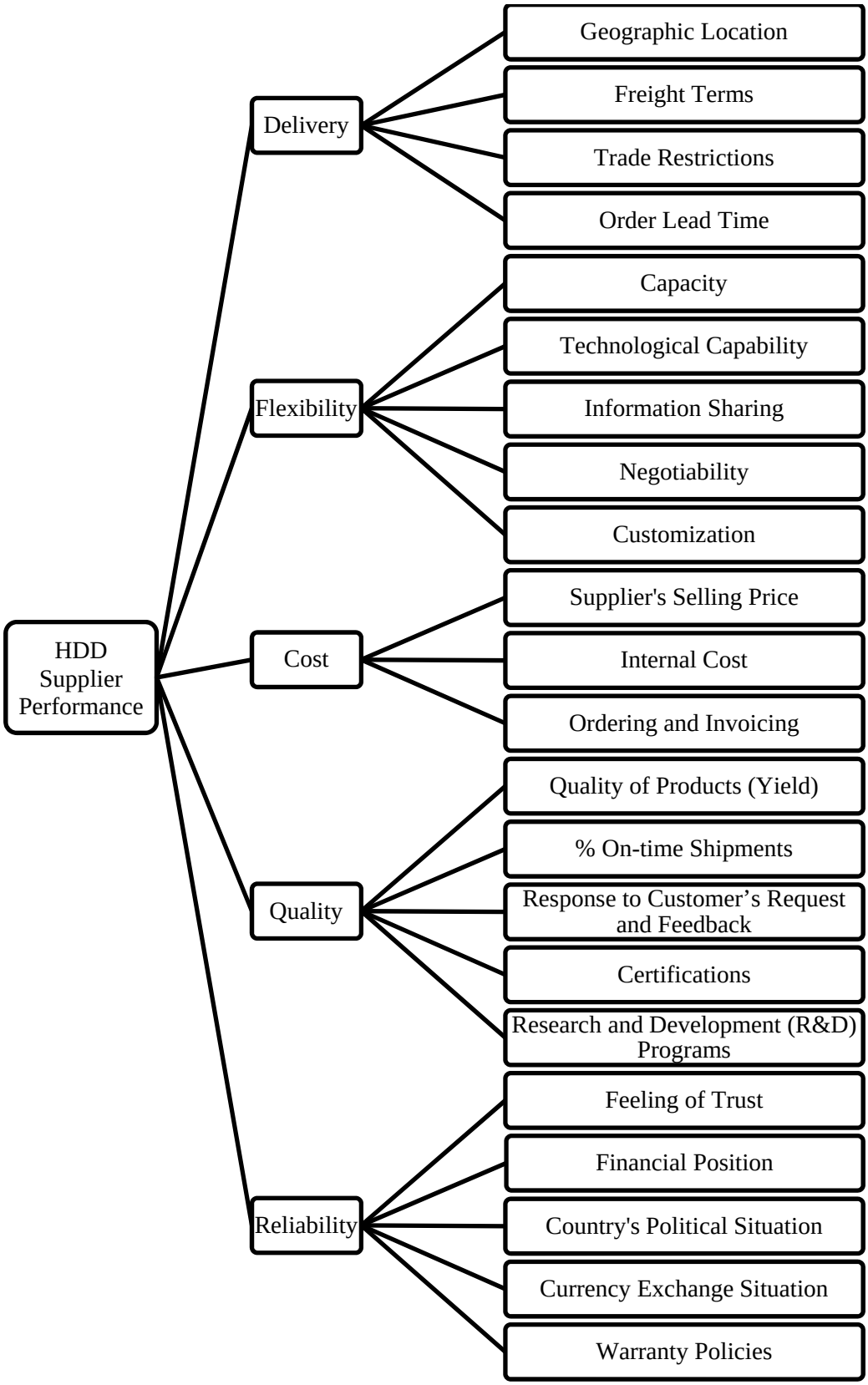

Figure 4.1

HDD's supplier evaluation criteria

4.1.2 Weight of each main criterion and weight of each sub-criterion

From the previous topic, the each cluster score are calculated from weight (C, K) and value (V) of each criterion. As we already describe that the value (V) is coming from the scale. For the weight of each main criterion (C) and weight of each sub-criterion (K), those weights are calculated from the AHP method.

4.2 The Development of a Questionnaire

A questionnaire was developed from the supplier evaluation model in previous section. It is important to note that the selection of this questionnaire was made after reviews with the practitioners in HDD industry and the experts from academic institutions on its comprehensive and applicability. There are four major sections in the questionnaire for the HDD manufacturers.

The first section is the general information about the interviewee's company. The questions in this section are open-ended and check-list question type. There are twelve questions inquiry about company profile.

The second section aims to collect data about the locations of the Thailand HDD industry's suppliers. Check-list question type is used in this section to identify which country that the Thailand's HDD manufacturers are selected to source each component part. There are 28 component parts and indirect materials that we are interested to study. The detail of each group of parts is in chapter 3.

The third section is the matrix that respondent will grade the suppliers in each criterion. The type of questions is rating scale. The score of each criterion is divided into 5 levels by using Likert scale concept. There are 22 criteria (the detail of each criterion is in the topic 4.1.1). The score interpretation is defined by the following range of calculated score;

Score range	Meaning
1.00-1.49	Very poor performance
1.50-2.49	Poor performance
2.50-3.49	Fair performance

3.50-4.49	Good performance
4.50-5.00	Excellent performance

The last section, the table was provided for weighting the importance of criteria. The type of questions is rating scale. Each question consisted of a pair-wise comparison of two criteria to obtain the judgment matrix. The technique consists of taking all pairs of criteria and asking two questions such as: Which criterion is more important, delivery or flexibility? and, How much more important? An example of questionnaire shows in Appendix A.

The questionnaire for the HDD industry's supplier has some differences. We eliminated the second and the third sections out of the questionnaire and the questions in section one have also been adjusted.

The analysis by AHP will give the result with avoiding the main drawback of the traditional linear weighting models as we already described in chapter 2. This thesis used AHP method to calculate the criteria weight and Likert scale to grade the suppliers in each criterion instead of using only specific one method. If the thesis approached only AHP in the questionnaire, it would make questionnaire much more complicated and hard to get the answers from the respondents. Likert scale offer more convenient for the respondents because most of the respondents will familiar with this type of questions much more than AHP method.

CHAPTER V
THE CRITERIA WEIGHTING AND THE SUPPLIER EVALUATION

The contents in this chapter are included 1) the HDD's supplier mapping by country in each component group, 2) the priority of each criteria in the supplier selection, and 3) the scores from the supplier evaluation.

5.1 The HDD's Supplier mapping

In order to evaluate the suppliers in each nation, we have to investigate that each nation are supplying which part to Thailand's HDD industry. Hence, the data from the interviews with the HDD makers in Thailand have been collected. This mapping represents the current upstream of the HDD industry. As we can see in table 5.1 and table 5.2 Thailand doesn't have any supplier that provides the hi-tech component (i.e. Wafer, Media). The hi-tech components are significant cost more than other components. These parts are cost about 50% of the total material cost in one unit of HDD. Most of Thailand's HDD industry suppliers are owned by the multinational enterprises (MNEs). While only a few companies are owned by Thai suppliers. Most of Thai suppliers supply the indirect materials to the HDD industry such as packaging, sponge. Besides those indirect materials, Thai suppliers could have an opportunity to supply precision parts or machinery tools. The HDD industry is now still need to import those value components from U.S.A. while Thailand, Malaysia, Singapore, China and Japan are also offering a variety of the HDD components. Hence, the supplier evaluation from this thesis will give more the explanations on the performance of each nation and the criteria that the HDD makers are considered as the important factors.

Table 5.1 The source of HDD component

Part Group	Part name	TH	MY	SG	CN	JP	US
Hi-Tech Component	Wafer				X	X	X
	Media		X	X		X	X
Read/Write Component	Slider Fabrication	X			X	X	X
	HGA	X	X		X		
	HSA	X	X		X		
Precision Component	Suspension	X			X	X	X
	Pivot	X	X				
	Actuator	X	X	X	X		
	Top Cover	X	X	X			
	Ramp	X	X	X		X	
	Screw	X		X	X	X	X
	Connector	X	X	X	X	X	
	Clamp	X	X	X			
	Latch	X	X	X	X	X	
	Disk Spacer	X	X	X	X		
Electrical & Electronic Component	PCBA	X	X		X	X	
	Semiconductor(IC)	X		X	X	X	X
	VCM	X	X	X	X	X	
	FPC	X		X	X		
	Motor Base	X	X		X	X	
Other Component	Seal	X				X	
	Filter	X	X		X	X	
	Label	X	X	X	X	X	
Indirect Material	Package (Box, Tray, Sponge)	X	X		X	X	
	Clothing (Smock, Hair Net)	X		X		X	
	ESD Related Material	X	X	X		X	
	Equipment / Tooling	X	X	X	X	X	X
	Chemical	X	X			X	X

Table 5.2 The overall source of HDD component divided by group of parts

Part Group	TH	MY	SG	CN	JP	US
Hi-Tech Component		X	X	X	X	X
Read/Write Component	X	X		X	X	X
Precision Component	X	X	X	X	X	X
Electrical & Electronic Component	X	X	X	X	X	X
Other Component	X	X	X	X	X	
Indirect Material	X	X	X	X	X	X

5.2 Criteria weighting analysis

In this thesis, there are five main criteria: delivery, quality, cost, reliability, and flexibility included in the questionnaire to help reflect supplier selection priorities. Each main criterion contains the sub criteria. The meanings of each sub criteria are in Appendix C. The definitions of five main criteria are as follows.

1) Deliver: Li (2000) described that delivery is a time-based issue. It concerns about how quickly customer receive a product or a service. It is also considered as a time-to-market of a new product.

2) Quality: The term of quality represents to a low-defect rate, product performance, certification etc. The definition of it leads to excellence, value, conformance to specifications, and meeting or exceeding customers; expectation (Reeves and Bednar, 1994)

3) Cost: In this thesis, cost is focused on the price of product and the external cost from supplier (i.e. supplier's internal cost, ordering and invoicing cost).

4) Reliability: The meanings of the reliability are the ability and stability of supplier's company and its country location such as currency fluctuation, the risk from financial status, the relationship between the HDD makers and their suppliers.

5) Flexibility: Flexibility in this study is about the supplier ability to adjust with the HDD makers needs which are volume changes, technology development, customization, negotiability, and information collaboration.

5.2.1 Criteria weighting analysis from the HDD makers' perspective

As a result from gathering data with the HDD makers in Thailand, three out of four companies were participated with our study. We conducted the designed questionnaire and the face-to-face interview with them. All the respondents from those HDD makers are top executives in a purchasing department. After that, we have to analyze the weighting of each criterion. In order to do that, we have to build the AHP model using Super Decision software. Figure 5.1 shows the structure of model for criteria weighting analysis in Super Decision software. The AHP model contains three elements. The first element is a goal which is the objective of our study. As we already described in previous chapter, the objective is to evaluate the Thailand HDD's suppliers. Hence, the goal in this model is finding the nation that has the best suppliers located. Next element is criteria which are already classified into five clusters: delivery, quality, cost, reliability, and flexibility. The last part is sub criteria. Normally, the AHP model would has an alternative as a last element but this study used data from several HDD makers. Hence, we will use the weighting results from each HDD maker and calculate the score in Microsoft excel.

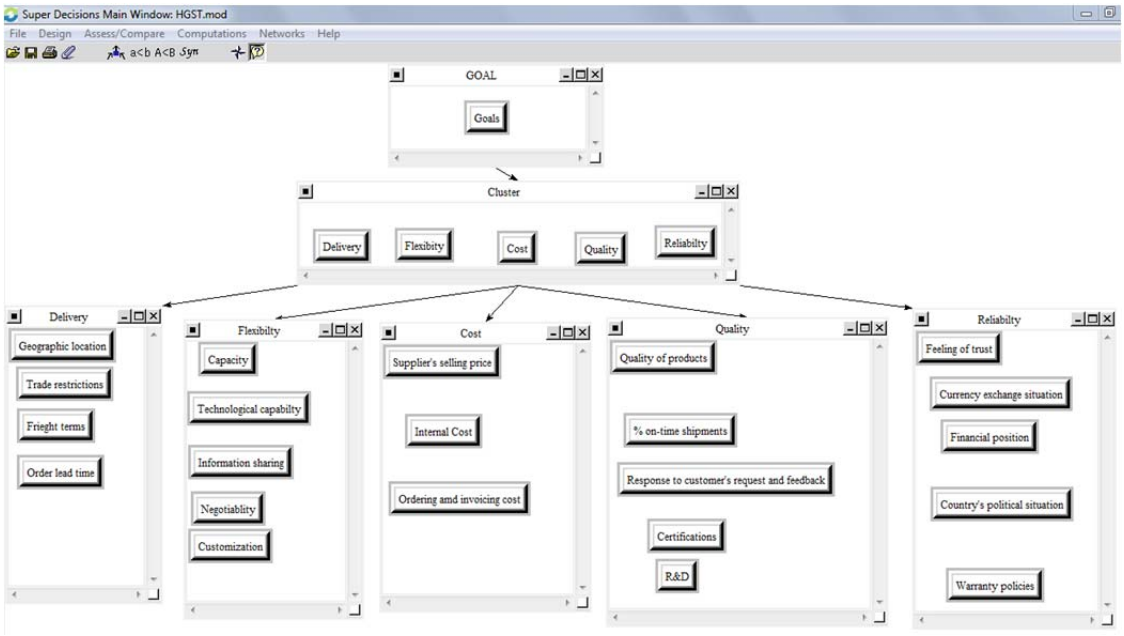

Figure 5.1

The structure of model for criteria weighting analysis in Super Decision software

The next step after we finished the AHP model, we fill in the weight of each criterion from the response questionnaires. Figure 5.2 shows the comparison form in Super Decision software. After we put all the weights from each HDD maker, we calculated the mean score of those weights.

