Supplier Performance Evaluation: A Case Study of Thai Offshore Oil & Gas Exploration and Production Company

Nathavat Sivapornpunlerd
Chulalongkorn Business School (CBS), Chulalongkorn University

Siri-on Setamanit
Chulalongkorn Business School (CBS), Chulalongkorn University

ABSTRACT

Procurement of materials and equipment is considered the first step in supply chain management of many companies. It is also broadly known that the performance of suppliers directly influences the company's efficiency and competitiveness. Supplier performance evaluation is a crucial process to identify strengths and weaknesses of suppliers which can help the company to manage their suppliers. There are various supplier performance evaluation methods; however, based on the nature of company and the nature of procurement of piping materials in this study, Analytical Hierarchy Process (AHP model) was selected. In order to develop a performance evaluation system for the company, four main-criteria, namely: quality, delivery, service, and flexibility, with eighteen sub-criteria were also selected. Then the survey using questionnaires was conducted to gather pair-wise comparison judgments of each main and sub-criteria from the key evaluators as well as the performance scores for each supplier. The result of AHP model approach showed that the most important criteria of piping materials supplier performance evaluation is quality followed by delivery, service and flexibility respectively. In general, supplier who attains the highest weighted score is the top-performer.

1. INTRODUCTION

Thai government has issued a policy to promote the use of natural gas for its power plants, industry sector, and also the use of natural gas for vehicles (NGV) instead of gasoline, which will lower the import level of crude oil from other countries. However, Thailand's natural gas production rate is far behind the consumption in the country. The record from British Petroleum's Statistical Review of World Energy, as of June, 2011, shows that, in year 2010, the natural gas consumption in Thailand equaled to 4.4 Billion Cubic Feet per day (BCF/day) while the production rate of natural gas was only 3.5 BCF/day. Consequently, oil and gas companies in Thailand need to construct large number of gas production platforms in the Gulf of Thailand to increase their gas production rate in order to fulfill the country's current consumption and they also have to make certain that their operations run smoothly without any unplanned plant shut down for maintenance.

Company XYZ is one of the oil and gas exploration and production companies in Thailand. It has attained concessions to explore and produce natural gas in several gas fields in the Gulf of Thailand. The company also expanded its investment in oversea projects as well. With the obligation to supply natural gas to its mother company, Company XYZ has to construct new offshore gas production and wellhead platforms every year and has to ensure that the operations of the existing platforms run smoothly.

Procurement of materials and equipment can be considered as the first step of XYZ's supply chain management. Materials, equipment, and spare parts required for both construction and maintenance work

will be sourced from local and oversea suppliers. The procurement process of company XYZ starts from the purchase requisitions (PRs) generated by stock controllers or engineers. The purchase requisition is the document which contains the information of the required materials, such as quantity, description, specification, required on site date, drawing, and etc. In the PR, the manufacturer or brand of each item will be clearly identified. For the standard or generic items, the PR creator may not specify the brand or manufacturer name. After receiving PR, procurement officer will request for quotations from the suppliers. Subsequently, engineer will conduct technical evaluation of supplier's quotation, if required, while procurement officer will carry out price comparison. The purchase order will be awarded to the technically acceptable supplier who proposed lowest cost.

It is very important for the company to maintain a well-managed performance from the suppliers. Currently, there is no systematic process to evaluate supplier performance. There is no logical and strategic decision on the supplier selection process. Most of the sourcing is based on experience of each individual purchaser. Materials will generally be procured from the familiar suppliers and/or suppliers with good reputation. Moreover, when new purchaser comes, he will have to manually track back and refer to the previous procurement records which include only information regarding historical price and lead time only. In addition, there is no record of the performance on other dimensions, such as product quality, delivery delay, and etc. Thus, the procurement lead time is extended.

The delay in supply of materials by suppliers, which is commonly found at Company XYZ, contributes to the delay and cost overrun in construction and maintenance. The quality of supplied materials is another problem commonly found. The authors believe that one of the causes of the aforementioned problems is that there is no systematic supplier's performance measurement put in place. Material sourcing based on experience of the procurement officer does not always guarantee that the company will award contract to the suppliers who have high performance.