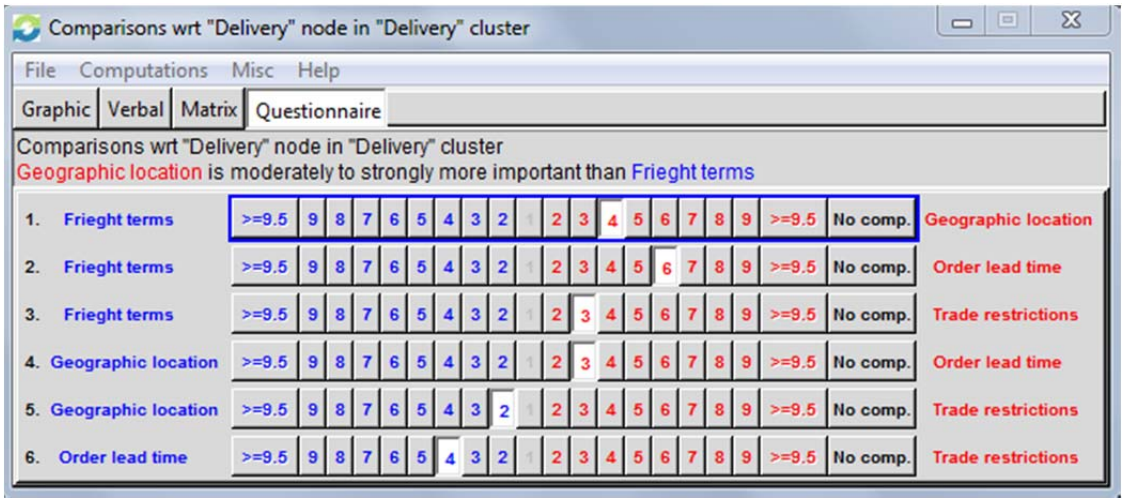

Figure 5.2

The example of comparison data input in each sub-criteria

The initial analysis has a goal to first identify the overall rankings of the five main criteria. The sub criteria would be later analyzed. The results show that cost was given highest rank of 35.65% while delivery, quality, reliability and flexibility were given rates of 28.93%, 19.41%, 10.87% and 5.14% respectively. It should also be noted that all the results from the responses were reliable, based on the low-consistency ratio of less than 0.20. Cost is the most important priority due to the HDD makers suggested that the nature of HDD industry is the large-volume industry and intensive-cost competitive industry. Hence, the HDD makers have to seek for the low price of the component parts to enhance its competitiveness. If we look closer to the sub criteria of cost, their relative importance is as follows:

1) Supplier's selling price 0.612

2) Internal Cost 0.248

3) Ordering and invoicing cost 0.140

It is obvious that the selling price is the most significant factor comparing to the two others sub criteria. Hence, we can predict that the price of HDD component parts has the most impact to the supplier selection decision.

In term of delivery, the locations of suppliers are concerned in this criterion. The closer of supplier to the HDD makers helps to ease the delivery process. In addition, the HDD makers have to reduce cost from inventory storages. They already use the pull system in their management to serve the operation lines. Suppliers need to ship the component parts on the time to make the operation lines in HDD industry run smoothly. For the delivery term, given four dimensions, their relative importance is as follow:

1) Order lead time 0.553
2) Trade restrictions 0.161
3) Geographic location 0.150
4) Freight terms 0.135

It is agreed that order lead time is greatly influence the HDD makers. While outsourcing from distant suppliers is possible, the term of trade restrictions, geographic location and freight terms are not as important as order lead time.

A third priority, quality, is also important in the hi-technology manufacturing. The HDD needs a high precision part and each HDD has a specification details. For the reason that quality is less significant than cost because the HDD makers pointed out that the suppliers have to meet their awareness of quality before entry into this industry. Therefore, it is most likely that most of suppliers are all have a quality as their qualifications. For the quality term, given five dimensions, their relative importance is as follow:

1) Response to customer's request and feedback 0.301
2) Quality of products 0.289
3) % on-time shipments 0.269
4) R&D 0.075
5) Certifications 0.066

The HDD makers clearly expect from the suppliers for the quality. Top three sub criteria are all equally important which are 1) response to customer’s request and feedback, 2) quality of products, and 3) % on-time shipments. The agility and the

responsiveness are playing a vital role in creating competitiveness. The technology is rapidly changing all the time as same as the HDD manufacturers that have to continuously adjust themselves. The designs of new product is continuously launching, so the suppliers are required to response the needs of the HDD makers. Surprisingly, research and development was given a low rank.

Reliability is defined by the relationship and the image of suppliers. It represents the stability both of suppliers' company and their nations' location. For the reliability term, given five dimensions, their relative importance is as follow:

1) Feeling of trust	0.277
2) Warranty policies	0.261
3) Country's political situation	0.200
4) Financial position	0.165
5) Currency exchange situation	0.097

The HDD makers admitted that the relationships between the suppliers and them affect in the selection decision. The long relationship can build the trust and the familiarity which help the HDD makers to choose the suppliers that they trust. The warranty policies provide the comfort to the HDD makers. It can be noticed that the political situation of each country is more important than supplier's finance position and the currency exchange situation. Thailand, for instance, the protest in International Airport affects the business operations in the delivery process.

A lack of flexibility influences to the capability of a long term sustainable competitiveness. For the flexibility term, given five dimensions, their relative importance is as follow:

1) Customization	0.312
2) Negotiability	0.224
3) Technological capability	0.195
4) Capacity	0.160
5) Information sharing	0.109

The analysis on the data from respondents also includes the use of global weight instead of separating the opinions into the individual criteria. The primary goal of performing this global-weight analysis is to help us giving more

insight explanation on the overall sub-criteria. Table 5.3 shows the results from the criteria global average weight calculations.

Table 5.3 Results on supplier selection priorities-the HDD makers' perspectives

Criteria	Average weight	Sub criteria	Local Average weight	Global Average weight
Cost	0.357	Supplier's selling price	0.612	0.218
		Internal Cost	0.248	0.089
		Ordering and invoicing cost	0.140	0.050
Delivery	0.289	Order lead time	0.553	0.160
		Trade restrictions	0.161	0.047
		Geographic location	0.150	0.044
		Freight terms	0.135	0.039
Quality	0.194	Response to customer's request and feedback	0.301	0.058
		Quality of products	0.289	0.056
		% on-time shipments	0.269	0.052
		R&D	0.075	0.015
		Certifications	0.066	0.013
Reliability	0.109	Feeling of trust	0.277	0.030
		Warranty policies	0.261	0.028
		Country's political situation	0.200	0.022
		Financial position	0.165	0.018
		Currency exchange situation	0.097	0.011
Flexibility	0.051	Customization	0.312	0.016
		Negotiability	0.224	0.012
		Technological capability	0.195	0.010
		Capacity	0.160	0.008
		Information sharing	0.109	0.006

The results from global average weight will be adopted with the Pareto principal. The Pareto diagram is constructed and applies the 80 percent rule. The cut-off point is selected when the accumulated weight is 80% off the sub criteria's total

weight. The sub-criteria, positioned before this cut-off point, are indicated to be important. From figure 5.3, there are nine sub-criteria that can be classified as significant importance. The top three priorities are outstanding differences in the priority compare to the other six sub criteria which are supplier's selling price, order lead time, and internal cost respectively. It could be noticed that two out of three most important sub criteria are categorized in the cost criterion. This confirmed that cost represents the most important criterion priority in the HDD industry' supplier selection. The other six criteria, placed before the cut-off point, are response to customer's request, quality of product, % on time shipment, ordering and invoicing cost, trade restrictions, and geographic location.

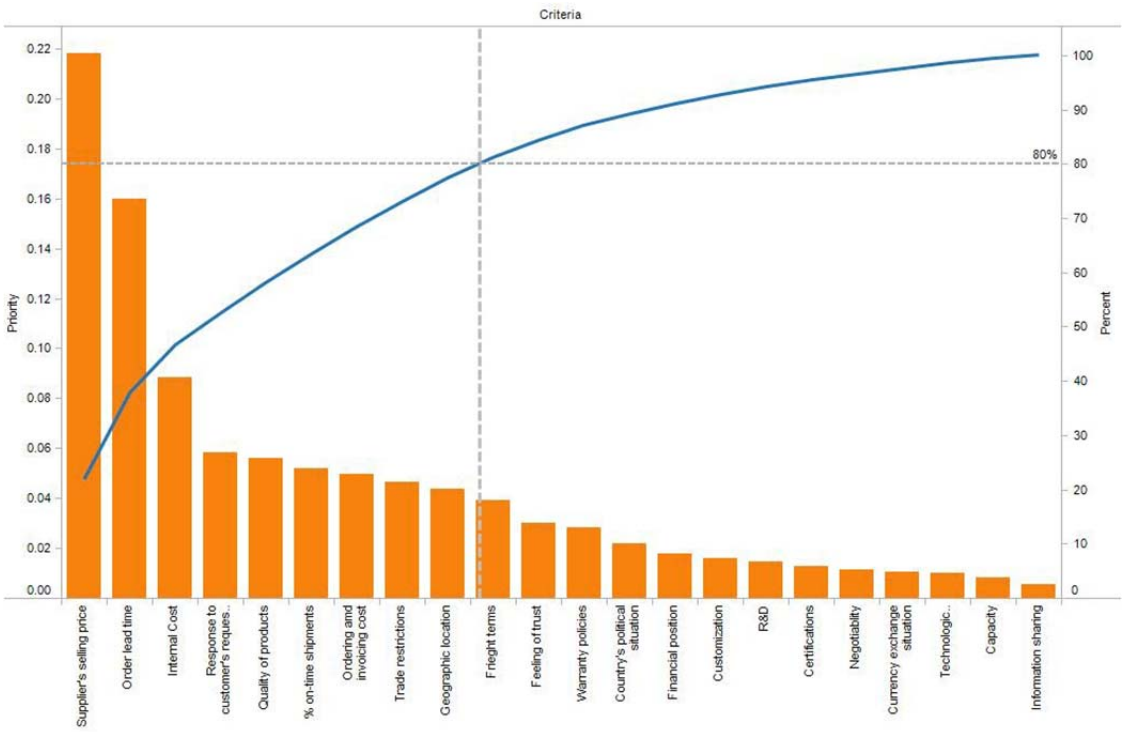

Figure 5.3

The cut-off points from Pareto principal with the global average weight-HDD makers' weighting

5.2.2 Criteria weighting analysis from the HDD suppliers' perspective

The data that we used in this analysis are collected from the questionnaires. There are eleven companies that response the questionnaire. Nine out

of eleven questionnaires can be used while the other two questionnaires are invalid and unreliable based on their answers. The steps of criteria weighting analysis from the HDD suppliers are the same with the previous topic. We also used the Super Decision software to analyze the data. All the results from the eleven responses were reliable, based on the low-consistency ratio of less than 0.20.

The preliminary analysis aims to first identify the overall rankings of the five main criteria. Surprisingly for the HDD suppliers' aspects, reliability is considered as the most important priority. The results show that reliability was given highest rank of 27.77% while cost, delivery, quality, and flexibility were given rates of 26.11%, 25.53%, 13.89% and 6.7% respectively. If we look closer to the sub criteria of reliability, their relative importance is as follows:

1) Financial position 0.273
2) Feeling of trust 0.260
3) Country's political situation 0.166
4) Warranty policies 0.159
5) Currency exchange situation 0.142

In the HDD suppliers' opinions, reliability is the most important especially for financial position and feeling of trust. To be a competitive supplier in the HDD industry, they have to be a stable in financial position to enhance their images and to attract the HDD makers. In addition, if they have a strong financial position, they will be able to take any risk from the HDD industry. The feeling of trust has a significant important. The HDD suppliers think that the more good relationship with the HDD makers makes it easier for the HDD makers to choose them.

Cost, the second main criterion priority, indicates that it is the most important impact as it is also the first priority in the HDD makers' point of views. For the cost term, given three dimensions, their relative importance is as follow:

1) Supplier's selling price 0.523
2) Internal Cost 0.245
3) Ordering and invoicing cost 0.232

The local average weight from HDD suppliers are also suggested the same results from the HDD makers that the selling price is the most significant factor

comparing to the two others sub criteria. This means that the price of component part can enhance the HDD suppliers' competitiveness.

From the results from HDD makers in above section and HDD suppliers in this section, as you can see that they are both agreed that quality is considered as a third priority. For the quality term, given five dimensions, their relative importance is as follow:

1) Quality of products	0.344
2) Response to customer's request and feedback	0.233
3) % on-time shipments	0.200
4) Certifications	0.121
5) R&D	0.101

The sub criteria: quality of product, response to customer's request and feedback, and % on-time shipments are all in the same high rank which are quite similar to the HDD makers' results. On the other hand, research and development is the lowest priority which implies that most of the HDD suppliers in Thailand are not focused on the research and development.

Unlike the priority from the HDD makers, delivery come to the forth for the HDD suppliers' results. Reliability is defined by the relationship and the image of suppliers. It represents the stability both of suppliers' company and their nations' location. For the delivery term, given four dimensions, their relative importance is as follow:

1) Order lead time	0.308
2) Trade restrictions	0.283
3) Freight terms	0.223
4) Geographic location	0.186

As we can see from the results here and the previous results from HDD makers, both results point into the same conclusion that order lead time has the most effects.

The last main criterion is flexibility. It can be noticed that information sharing is the sub criterion that is in the lowest rank. This implies that the information linkages between the HDD makers and their suppliers are low. For the flexibility term, given five dimensions, their relative importance is as follow:

1) Capacity 0.293

2) Customization 0.252

3) Technological capability 0.212

4) Negotiability 0.139

5) Information sharing 0.104

Table 5.4 shows the results of the local average weight ranking and the global average weight ranking of each sub criterion.

Table 5.4 Results on supplier selection priorities-the Suppliers' perspectives

Criteria	Average weight	Sub criteria	Local average weight	Global average weight
Reliability	0.278	Financial position	0.273	0.076
		Feeling of trust	0.260	0.072
		Country's political situation	0.166	0.046
		Warranty policies	0.159	0.044
		Currency exchange situation	0.142	0.039
Cost	0.261	Supplier's selling price	0.523	0.137
		Internal Cost	0.245	0.064
		Ordering and invoicing cost	0.232	0.061
Quality	0.255	Quality of products	0.344	0.088
		Response to customer's request and feedback	0.233	0.060
		% on-time shipments	0.200	0.051
		Certifications	0.121	0.031
		R&D	0.101	0.026
Delivery	0.139	Order lead time	0.308	0.043
		Trade restrictions	0.283	0.039
		Freight terms	0.223	0.031
		Geographic location	0.186	0.026
Flexibility	0.067	Capacity	0.293	0.020
		Customization	0.252	0.017
		Technological capability	0.212	0.014
		Negotiability	0.139	0.009
		Information sharing	0.104	0.007

The results from global average weight in table 5.4 will be also adopted with the Pareto principal. The cut-off point is at the 80% accumulated weight off the sub criteria's total weight. The sub-criteria, positioned before this cut-off point, are indicated to be important. From figure 5.4, there are twelve sub-criteria that can be classified as significant importance. Supplier's selling price, the first top priority, is outstanding differences in the priority compare to the other eleven sub criteria. It should be noticed that supplier's selling price is the most importance to both HDD makers' weighting which is 0.218 and HDD suppliers' weighting which is 0.137. The other eleven sub-criteria that are placed before the cut-off point are quality of products, financial position, feeling of trust, internal cost, ordering and invoicing cost, response to customer's request and feedback, % on-time shipments, country's political situation, warranty policy, order lead time, and currency exchange situation.

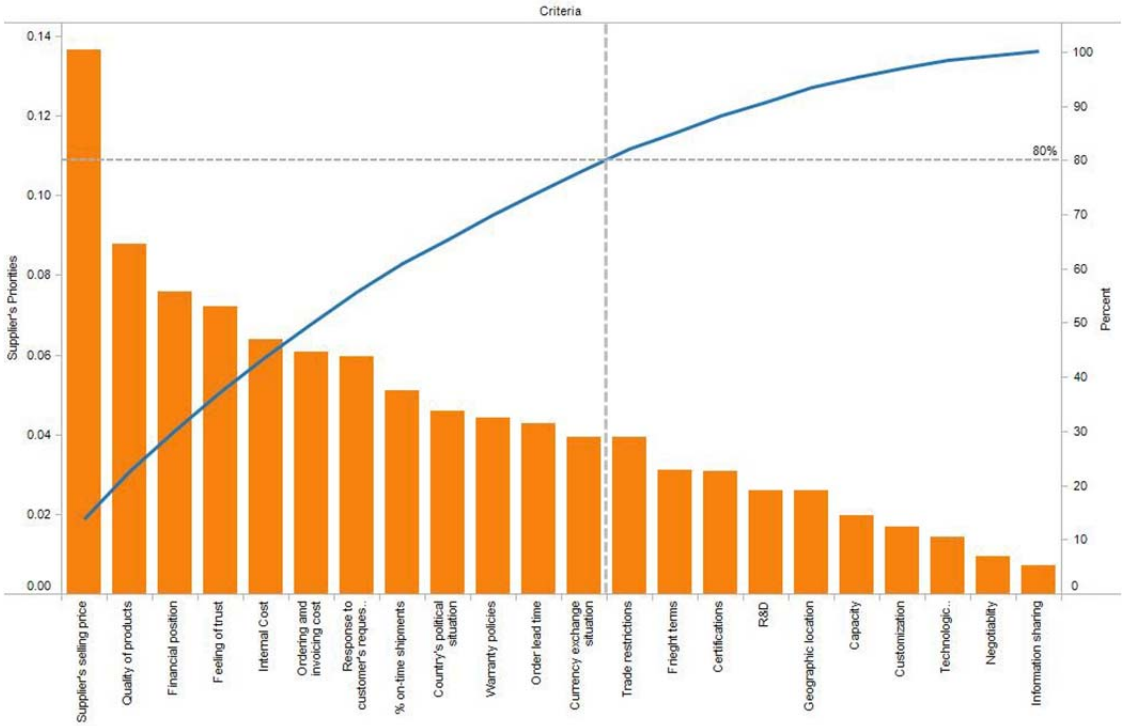

Figure 5.4

The cut-off points from Pareto principal with the global average weight-Suppliers' weighting

The results from the HDD makers and their suppliers of the main criteria and sub-criteria weighting are illustrated in figure 5.5 and figure 5.6

Figure 5.5

The scatter plot of the main criteria weight between the HDD makers and their suppliers

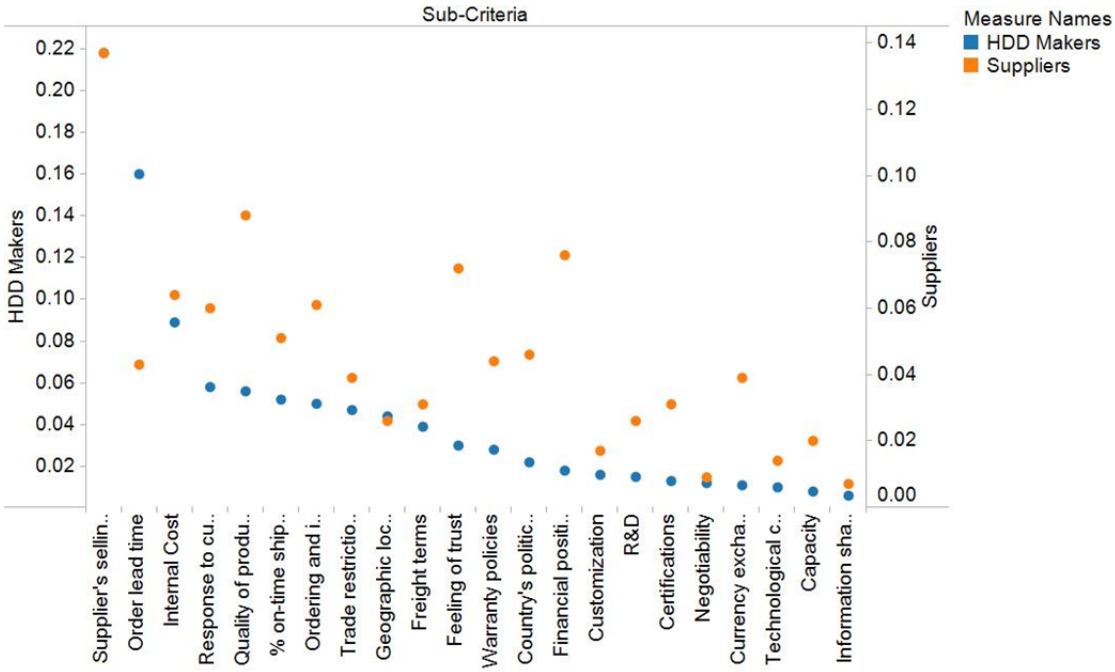

Figure 5.6

The scatter plot of the sub-criteria weight between the HDD makers and their suppliers

5.3 The results of supplier evaluation

The last stage of this thesis is to evaluate the performance of suppliers of each country by component group. Data that we used are also given from the HDD makers by using questionnaire. The respondents were asked to give the score in each component group by countries that are currently sourcing that component group to the HDD makers. After we knew the priority of each criteria and sub criteria from using AHP method, then we are able to calculate the score.

5.3.1 Supplier evaluation: Hi-tech component

Table 5.5 The score results in all criteria-Hi-tech component

CRITERIA	SUB CRITERIA	MY	SG	CN	JP	US
Delivery	Geographic location	0.174	0.174	0.131	0.131	0.044
	Freight terms	0.157	0.170	0.118	0.170	0.170
	Trade restrictions	0.187	0.218	0.140	0.202	0.187
	Order lead time	0.720	0.747	0.800	0.747	0.640
Quality	Quality of products	0.253	0.225	0.168	0.281	0.243
	% on-time shipments	0.235	0.243	0.209	0.261	0.243
	Response to customer's request and feedback	0.263	0.273	0.175	0.273	0.273
	Certifications	0.064	0.064	0.064	0.064	0.064
	R&D	0.066	0.068	0.073	0.073	0.073
Cost	Supplier's selling price	0.655	0.582	0.655	0.582	0.509
	Internal Cost	0.266	0.354	0.177	0.325	0.354
	Ordering and invoicing cost	0.174	0.182	0.100	0.182	0.182
Reliability	Feeling of trust	0.135	0.140	0.120	0.140	0.150
	Financial position	0.081	0.090	0.072	0.084	0.078
	Country's political situation	0.087	0.109	0.109	0.109	0.080
	Currency exchange situation	0.042	0.042	0.042	0.025	0.039
	Warranty policies	0.099	0.142	0.114	0.142	0.123
Flexibility	Capacity	0.033	0.027	0.033	0.027	0.025
	Technological capability	0.045	0.047	0.040	0.050	0.050
	Information sharing	0.022	0.021	0.022	0.024	0.024
	Negotiability	0.040	0.042	0.046	0.042	0.054
	Customization	0.064	0.069	0.080	0.075	0.069
Total		3.861	**4.028**	3.486	4.007	3.673

In the hi-tech component group, there are five countries that are the location of the HDD suppliers which are Malaysia, Singapore, China, Japan and USA.

In table 5.5, it shows that the highest score is 4.028 which can indicate that Singapore has the best performance of being a source of hi-tech component to Thailand. The scores for Malaysia, China, Japan, and USA are 3.861, 3.486, 4.007, and 3.673 respectively. The scores from order lead time and supplier's selling price contribute the most to Singapore score total. This is confirmed that those two sub criteria have the significant impact on the HDD makers' supplier selection.