The rest of this paper is organized as follow: Section 2 describes a background of a case study company. Section 3 and 4 briefly discuss the objective of the study and the methodology. Section 5 provides literature review regarding supplier evaluation methods and criteria. Section 6 shows conceptual framework on supplier performance evaluation. Section 7 presents a discussion of results. Lastly, conclusion is provided in Section 8.

2. COMPANY BACKGROUND

This study selects a case study company, named company XYZ, which is one of the oil and gas exploration and production companies in Thailand. It has attained concessions to explore and produce natural gas in several gas fields in the Gulf of Thailand. The main purpose of the study is to develop a systematic performance evaluation for Pipe, Fitting, and Flange suppliers of company XYZ in order to set up a best practice for supplier evaluation. Currently, there are five piping materials suppliers who are frequently contracted by company XYZ. For confidentiality purpose, these suppliers will be named AAA, BBB, CCC, DDD, and EEE.

Pipe, fitting, and flange materials are regularly purchased by company XYZ. With 22 percent spending on pipe, fitting, and flange materials in year 2010, they are the second high-spending type of materials in company XYZ. Therefore, it is very crucial that a systematic supplier performance evaluation system is employed to facilitate supplier selection process as well as to improve the supply chain management of the company.

It is expected that the proposed approach can provide the logical and reliable evaluation results which accurately reflect the supplier performance. The supplier performance evaluation system can also be applied to monitor day-to-day operations with the suppliers. This will directly affect the company's capability and competitiveness in the borderless business nowadays.

3. OJECTIVE OF THE STUDY
The objectives of this study are:
1) To identify the relevant performance evaluation criteria for pipe, fitting, and flange suppliers of Company XYZ
2) To develop a performance evaluation system for pipe, fitting, and flange suppliers of Company XYZ

4. METHODOLOGY OF THE STUDY
In order to achieve the two objectives above, there are several steps to perform including:
1. Review of related journals and theories to discover the performance evaluation method and related performance evaluation criteria. (Secondary data)
2. Develop a conceptual framework on supplier performance evaluation for pipe, fitting, and flange suppliers of Company XYZ
3. Conduct In-depth interview with key experts and managements in Company XYZ who are involving in supply chain management of the company to identify and confirm the relevant performance evaluation criteria developed in step 2 (Primary data)
4. Survey by using questionnaire to identify the importance level of each evaluation criterion and performance score of each supplier (Primary data)
5. Analyze data using quantitative methods including statistical method and Analytic Hierarchy Process (AHP model)

5. LITERATURE REVIEW
The literature review can be divided in to two parts. The first part discusses about different Supplier Performance Evaluation Methods. Short description regarding each approach and comparison among them will be provided. The second part provided information regarding supplier performance evaluation criteria. The authors also summarize the important criteria mentioned in the literature.

5.1 Supplier Performance Evaluation Methods
There are a number of approaches being used to assist the supplier performance evaluation. Four commonly-used traditional methods stated in several studies are Categorical method, Weighted-point method, Cost ratio approach and Dimensional analysis model (Teng and Jaramillo, 2005 and Humphreys et al., 1998).
5.1.2 Categorical method
        Categorical method is the most uncomplicated method. The lists of relevant performance variables or factors are defined. The buyers will assign performance ratings of each evaluating attribute in categorical terms, e.g. "good", "neutral", and "poor". The ratings are judged by agreement between various representatives from several functions in the company such as procurement, logistics, production, and etc. The supplier who obtains highest score will then be the best performer
5.1.2 Weighted-point method
        Weighted-point method is the most frequently used method for evaluation process. With weighted-pointed method, different attributes which are important to the customers are weighted as per their importance level. The evaluator assigns the score to each supplier performance in each attribute and then the score will be multiplied by the assigned weight of each factor. Finally, the weighted score will be totaled to find out the final performance rating of each supplier. The supplier who obtains highest score will then be the best performer.
5.1.3 Cost ratio approach
        With cost ratio approach, the total cost of each purchase including selling price with the buyer's internal operating costs, which are connected with the quality, delivery, and service components of the purchase, is calculated as the total company's purchasing price. Each internal operating cost will be converted to a cost ratio which expresses the percentage of the total value of the purchase. Lastly, the overall cost ratio is applied to the supplier's quoted unit price to obtain the net adjusted cost. The supplier

with the lowest net adjusted cost would be the best preferred supplier. However, this approach is complicated and requires a comprehensive accounting system to identify the accurate cost data. Hence, it is usually used only in the big-sized companies (Humphreys et al., 1998).