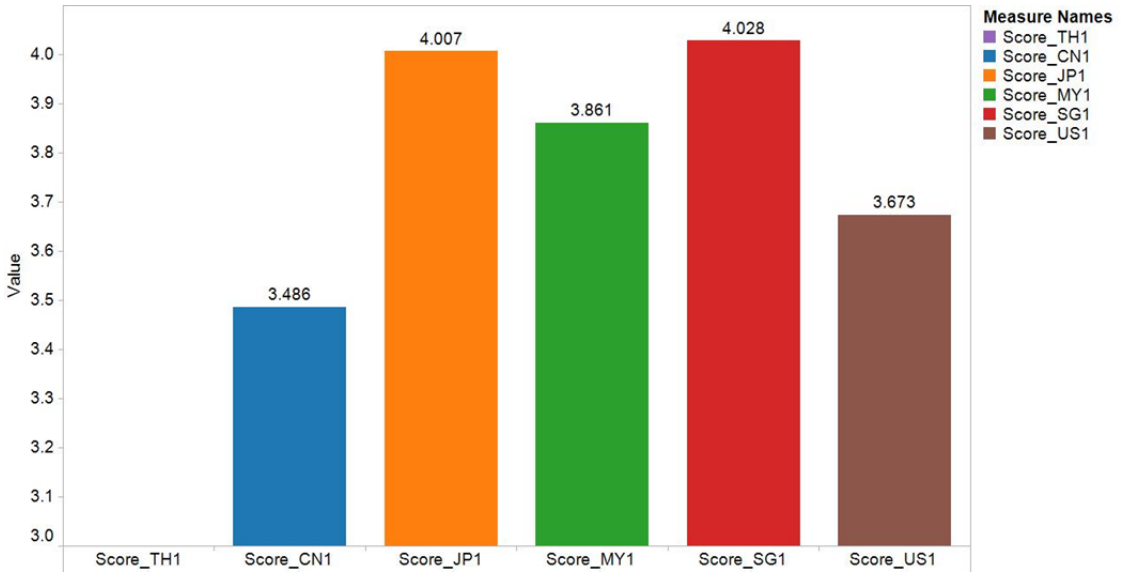

Figure 5.7

The total score of each country in the hi-tech component group

5.3.2 Supplier evaluation: Read/Write component

For a supplier evaluation in read/write component, the calculated scores are shown in table 5.6. Five countries are the location of the HDD suppliers which are Thailand, Malaysia, China, Japan and USA. According to the HDD makers in Thailand, Singapore are no longer supply the read/write component to them due to the price. The highest score in this part group is Thailand which is 3.996. While the scores for Malaysia, China, Japan, and USA are 3.908, 3.456, 3.759, 3.467, and 3.861 respectively. The reason that Thailand has the best performance is because most of the HDD makers are producing the read/write component by themselves in Thailand.

Table 5.6 The score results in all criteria-Read/Write component

CRITERIA	SUB CRITERIA	TH	MY	CN	JP	US
Delivery	Geographic location	0.218	0.174	0.131	0.131	0.044
	Freight terms	0.176	0.157	0.118	0.157	0.157
	Trade restrictions	0.210	0.187	0.140	0.140	0.163
	Order lead time	0.800	0.640	0.640	0.640	0.640
Quality	Quality of products	0.253	0.225	0.206	0.281	0.281
	% on-time shipments	0.235	0.261	0.209	0.261	0.209
	Response to customer's request and feedback	0.263	0.292	0.214	0.234	0.234
	Certifications	0.064	0.064	0.060	0.064	0.064
	R&D	0.058	0.073	0.068	0.073	0.073
Cost	Supplier's selling price	0.655	0.655	0.655	0.655	0.436
	Internal Cost	0.310	0.354	0.236	0.266	0.310
	Ordering and invoicing cost	0.199	0.149	0.166	0.149	0.174
Reliability	Feeling of trust	0.120	0.150	0.120	0.150	0.150
	Financial position	0.072	0.090	0.066	0.090	0.081
	Country's political situation	0.043	0.087	0.087	0.109	0.076
	Currency exchange situation	0.021	0.042	0.035	0.021	0.037
	Warranty policies	0.099	0.114	0.114	0.142	0.128
Flexibility	Capacity	0.037	0.025	0.030	0.033	0.029
	Technological capability	0.050	0.050	0.043	0.050	0.050
	Information sharing	0.022	0.022	0.022	0.017	0.022
	Negotiability	0.035	0.035	0.038	0.035	0.046
	Customization	0.056	0.064	0.059	0.064	0.064
Total		**3.996**	3.908	3.456	3.759	3.467

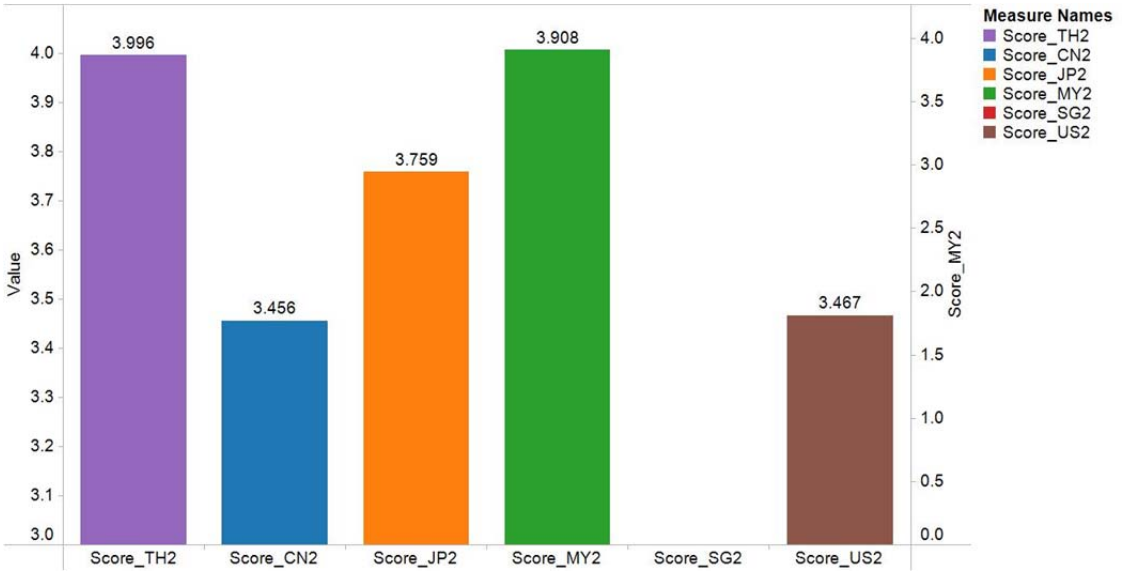

Figure 5.8

The total score of each country in the read/write component group

5.3.3 Supplier evaluation: Precision component

In the precision component group, six countries that we are focused on are all the location of the HDD suppliers which are Thailand, Malaysia, Singapore, China, Japan and USA. The results of the supplier evaluation are in table 5.7. Singapore has gained the highest total score which is 3.978. The scores for Thailand, Malaysia, China, Japan, and USA are 3.928, 3.833, 3.398, 3.493, and 3.492 respectively.

Table 5.7

The score results in all criteria-Precision component

CRITERIA	SUB CRITERIA	TH	MY	SG	CN	JP	US
Delivery	Geographic location	0.218	0.174	0.174	0.131	0.131	0.044
	Freight terms	0.183	0.170	0.183	0.118	0.157	0.157
	Trade restrictions	0.218	0.202	0.202	0.155	0.171	0.187
	Order lead time	0.800	0.640	0.693	0.533	0.640	0.560
Quality	Quality of products	0.187	0.206	0.225	0.187	0.225	0.281
	% on-time shipments	0.226	0.226	0.243	0.191	0.226	0.209
	Response to customer's request and feedback	0.253	0.234	0.253	0.214	0.214	0.234
	Certifications	0.055	0.060	0.060	0.055	0.064	0.064
	R&D	0.054	0.058	0.068	0.063	0.073	0.073

Cost	Supplier's selling price	0.727	0.727	0.727	0.800	0.436	0.546
	Internal Cost	0.325	0.325	0.295	0.236	0.295	0.310
	Ordering and invoicing cost	0.166	0.166	0.182	0.149	0.166	0.174
Reliability	Feeling of trust	0.100	0.130	0.140	0.100	0.140	0.135
	Financial position	0.054	0.090	0.078	0.060	0.084	0.081
	Country's political situation	0.043	0.087	0.109	0.087	0.109	0.076
	Currency exchange situation	0.025	0.035	0.035	0.035	0.025	0.037
	Warranty policies	0.095	0.104	0.114	0.095	0.142	0.128
Flexibility	Capacity	0.027	0.027	0.025	0.030	0.027	0.025
	Technological capability	0.037	0.040	0.040	0.040	0.047	0.045
	Information sharing	0.022	0.021	0.021	0.019	0.019	0.020
	Negotiability	0.050	0.042	0.042	0.035	0.035	0.046
	Customization	0.064	0.069	0.069	0.064	0.069	0.064
Total		3.928	3.833	**3.978**	3.398	3.493	3.492

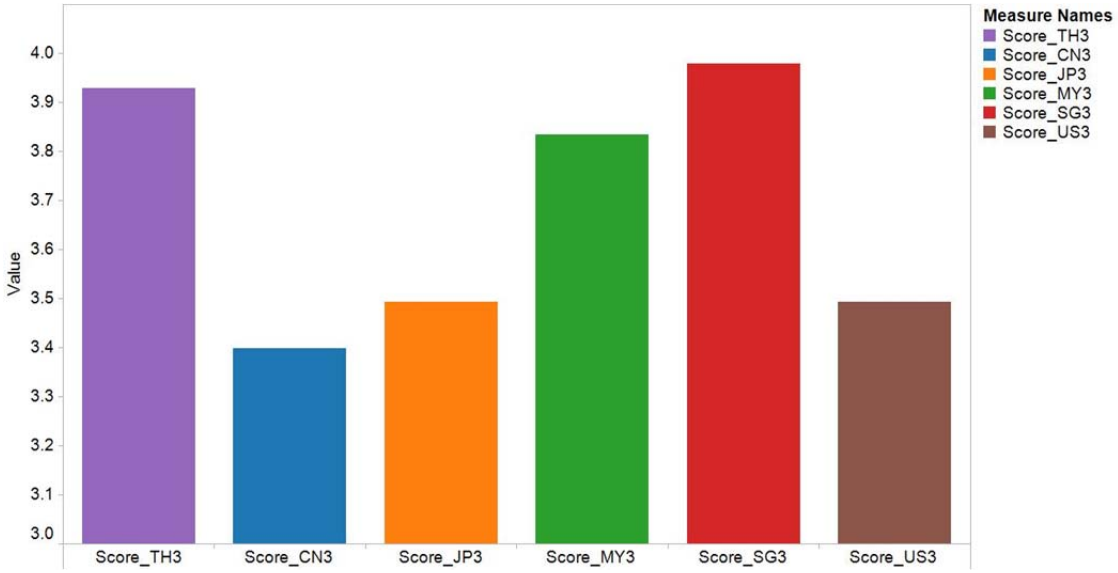

Figure 5.9

The total score of each country in the precision component group

5.3.4 Supplier evaluation: Electrical & Electronic component

For a supplier evaluation in electrical and electronic component, the calculated scores are shown in table 5.8. Six countries are the location of the HDD suppliers which are Thailand, Malaysia, Singapore, China, Japan and USA. The highest total score in this part group is Singapore which is 3.773. While the scores for

Thailand, Malaysia, China, Japan, and USA are 3.547, 3.592, 3.069, 3.387, and 3.320 respectively.

Table 5.8The score results in all criteria- Electrical & Electronic component

CRITERIA	SUB CRITERIA	TH	MY	SG	CN	JP	US
Delivery	Geographic location	0.218	0.174	0.174	0.131	0.131	0.044
	Freight terms	0.183	0.176	0.176	0.118	0.157	0.157
	Trade restrictions	0.218	0.210	0.210	0.163	0.163	0.171
	Order lead time	0.800	0.640	0.720	0.560	0.640	0.640
Quality	Quality of products	0.187	0.168	0.253	0.168	0.253	0.262
	% on-time shipments	0.209	0.183	0.235	0.156	0.183	0.174
	Response to customer's request and feedback	0.175	0.205	0.234	0.146	0.175	0.214
	Certifications	0.051	0.057	0.064	0.045	0.064	0.064
	R&D	0.044	0.058	0.073	0.051	0.073	0.068
Cost	Supplier's selling price	0.582	0.655	0.546	0.655	0.436	0.436
	Internal Cost	0.236	0.310	0.266	0.177	0.266	0.295
	Ordering and invoicing cost	0.133	0.149	0.149	0.100	0.149	0.149
Reliability	Feeling of trust	0.110	0.120	0.135	0.105	0.150	0.130
	Financial position	0.060	0.072	0.081	0.072	0.090	0.078
	Country's political situation	0.043	0.098	0.109	0.109	0.109	0.080
	Currency exchange situation	0.025	0.037	0.037	0.037	0.021	0.039
	Warranty policies	0.095	0.099	0.128	0.099	0.142	0.123
Flexibility	Capacity	0.025	0.025	0.025	0.033	0.029	0.025
	Technological capability	0.037	0.040	0.045	0.040	0.050	0.047
	Information sharing	0.019	0.020	0.017	0.014	0.017	0.019
	Negotiability	0.046	0.040	0.035	0.035	0.035	0.042
	Customization	0.053	0.056	0.064	0.056	0.056	0.064
Total		3.547	3.592	**3.773**	3.069	3.387	3.320

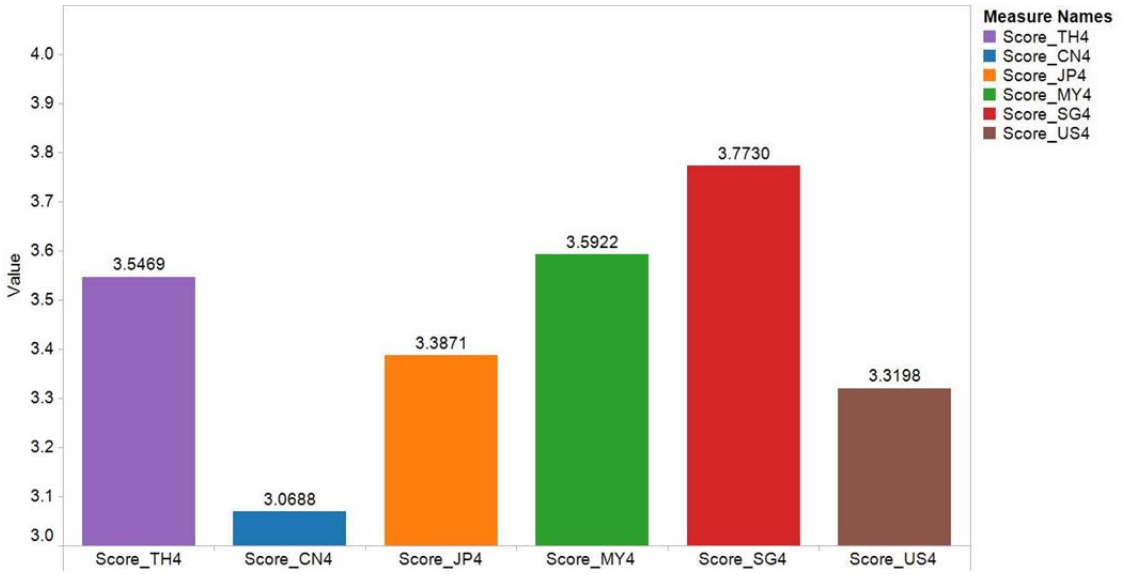

Figure 5.10

The total score of each country in the electrical & electronic component group

5.3.5 Supplier evaluation: Other component

In the other component group (i.e. seal, filter, label), there are five countries that are the location of the HDD suppliers which are Thailand, Malaysia, Singapore, China, and Japan. In Table 5.9, it shows that the highest score is 3.833 which can indicate that Thailand has the best performance of being a source of this component group for Thailand's HDD industry. The scores for Malaysia, Singapore, China, and Japan are 3.663, 3.583, 3.343, and 3.480 respectively. U.S.A. is not in the list of country that Thailand's HDD makers choose. It is unnecessary for the HDD makers to select U.S.A. to supply the component that the closer locations also have an ability to support them.

Table 5.9 The score results in all criteria- Other component

CRITERIA	SUB CRITERIA	TH	MY	SG	CN	JP
Delivery	Geographic location	0.218	0.174	0.174	0.131	0.131
	Freight terms	0.183	0.157	0.157	0.137	0.157
	Trade restrictions	0.218	0.187	0.187	0.163	0.140
	Order lead time	0.800	0.640	0.640	0.560	0.640
Quality	Quality of products	0.206	0.225	0.225	0.168	0.281
	% on-time shipments	0.226	0.209	0.209	0.156	0.209
	Response to customer's	0.234	0.234	0.175	0.175	0.234

	request and feedback					
	Certifications	0.047	0.064	0.051	0.038	0.064
	R&D	0.054	0.073	0.058	0.051	0.073
Cost	Supplier's selling price	0.727	0.655	0.655	0.873	0.436
	Internal Cost	0.295	0.266	0.266	0.221	0.266
	Ordering and invoicing cost	0.149	0.149	0.149	0.100	0.149
Reliability	Feeling of trust	0.090	0.120	0.120	0.105	0.150
	Financial position	0.054	0.072	0.090	0.054	0.090
	Country's political situation	0.029	0.087	0.109	0.098	0.109
	Currency exchange situation	0.025	0.042	0.042	0.037	0.021
	Warranty policies	0.085	0.114	0.114	0.099	0.142
Flexibility	Capacity	0.030	0.025	0.025	0.037	0.025
	Technological capability	0.033	0.040	0.040	0.045	0.050
	Information sharing	0.021	0.022	0.017	0.017	0.017
	Negotiability	0.046	0.046	0.035	0.029	0.035
	Customization	0.064	0.064	0.048	0.048	0.064
Total		**3.833**	3.663	3.583	3.343	3.480

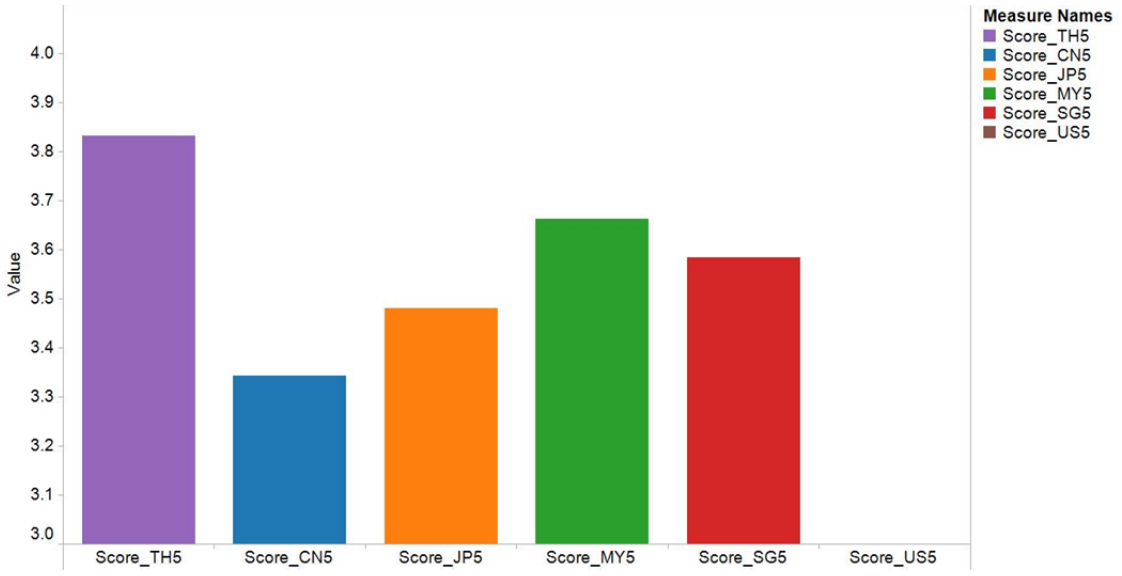

Figure 5.11

The total score of each country in the other component group

5.3.6 Supplier evaluation: Indirect material

For a supplier evaluation in the indirect material group, the calculated scores are shown in table 5.10. Six countries are the location of the HDD suppliers which are Thailand, Malaysia, Singapore, China, Japan and USA. The highest total

score in this part group is Singapore which is 3.673. While the scores for Thailand, Malaysia, China, Japan, and USA are 3.532, 3.553, 3.293, 3.394, and 3.296 respectively. The level of technology to produce the indirect material is not high. Almost every country is able to produce it. Some of the suppliers in Thailand of this group are Thai manufacturer. Thai supplier may have a high competitive advantage in delivery criteria but have a low competitive advantage in quality criteria. According from the interview with the HDD makers in Thailand, some of Thai suppliers are not qualify to entry to the HDD industry due to their capability in quality, and capacity.

Table 5.10 The score results in all criteria- Indirect material

CRITERIA	SUB CRITERIA	TH	MY	SG	CN	JP	US
Delivery	Geographic location	0.218	0.174	0.174	0.131	0.131	0.044
	Freight terms	0.183	0.170	0.176	0.137	0.157	0.157
	Trade restrictions	0.218	0.202	0.210	0.163	0.171	0.171
	Order lead time	0.800	0.640	0.640	0.640	0.640	0.640
Quality	Quality of products	0.168	0.187	0.196	0.168	0.243	0.262
	% on-time shipments	0.174	0.209	0.235	0.183	0.209	0.209
	Response to customer's request and feedback	0.195	0.175	0.205	0.146	0.175	0.195
	Certifications	0.034	0.043	0.057	0.051	0.055	0.060
	R&D	0.034	0.049	0.066	0.051	0.063	0.068
Cost	Supplier's selling price	0.655	0.655	0.655	0.655	0.436	0.436
	Internal Cost	0.266	0.295	0.266	0.310	0.295	0.266
	Ordering and invoicing cost	0.149	0.149	0.149	0.149	0.149	0.149
Reliability	Feeling of trust	0.080	0.120	0.135	0.075	0.140	0.140
	Financial position	0.054	0.078	0.090	0.045	0.084	0.078
	Country's political situation	0.036	0.094	0.109	0.098	0.109	0.080
	Currency exchange situation	0.025	0.039	0.042	0.037	0.025	0.039
	Warranty policies	0.076	0.114	0.099	0.099	0.142	0.123
Flexibility	Capacity	0.019	0.025	0.025	0.029	0.025	0.027
	Technological capability	0.027	0.033	0.040	0.035	0.040	0.040
	Information sharing	0.013	0.015	0.014	0.014	0.017	0.017
	Negotiability	0.046	0.035	0.035	0.029	0.035	0.038
	Customization	0.064	0.053	0.056	0.048	0.053	0.059
Total		3.532	3.553	**3.673**	3.293	3.394	3.296

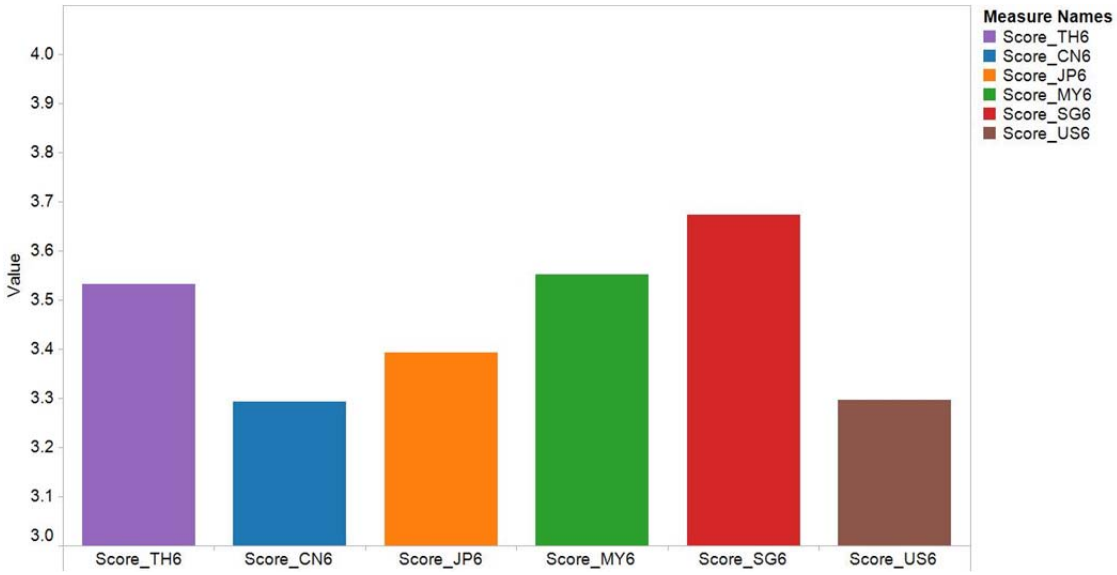

Figure 5.12

The total score of each country in the indirect material group

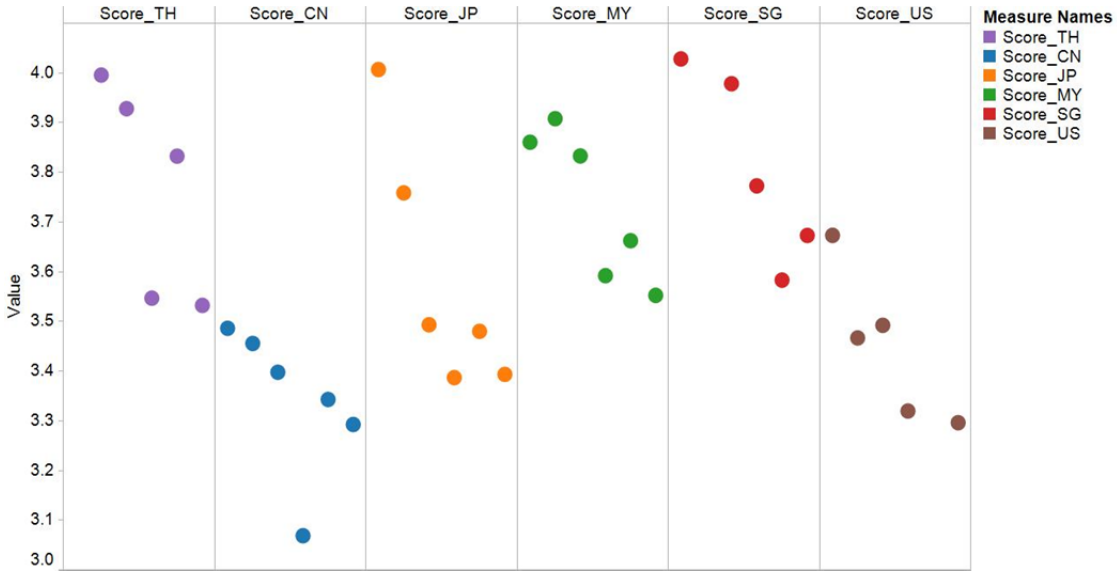

Figure 5.13

The overall total score of each country

CHAPTER VI
CONCLUSION

This is the last chapter of the thesis. The conclusion of the study will be summarized in this chapter. The contents are also included the suggestion for future study.