5.1.4 Dimensional analysis model

Dimensional analysis model proposed by Willis et al. (1993) is a supplier evaluation technique with the purpose to resolve some of the drawbacks of the other approaches. The model combines several criteria of different dimensions and relative importance into a single entity for each supplier. Then the supplier performance index is calculated based on the supplier performance against the standard performance for a set of criteria and the relative importance of the criteria. Each supplier is evaluated according to the performance index created in this way. Criteria may have either positive of negative weight. For example, quality represents positive weight criterion while price represents negative weight criterion. In conclusion, the dimensional analysis model is used to measure each supplier against a standard set of criteria. The main disadvantage of this model is that it requires the highest costs to implement and to provide training in its operation to the related personnel comparing to the other three (Teng and Jaramillo, 2005 and Humphreys et al., 1998).

Apart from these four common evaluation methods, several researchers like Kannan and Bose (2011) have applied the Analytic Hierarchy Process (AHP) in supplier selection and evaluation. Percin (2006) stated in his literature that Analytic Hierarchy Process (AHP), initiated by Saaty (1980), is a theory of measurement that has the capability to include both qualitative and quantitative factors to carry out evaluation.

5.1.5 Analytical Hierarchy Process (AHP)

AHP can be considered as a problem-solving tool with flexibility and systemization to signify the elements of a complicate problem. The AHP is designed to break down a complicate, multiple criteria problem into levels of hierarchy with the top level as the objective, the intermediate levels as the criteria and sub-criteria, with the lowest level as alternatives. Figure 1 illustrates the general structure of AHP. The relative importance of each criterion determining which criterion has the highest priority. Interviews with the experts will be conducted to obtain pair-wise comparison for paired of homogenous criteria (Saaty, 1980). With a series of pair-wise comparisons of all criteria, the weights of the criteria are determined and can be used to construct a supplier evaluation system (Ordoobadi and Wang, 2010).
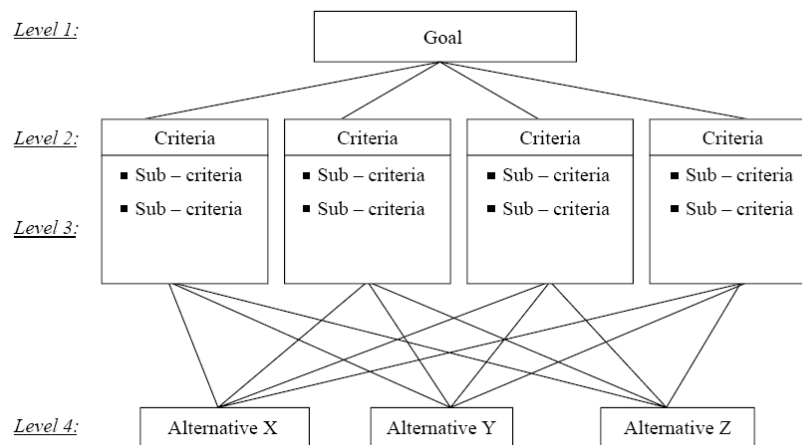
Source: Chan et al., 2006

Figure 1: General structure of AHP

The AHP is broadly applied in various areas. According to Vaidya and Kumar (2006), there are over ten various applications within nine different areas. One of the applications is priority and ranking which is widely used in different areas, e.g. manufacturing and engineering (Chin et al. 2006). As

mentioned before, there are several methods available to be applied for supplier performance measurement. However, each method has different strengths and limitations. Therefore, no single model can address and solve all the concerned issues a company might have. The selection of supplier performance evaluation method depends on the nature of company and its product. Table 1 summarizes the comparison of these performance evaluation systems on critical assumptions, stakeholder involvement, data type used, emphasis of the model, and unique perspective.