6.1 Conclusion

The objectives of the thesis are developing the model for evaluate the suppliers of Thailand's HDD industry and assessing their performances. Data were collected from the HDD makers and their suppliers in Thailand by using the questionnaires. Firstly, we identified which countries are the sources of the HDD component for Thailand. Secondly, we calculated the weighting of each criterion by employing the APH method. Once we had the results of the priority of those criteria, then we can evaluate the HDD suppliers by comparing at the nation level.

The results from mapping the upstream of the HDD industry in Thailand pointed out that there is no supplier in Thailand who can support the hi-tech component (i.e. Wafer, Media). The HDD makers in Thailand have to import those parts from other countries. Malaysia, Singapore, China, Japan and U.S.A. are all the important players as the upstream of HDD makers. While the material prices from Japan and U.S.A might be expensive more than other countries but the HDD makers are still need those quality components from them.

6.1.1 Findings from criteria weighting: Reliability vs. Cost

In order to get the insight idea, we studied the weighting separately between HDD makers and their suppliers. The main criteria weighting from the HDD makers' responses, cost is in the highest rank while flexibility is in the lowest rank. Cost is the most important because the HDD makers are focused on the cost

competitive advantage due to the nature of HDD industry is a very high-volume intensive industry and has to compete among the other companies in the selling price. The findings from the HDD suppliers indicate that reliability is in the highest rank while flexibility is in the lowest rank. For the sub-criteria global average weighting, the results from the HDD makers and their suppliers are both agreed that supplier's selling price is the most important factor and information sharing is the least important factor. These reflect that the level of their collaboration is low.

It can be noticed that the HDD suppliers in Thailand ranked reliability as the top priority importance while the HDD makers ranked cost as the top priority importance. As for the HDD suppliers, this study surveyed the HDD suppliers in Thailand only. The aspect from the HDD suppliers as the chosen not the chooser, the new comer suppliers have to make the first impression with the HDD makers and their headquarters by reliability. The suppliers' images from their reputation, authorized capital affect the HDD companies' decisions. The supplies have to build up a decent reliability to attract the HDD companies. The dominant position of the suppliers as the reliability company can be easily judged while other factors need the further investigation from the HDD companies.

From the interview with the HDD makers, reliability was built from the trust relationship between the headquarters of their company and the HDD suppliers. The supplier selections from reliability factor are mostly decided by their headquarters not by the HDD makers in Thailand. The longer relationship between the HDD headquarters and the suppliers help the suppliers easier to be chosen to supply the materials to the HDD makers. The sub criteria in reliability that ranked by the HDD makers as the highest important is feeling of trust which supports this idea. Therefore, the decisions from the HDD makers in Thailand mostly are relevant with other criteria such as cost and quality.

6.1.2 Findings from supplier evaluation

An analysis in each location of suppliers is also conducted. We used the results from the HDD makers' weighting to calculate the score of each country. From the total findings, Singapore have the highest score in hi-tech component group, precision group, electrical and electronic component, and indirect material group while

Thailand is considered to be competitive suppliers' bases in read/write component group and other component group. From the follow up discussion with the HDD makers, Singapore has a good performance in both cost and quality but the variety and number of suppliers in Singapore is not as many as Thailand. Singapore is now shifting itself from the manufacturing base to the research and development center. On the other hand, the suppliers that owned by Thai company is facing the difficulty in entry to the HDD industry. They need to have a large amount of capacity and ability to response the HDD makers' needs. It is more likely that in the future only a few of Thai suppliers to join this industry unless they have a support from the government. The HDD makers in Thailand suggested that there should be a consortium that can represent the Thai suppliers and delegate the job to the Thai suppliers. A consortium can help the Thai suppliers to take a risk and build a trust from the HDD makers. For now, the opportunity for Thai suppliers is the indirect material because the volume of this type of material is not as large as other groups and not requires the hi-technology.

The findings from this thesis can compare the significant criteria of the HDD industry with other available literatures. There are three similar literatures on Thailand, Taiwanese, and Chinese manufacturers studied by Phusavat and Kanchana (2007), Chen (1999), and Chao et al.(2002) respectively. The definitions of each criterion may not be the same but their studies are also compatible with this thesis.

From table 6.1, our study is difference with other studies. Our findings reflect that cost is the top priority while other passed studies in Thailand and China are considered that cost is not important. This is because those studies are focused on the overall manufacturing not specific to the type of products and if we look at the entire manufacturing, Thailand and China with an advantage in labor wages, already have competitiveness in cost. Unlike our study, we are specifically focused on the HDD industry and those HDD companies have many suppliers in both Thailand and China. Due to the high competitive in cost per unit, the HDD makers see cost as the most important determinant.

Table 6.1 The illustration on the comparison with other studies

Main criteria	Our study based on the HDD makers' aspect	Our study based on the HDD suppliers	Thailand (Phusavat and Kanchana, 2007)	Taiwan (Chen, 1999)	China (Zhao et al, 2002)
Cost	1	2	4	2	4
Delivery	2	4	2	4	1
Quality	3	3	1	1	3
Reliability	4	1	-	-	-
Flexibility	5	5	3	3	2

If we look closer to the sub-criteria, all of those studies in those countries are considered research and development in a low rank, except Taiwan. This can imply that Taiwan is focusing in the innovation which can help Taiwan develop their technology level. In the long term, suppliers in Thailand might not be able to compete with other nations such as China, India, Vietnam because those countries can offer a low manufacturing cost. In order to enhance their competitiveness, suppliers in Thailand have to improve their human capital, knowledge among workers and intellectual capital to create their value added and unique skills.

6.2 Future research

6.2.1 Future study recommendation

This study can be adapted with other future study on the criteria in supplier's selection, especially in the industry that similar to the HDD industry. Moreover, the future study can also conduct the supplier's evaluation by using the weightings in each criterion from our results.

For a further research, it should be a study that comparing the important criteria between the specific important industry in Thailand such as automobile

industry, integrated circuit industry, electrical appliance industry. The differences in the important criteria in supplier selection in each industry might be affected from the level of technology.

6.2.2 Remarks for this study limitations

Firstly, other than these studied criteria, there is also the impacted factor from the corporations between the HDD makers and their suppliers. Some of components need the suppliers to supervise with the HDD makers during the component design stage. The suppliers will gain more competitive advantage if they located themselves near the HDD makers. This is why there is a presence of many HDD suppliers in Thailand.

Secondly, this thesis categorized the HDD components into 6 groups. It should be noted that each part by itself might has a difference weight in the criteria. For instance, a motor and a PCB are in the electrical and electronics group. The motor is the part that is only owned by a few of companies while there are many suppliers can produce the PCB. Hence, the decision and the wright of each criterion to choose those suppliers might have some differences. If we studied every component separately, the questionnaire would be too complicated and difficult to get all the answer from the respondents. The future research might choose to study in only some specific components to get more insight result.

Lastly, the limitation of this study is the data that have been used are not included all of the four HDD companies in Thailand (three out of four HDD companies cooperated with this study) due to their confidentiality. The number of respondents from the HDD suppliers is also low. The survey from the HDD suppliers by using the mail might not be affective as much as collecting data from the face-to-face interviews. However it will take much more resources to complete the study (e.g. time, cost).

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APPENDICES

APPENDIX A
THE DEVELOPED QUESTIONNAIRE

การประเมินศักยภาพ (Evaluation)

กรุณาให้คะแนนแยกตามแต่ละปัจจัย โดยเปรียบเทียบศักยภาพของแต่ละประเทศในฐานะที่มีบริษัทที่เป็น Supplier ให้กับอุตสาหกรรมฮาร์ดดิสก์ไดรฟ์ในประเทศไทย โดยแต่ละปัจจัยสามารถให้คะแนนได้ตั้งแต่ 1 ถึง 5 ซึ่งคะแนนจะมีความหมายในแต่ละปัจจัยตามที่ระบุไว้ในตาราง

รายละเอียดในการให้คะแนน :

- เป็นตารางสำหรับประเมินศักยภาพในแต่ละปัจจัย เปรียบเทียบระหว่าง Supplier ที่ตั้งในไทยและ Supplier ที่ตั้งในต่างประเทศ
- ท่านสามารถให้คะแนนได้ตั้งแต่ 1 ถึง 5 ซึ่งแต่ละคะแนนจะมีความหมายในแต่ละปัจจัยตามที่ระบุไว้ในตาราง
- อักษรย่อในตารางแทนชื่อประเทศดังต่อไปนี้ :
  TH = Thailand (ไทย), MY = Malaysia (มาเลเซีย), SG = Singapore (สิงคโปร์), CN = China (จีน),
  JP = Japan (ญี่ปุ่น), US = United States of America (สหรัฐอเมริกา)

ตัวอย่างการให้คะแนน :

Criteria	Factors	Countries of Supplier								Score Remark
		TH	MY	SG	CN	HK	TW	JP	US	
Delivery	Geographic location ตำแหน่งทางภูมิศาสตร์ของ Supplier	5	4		3			3	1	5 : ตั้งอยู่ในประเทศไทย 4 : ตั้งอยู่ในเอเชียตะวันออกเฉียงใต้ 3 : ตั้งอยู่ในเอเชียตะวันออก 2 : ตั้งอยู่ในส่วนที่เหลือของทวีปเอเชีย 1 : ตั้งอยู่นอกทวีปเอเชีย
	Order lead time ช่วงเวลานำในการสั่งสินค้าจากSupplier มายังบริษัท HDD Maker ในประเทศไทย	5	4		4			3	2	5 : ดีเยี่ยม 4 : ดี 3 : พอใช้ 2 : แย่ 1 : แย่มาก

หมายเหตุ : ตัวเลขในตารางตัวอย่างเป็นคะแนนที่สมมติขึ้นเพื่อเป็นตัวอย่างเท่านั้น ทั้งนี้คะแนนที่ท่านให้อาจแตกต่างจากตัวอย่างข้างต้น

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Delivery	Geographic location ตำแหน่งทางภูมิศาสตร์ของ Supplier							5 : ตั้งอยู่ในประเทศไทย 4 : ตั้งอยู่ในเอเชียตะวันออกเฉียงใต้ 3 : ตั้งอยู่ในเอเชียตะวันออก 2 : ตั้งอยู่ในส่วนที่เหลือของทวีปเอเชีย 1 : ตั้งอยู่นอกทวีปเอเชีย
	Freight terms ขั้นตอนและกระบวนการการขนส่งรวมไปถึงที่การคุลกากรจากประเทศ Supplier มายังประเทศไทย							5 : ดีเยี่ยม - มีความสะดวกในการขนส่งสูง, พิธีการศุลกากรไม่ยุ่งยาก 4 : ดี – มีความสะดวกในการขนส่งสูง, พิธีการศุลกากรเป็นไปตามขั้นตอนปกติ 3 : พอใช้ - มีความสะดวกในการขนส่งเป็นปกติ, พิธีการศุลกากรเป็นไปตามขั้นตอนปกติ 2 : แย่ - การขนส่งทำได้ลำบาก, พิธีการศุลกากรเป็นไปตามขั้นตอนปกติ 1 : แย่มาก - การขนส่งทำได้ลำบาก, พิธีการศุลกากรยุ่งยาก
	Trade restrictions ข้อจำกัดทางการค้า อัตราภาษี (Tariffs and Custom Duties) จากประเทศ Supplier มายังประเทศไทย							5 : อยู่ภายใต้ FTA 4 : ข้อจำกัดน้อย ภาษีต่ำ 3 : ข้อจำกัดปานกลาง ภาษีปานกลาง 2 : ข้อจำกัดสูง ภาษีสูง 1 : ข้อจำกัดสูงมาก ภาษีสูงมาก
	Order lead time ช่วงเวลาในการสั่งสินค้า จาก Supplier มายังบริษัท HDD Maker ในประเทศไทย							5 : ดีเยี่ยม (น้อยกว่า 7 วัน) 4 : ดี (8 -15 วัน) 3 : พอใช้ (16 -30 วัน) 2 : แย่ (31-45 วัน) 1 : แย่มาก (มากกว่า 45 วัน)

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Quality	Quality of product (Yield) คุณภาพของสินค้า อัตราส่วนประสิทธิภาพจาก Supplier							5 : ดีเยี่ยม (มากกว่า 99.5%) 4 : ดี (มากกว่า 95 – 99.5%) 3 : พอใช้ (มากกว่า 90 - 95%) 2 : แย่ (มากกว่า 85% - 90%) 1 : แย่มาก (ต่ำกว่า 85%)
	Percent of on-time shipment อัตราการส่งของตรงเวลาของ Supplier							5 : ดีเยี่ยม (มากกว่า 98%) 4 : ดี (มากกว่า 95 - 98%) 3 : พอใช้ (มากกว่า 90 - 95%) 2 : แย่ (มากกว่า 85% - 90%) 1 : แย่มาก (ต่ำกว่า 85%)
	Response to customer's request and feedback การตอบสนองจาก Supplier ต่อคำขอหรือข้อคิดเห็นต่างๆของ HDD Maker							5 : ดีเยี่ยม (ตอบสนองตามความต้องการของบริษัทมากกว่า 95%) 4 : ดี (ตอบสนองตามความต้องการของบริษัทมากกว่า 90- 95%) 3 : พอใช้ (ตอบสนองตามความต้องการของบริษัทมากกว่า 85-90%) 2 : แย่(ตอบสนองตามความต้องการของบริษัทมากกว่า 80-85%) 1 : แย่มาก(ตอบสนองตามความต้องการของบริษัทต่ำกว่า 80%)

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Quality	Certifications ใบรับรองคุณภาพของ Supplier							5 : ดีเยี่ยม - ได้มาตรฐาน ISO และ ใบรับรองคุณภาพอื่นๆในระดับสากล 4 : ดี - ได้มาตรฐาน ISO 3 : พอใช้ – ได้ใบรับรองคุณภาพอื่นๆในระดับสากล 2 : แย่ – ได้ใบรับรองคุณภาพระดับประเทศ 1 : แย่มาก - ไม่มีใบรับรองคุณภาพ
	Research and Development (R&D) programs การวิจัยและพัฒนาอย่างต่อเนื่องของ Supplier ให้ก้าวทันในอุตสาหกรรม HDD							5 : ดีเยี่ยม – แสดงให้เห็นถึงการวิจัยและพัฒนาที่สูงอยู่ตลอดเวลา 4 : ดี - มีการวิจัยและพัฒนาในเกณฑ์ดี 3 : พอใช้ – มีการวิจัยและพัฒนาในเกณฑ์ปกติ 2 : แย่ – มีการวิจัยและพัฒนาในเกณฑ์ต่ำ 1 : แย่มาก - ไม่แสดงให้เห็นถึงการวิจัยและพัฒนา

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Cost	**Supplier's selling price** ราคาที่ Supplier ขายชิ้นส่วนประกอบให้กับ HDD Maker							5 : ราคาต่ำมาก 4 : ราคาต่ำกว่าเกณฑ์เฉลี่ย 3 : ราคาอยู่ในเกณฑ์เฉลี่ย 2 : ราคาสูงกว่าเกณฑ์เฉลี่ย 1 : ราคาสูงมาก
	Internal cost ค่าใช้จ่ายอื่นๆที่อาจเกิดในบริษัท HDD Maker อันเนื่องมาจากการซื้อสินค้ามาจาก Supplier เช่น ค่าขนส่งเพิ่มเติม, ค่าของที่ชำรุด, ของเสีย เป็นต้น							5 : ค่าใช้จ่ายต่ำมาก 4 : ค่าใช้จ่ายต่ำกว่าเกณฑ์เฉลี่ย 3 : ค่าใช้จ่ายอยู่ในเกณฑ์เฉลี่ย 2 : ค่าใช้จ่ายสูงกว่าเกณฑ์เฉลี่ย 1 : ค่าใช้จ่ายสูงมาก
	Ordering and invoicing ค่าใช้จ่ายที่อาจเกิดในบริษัท HDD Maker ในกระบวนการสั่งสินค้าจาก Supplier และออกเอกสารต่างๆ (พิจารณาจากระบบ EDI , การใช้คนมากหรือน้อย)							5 : ต่ำมาก – มีระบบ EDI มาช่วย ใช้คนน้อย ทำให้ประหยัดมาก 4 : ต่ำ - มีระบบ EDI ขั้นตอนเป็นไปตามปกติ 3 : ปานกลาง - ไม่มีระบบ EDI ขั้นตอนเป็นไปตามปกติ 2 : สูง – ไม่มีระบบ EDI ใช้คนมาก ขั้นตอนยุ่งยาก 1 : สูงมาก - ไม่มีระบบ EDI ใช้คนมาก ขั้นตอนยุ่งยากมาก

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Flexibility	Capacity กำลังในการผลิตของ Supplier							5 : สูงมาก – สามารถรองรับ Demand ที่เพิ่มขึ้นสูงมากอย่างกะทันหัน และสามารถผลิตได้ทันเวลา 4 : สูง - สามารถรองรับ Demand ที่เพิ่มขึ้นมาก และสามารถผลิตได้ทันเวลา 3 : ปกติ - สามารถรองรับ Demand ในระดับปกติ หรือเพิ่มขึ้นไม่มากนัก และส่วนใหญ่สามารถผลิตได้ทันเวลา 2 : ต่ำ - ไม่สามารถรองรับ Demand ที่เพิ่มขึ้น และบางครั้ง ไม่สามารถผลิตได้ทันเวลา 1 : ต่ำมาก – ไม่สามารถรองรับ Demand ที่เพิ่มขึ้น และบ่อยครั้ง ไม่สามารถผลิตได้ทันเวลา
	Technological Capability ระดับเทคโนโลยีในการผลิตของ Supplier							5 : ระดับเทคโนโลยีสูงมาก มีความทันสมัยมาก 4 : ระดับเทคโนโลยีสูง มีความทันสมัย 3 : ระดับเทคโนโลยีปกติ มีการพัฒนาต่อเนื่อง 2 : ระดับเทคโนโลยีต่ำ มีการพัฒนาน้อย 1 : ระดับเทคโนโลยีต่ำมาก มีการพัฒนาน้อยมาก
	Information sharing การแลกเปลี่ยนข้อมูล เช่น ระดับสินค้าคงคลัง แผนการผลิต สถานะสินค้า เป็นต้น ระหว่าง Supplier กับ HDD Maker ในประเทศไทย							5 : ดีเยี่ยม - เป็นแบบ Real time ด้วยระบบ EDI 4 : ดี - มีการ update ภายใน 7 วัน 3 : พอใช้ - มีการ update ภายใน 8-15 วัน 2 : แย่ - มีการ update ภายใน 16-30 วัน 1 : แย่มาก - มีการ update ภายใน ตั้งแต่ 31 วันขึ้นไป หรือไม่มีเลย

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Flexibility	**Negotiability** ความสามารถในการเจรจาต่อรองกันได้ ระหว่าง Supplier กับ HDD Maker							5 : ดีเยี่ยม – มีการสื่อสารเจรจาต่อรองสะดวกอยู่ในเกณฑ์ดีมาก 4 : ดี – มีการสื่อสารเจรจาต่อรองสะดวกมากอยู่ในเกณฑ์ดี 3 : พอใช้- มีการสื่อสารเจรจาต่อรองสะดวกมากอยู่ในเกณฑ์ปานกลาง 2 : แย่- มีการสื่อสารเจรจาต่อรองสะดวกมากอยู่ในเกณฑ์ต่ำ 1 : แย่มาก- มีการสื่อสารเจรจาต่อรองยุ่งยากมากและเป็นไปได้ยาก
	Customization ความสามารถของ Supplier ในการปรับเปลี่ยนรูปแบบสินค้าตามที่ HDD Maker ต้องการ							5 : ดีเยี่ยม – มีความสามารถในการปรับเปลี่ยนตามความต้องการของลูกค้าสูงมาก 4 : ดี– มีความสามารถในการปรับเปลี่ยนตามความต้องการของลูกค้าสูง 3 : พอใช้– มีความสามารถในการปรับเปลี่ยนตามความต้องการของลูกค้าปานกลาง 2 : แย่– มีความสามารถในการปรับเปลี่ยนตามความต้องการของลูกค้าต่ำ 1 : แย่มาก – มีความสามารถในการปรับเปลี่ยนตามความต้องการของลูกค้าต่ำมาก

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Reliability	Feeling of trust ความเชื่อถือที่ HDD Maker มีต่อ Supplier							5 : มีระดับความสัมพันธ์และความเชื่อถือสูงมาก 4 : มีระดับความสัมพันธ์และความเชื่อถือสูง 3 : มีระดับความสัมพันธ์และความเชื่อถือปานกลาง 2 : มีระดับความสัมพันธ์และความเชื่อถือน้อย 1 : มีระดับความสัมพันธ์และความเชื่อถือน้อยมาก
	Financial Position สถานะการเงินของ Supplier							5 : ทุนจดทะเบียนและสถานะการเงินดีเยี่ยม 4 : ทุนจดทะเบียนและสถานะการเงินดี 3 : ทุนจดทะเบียนและสถานะการเงินปานกลาง 2 : ทุนจดทะเบียนและสถานะการเงินต่ำ 1 : ทุนจดทะเบียนและสถานะการเงินต่ำมาก
	Country's political situation สถานการณ์ทางการเมืองของประเทศที่ Supplier ตั้งอยู่							5 : มีเสถียรภาพสูงมาก 4 : มีเสถียรภาพสูง 3 : มีเสถียรภาพระดับปกติ 2 : มีเสถียรภาพต่ำ 1 : ไม่มีเสถียรภาพ

Criteria	Factors	Countries of Supplier						Score Remark
		TH	MY	SG	CN	JP	US	
Reliability	Currency exchange situation สถานการณ์ของอัตราแลกเปลี่ยนเงินระหว่างประเทศ Supplier กับประเทศไทย							5 : ดีเยี่ยม (ค่าเงินอ่อนมาก) 4 : ดี (ค่าเงินอ่อน) 3 : ปกติ (ค่าเงินปกติ) 2 : แย่ (ค่าเงินแข็ง) 1 : แย่มาก (ค่าเงินแข็งมาก)
	Warranty policies เงื่อนไขการรับประกันสินค้าของ Supplier							5 : มีการรับผิดชอบต่อความเสียหายและการรับประกันของสินค้าดีเยี่ยม 4 : มีการรับผิดชอบต่อความเสียหายและการรับประกันของสินค้าดี 3 : มีการรับผิดชอบต่อความเสียหายและการรับประกันของสินค้าพอใช้ 2 : มีการรับผิดชอบต่อความเสียหายและการรับประกันของสินค้าต่ำ 1 : มีการรับผิดชอบต่อความเสียหายและการรับประกันของสินค้าต่ำมาก

<u>ความสำคัญของ Criteria</u>

ท่านคิดว่า Criteria ใดมีความสำคัญต่อการเลือก Supplier ของบริษัทผลิตและประกอบฮาร์ดดิสก์ไดรฟ์

กรุณาวงกลมล้อมรอบตัวเลขเพียงหนึ่งตัวระหว่างปัจจัยแต่ละคู่ เพื่อให้น้ำหนักความสำคัญระหว่างปัจจัยแต่ละคู่นั้นๆ ว่าท่านให้น้ำหนักกับปัจจัยฝั่งใดมากกว่ากันมากน้อยเพียงใด

รายละเอียดในการให้น้ำหนัก :

- ถ้าท่านวงกลมล้อมรอบเลข 9 ทางฝั่งซ้ายมือ แสดงว่าท่านให้น้ำหนักความสำคัญปัจจัยทางฝั่ง A (ฝั่งซ้าย) อย่างเต็มที่ น้ำหนักทางฝั่ง A จะลดลงเรื่อยๆจากเลข 9 จนถึงเลข 2
- ถ้าท่านเลือกเลข 1 หมายถึงปัจจัยทั้งสองฝั่งมีน้ำหนักความสำคัญเท่าเทียมกัน
- เช่นเดียวกัน น้ำหนักของปัจจัยทางฝั่ง B (ฝั่งขวา) จะเพิ่มขึ้นเรื่อยๆจากเลข 2 จนถึงเลข 9 ซึ่งถ้าท่านวงกลมล้อมรอบเลข 9 ทางฝั่งขวามือ แสดงว่าท่านให้น้ำหนักความสำคัญปัจจัยทางฝั่ง B (ฝั่งขวา) อย่างเต็มที่
- **กรุณาให้น้ำหนักเปรียบเทียบระหว่างปัจจัยจนครบทุกคู่**

ตัวอย่างการให้น้ำหนัก :

A	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	B
	A important / A and B equally important / B important	
Main criteria		
Delivery	9 8 7 **(6)** 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility
Delivery	9 8 7 6 5 4 **(3)** 2 1 2 3 4 5 6 7 8 9	Cost
Delivery	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 **(8)** 9	Quality
Delivery	9 **(8)** 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Reliability
Flexibility	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 **(9)**	Cost
Flexibility	9 8 7 6 5 4 3 2 1 2 3 4 5 **(6)** 7 8 9	Quality
Flexibility	9 8 7 6 5 4 3 2 **(1)** 2 3 4 5 6 7 8 9	Reliability
Cost	9 8 7 6 5 4 3 2 1 2 3 **(4)** 5 6 7 8 9	Quality
Cost	9 8 7 6 5 4 3 2 1 2 **(3)** 4 5 6 7 8 9	Reliability
Quality	9 8 7 6 **(5)** 4 3 2 1 2 3 4 5 6 7 8 9	Reliability

หมายเหตุ : ในตารางตัวอย่างเป็นน้ำหนักความสำคัญที่สมมติขึ้นเพื่อเป็นตัวอย่างเท่านั้น ทั้งนี้น้ำหนักความสำคัญที่ท่านให้อาจแตกต่างจากตัวอย่างข้างต้น

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
	A important								A and B equally important						B important			
Main criteria																		
Delivery	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Flexibility
Delivery	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost
Delivery	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Quality
Delivery	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reliability
Flexibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost
Flexibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Quality
Flexibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reliability
Cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Quality
Cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reliability
Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reliability
Delivery criterion																		
Geographic location	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Freight terms
Geographic location	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Trade restrictions
Geographic location	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Order lead time
Freight terms	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Trade restrictions
Freight terms	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Order lead time
Trade restrictions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Order lead time
Flexibility criterion																		
Capacity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Technological capability
Capacity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Information sharing
Capacity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Negotiability
Capacity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customization
Technological capability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Information sharing
Technological capability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Negotiability
Technological capability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customization
Information sharing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Negotiability
Information sharing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customization
Negotiability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customization

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
	A important							A and B equally important					B important					
Cost criterion																		
Supplier's selling price	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Internal cost
Supplier's selling price	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ordering and invoicing
Internal cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ordering and invoicing
Quality criterion																		
Quality of products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% on-time shipments
Quality of products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Response to customer's request and feedback
Quality of products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Certifications
Quality of products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Research and development (R&D) programs
% on-time shipments	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Response to customer's request and feedback
% on-time shipments	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Certifications
% on-time shipments	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Research and development (R&D) programs
Response to customer's request and feedback	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Certifications
Response to customer's request and feedback	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Research and development (R&D) programs
Certifications	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Research and development (R&D) programs
Reliability criterion																		
Feeling of trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Financial position
Feeling of trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Country's political situation
Feeling of trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Currency exchange situation
Feeling of trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Warranty policies
Financial position	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Country's political situation
Financial position	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Currency exchange situation
Financial position	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Warranty policies
Country's political situation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Currency exchange situation
Country's political situation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Warranty policies
Currency exchange situation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Warranty policies

APPENDIX B

MAIN COMPONENTS OF HARD DISK DRIVE

The goal of this section is to show that what are its main parts, how do they look and what are these parts names and abbreviations.

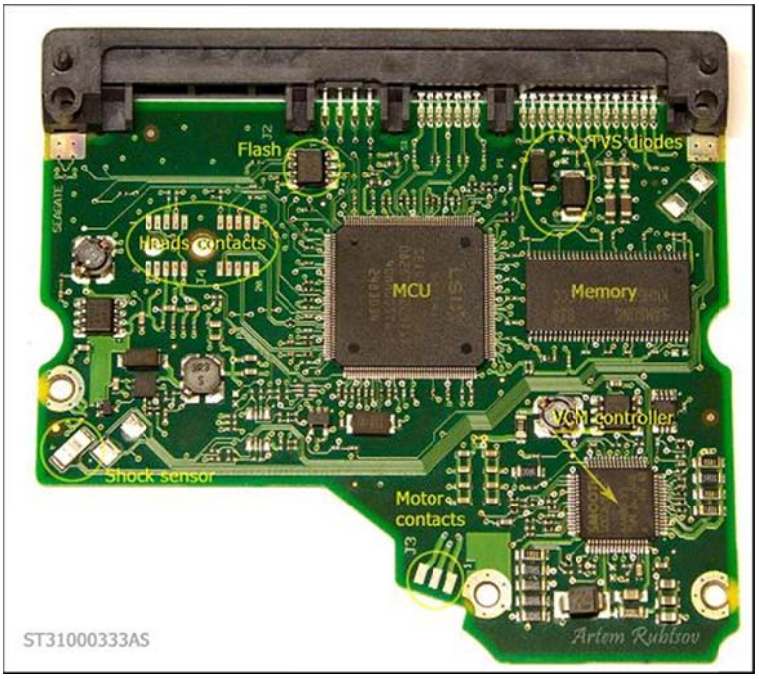
HDD

Source: http://hddscan.com/

Printed Circuit Board

Printed Circuit Board (PCB) is the piece of green woven glass and copper with SATA and power connectors. PCB holds on place and wires electronic components of HDD.

PCB



Source: http://hddscan.com/

The heart of PCB is the chip called Micro Controller Unit (MCU). On modern HDD, MCU usually consists of Central Processor Unit (CPU) which makes all calculations and read/write channel. The read/write channel is special unit which converts analog signals from heads into digital information during read process and encodes digital information into analog signals when drive needs to write. MCU also has input/output ports to control everything on PCB and transmit data through SATA interface. The next important chip is memory chip. CPU consumes some memory to store some firmware. Next chip is Voice Coil Motor (VCM) controller. This controller controls spindle motor rotation and heads movements. Shock sensor can detect excessive shock applied on a drive and send signal to VCM controller. VCM controller immediately parks heads and sometimes spins down the drive. Another protection device called Transient Voltage Suppression diode or TVS diode. It protects PCB from power surges from external power supply.

Media

The media (or platters) is used for store the data. Media made of polished aluminum or glass and covered with several layers of different compounds including ferromagnetic layer which actually stores all the data.

HDA

Source: http://hddscan.com/

Dumper

Part of the media covered with the dumper. Dumpers sometimes called as separators located between media, they reduce air fluctuations and acoustic noise. Usually dumpers made of aluminum or plastic.

Dumper

Source: http://hddscan.com/

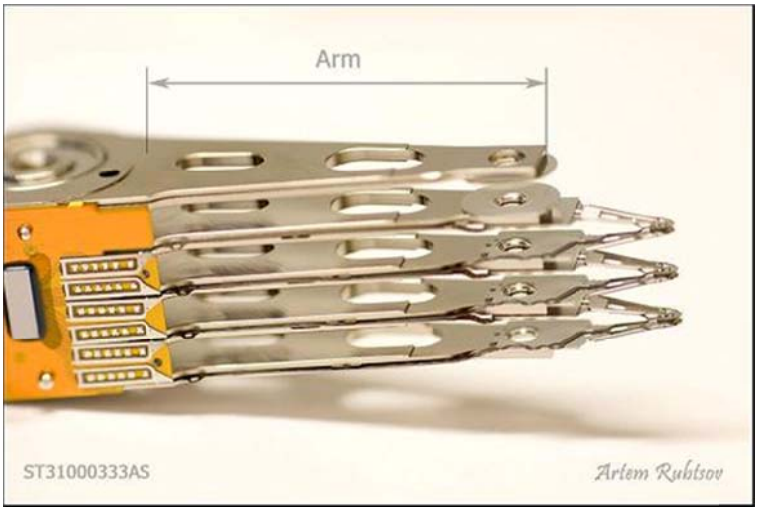
Read-Write Heads

The media are accessed for read and write operations using the read-write heads mounted on the top and bottom surfaces of each media. These read-write heads are the interface between the magnetic physical media and the electronic components. The heads are mounted on head sliders. The function of the slider is to support the head and hold it in the correct position. The sliders are suspended over the surface of the media at the ends of suspensions. The suspensions are thin pieced of lightweight metal usually triangular in shape. A set of slider, suspension and tubing wire is called Head Gimbal Assembly (HGA). The suspensions are all mechanically fused into a single structure that is moved around the surface of the media by the actuator. A set of HGA that is connected to actuator, coil assembly, and flexible printed circuit (FPC) becomes a complete read-write set can be called Head Stack Assembly (HSA).

Slider

Source: http://hddscan.com/

Arm



Source: http://hddscan.com/

HGA

Source: http://hddscan.com/

HSA

Source: http://hddscan.com/

Clamp

The platters clamp squeezes the media into the media packet. Media sitting on the spindle hub, the media clamp creates enough friction to hold media on the hub when spindle rotates.

Clamp

Source: http://hddscan.com/

Spacer ring

The spacer ring is a precision detail made of non-magnetic alloy or polymer. The media lies on spacer rings. Thus, there is a space for heads in the media packet.

Spacer ring

Source: http://hddscan.com/

Spindle motor

The spindle motor is responsible for rotating the hard disk media. It must be of high quality, run smoothly and with a minimum of vibration, and not generate excessive of heat or noise.

Spindle and breath filter

Source: http://hddscan.com/

Breath filter

Because air from outside definitely has dust, the breath filter has several layers of filtration. It also may have some silica gel inside to reduce air moisture.

Filter

HDD is a precision mechanism and in order to work it requires very clean air inside. During work HDD may create some very small particles of metal and oil inside. To clean air immediately, a drive uses recirculation filter. This hi-tech filter permanently collects and absorbs even finest particles. The filter located on the way of air motion created by media rotation.

Filter

Source: http://hddscan.com/

Base and cover

Because of the requirement of keeping the internal environment free of dust and other contamination that could get between the read-write heads and the media over which they float, the entire hard disk is mounted into a physical enclosure designed to protect it and also keep its internal environment separated from the outside air. The base and cover are attached using a number of small screws. A rubber gasket is placed between the base and cover to ensure a tight seal.

Cover

Source: http://hddscan.com/

HDA

The entire contents of the base and cover chamber (including the media, heads and actuator components) are called as a Head and Disk Assembly (HDA).

HDA

Source: http://hddscan.com/

APPENDIX C

THE DESCRIPTIONS OF EACH SUB CRITERION

Criteria	Description
Delivery Cluster	
Geographic location	The proximity to customer and is determinant to supplier selection from the logistics point of view
Freight terms	The expedience of shipping conditions from the supply chain point of view
Trade restrictions	The tariffs, custom duties, and government regulations for the products in both side of the supply chain
Order lead time	The time from the moment the buyer places an order to the moment it is received by the buyer
Quality Cluster	
Quality of product	The percentage of the yield of good product that received from the supplier
Percentage of on-time shipments	The percentage of shipments on agreed time
Response to customer's request and feedback	The actions of the supplier that response to buyer's request and feedback
Certifications	The recognition of the supplier's quality level
Research and development	Capability to search for and invent new products or technologies

Criteria(cont.)	Description(cont.)
Cost Cluster	
Supplier's selling price	Cost of materials or parts from supplier
The internal cost	The total cost of each purchase. In addition to the product price that a buyer has to pay for, other costs related with transportation and quality must also be considered
Ordering and invoicing	The ease of order placing
Reliability Cluster	
Feeling of trust	The buyer's perception of a given supplier determined by an on-going partnership between supply chain partners and supplier evaluations over the years also a supplier's reputation
Financial position	The financial status of each supplier
Country's political situation	The concerns regarding the supplier country's political stability and disruptive events in supply chain activities.
Currency exchange situation	The advantage from currency exchange situation in different planning horizons
Warranty policies	The responsibility on non-conformities
Flexibility Cluster	
Capacity	The order quantities that a supplier can deal with
Technological capability	The supplier's level of technology in production
Information sharing	The level of information shared between the supplier and the buyer
Negotiability	The mutual trust existed between the supplier and the buyer

Criteria(cont.)	Description(cont.)
Customization	The supplier’s ability to take orders with unusual requests from the buyer

BIOGRAPHY

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