Table 1: Suppliers Performance Evaluation Methods Evaluation

Model	Critical assumptions	Stakeholder involvement	Data type used	Emphasis of the model	Unique perspective
Categorical method	Independent attributes, equal importance assigned to all attributes	Very high	Subjective	Easy to use and subjective judgment	Free voting perspective
Weighted point method	Independent attributes, attribute importance assigned subjectively by the decision maker	High	Subjective	Weighted subjective judgment on unequally important criteria	Controlled voting perspective
Cost ratio method	Attributes can be measured in monetary values	Low	Objective	Hard data of cost performance	Cost-emphasis perspective
Dimensional analysis model	Performances of the suppliers are compared one at a time	Low	Objective	Progressive comparison of alternatives	One-to-one contending perspective
Analytic hierarchy process	Hierarchical structure is formed with overall objective of best supplier at the highest level and supplier candidates at the lowest level of hierarchy.	Moderate	Subjective and Objective	Flexibility for attribute selection and weighted judgment on the importance of criteria	User super-competency perspective

Source: Adapted from Ordoobadi and Wang, 2010

Based on the summarized comparison between five supplier performance evaluation methods, the Analytical Hierarchy Process (AHP model) is selected to be used as the method to construct suppliers' performance evaluation system in company XYZ. This is because AHP model provides flexibility and systemization to identify the relative importance level of evaluation criteria by base on perspective of experts or staffs whose current work involved with the procurement of pipe, fitting, and flange without the need to have access to a comprehensive accounting data.

5.2 Supplier Performance Evaluation Criteria
The most important part in supplier performance evaluation process is identifying the evaluation criteria which are related to the supplier performance. Several literatures have tried to examine and conclude the major criteria for supplier performance evaluation. Plenty of questionnaires, surveys, and interviews have been conducted with key experts in procurement functions and other associated functions to collect and discover the performance evaluation criteria which are currently applied in the real business. Tracey and Tan (2001) stated in their study that effective supplier evaluation is not easy to achieve if the customer satisfaction is not considered. Thereby, the criteria used in evaluating suppliers are inclusive of quality, reliability, and performance of the product. This is to ensure that the customer satisfaction will be fulfilled. Ohdar and Ray (2004) cited that there are two main performance measurement attributes for manufacturing company. The two attributes are "soft" or non-quantifiable criteria like supplier commitment and "hard" or quantifiable criteria like suppler capability.

The research done by Schmitz and Platts (2003) illustrates how the European automotive manufacturers evaluate and asses performance of their suppliers. The research methods used were structured interviews and questionnaires. Tan et al. (2002), in their study, tried to explain the supplier evaluation processes in various industries. They sent the questionnaires to more than one thousand respondents who were senior managers of manufacturing companies to identify the evaluation criteria and evaluation practices in which their companies applied for evaluating their suppliers. The research used the five-point Likert scale. Teng and Jaramillo (2005), in their study, grouped the evaluating factors by following the Saaty (1996) recommendation. The factors were selected based on the most commonly used and significant issues in textile/apparel industry and then grouped into five clusters namely as deliver, flexibility, cost, quality, and reliability.

Several literatures point out that the supplier performance is not just related to price or quality, instead, supplier performance evaluation requires a multi-criteria evaluation process (Kwong et al., 2002). However, it is fair to accept that the quality will be on the top priority to satisfy the customer (Tracey and Tan, 2001), but there are other attributes which are important and need to be considered. Therefore, the buying companies need to select and identify the evaluation criteria which will serve the company's objectives, activities, and to satisfy the customers. In conclusion, it is very important to identify the criteria and metrics which are objectively relevant to the company at all levels (Cormican and Cunningham, 2007).

Based on the literature review, 4 main-criteria with 18 sub-criteria for pipe, fitting, and flange suppliers performance evaluation are identified. Those 4 main criteria are Quality, Delivery, Service, and Flexibility. However, Price is not included as one of the main criteria though many researchers incorporated this criterion in their studies. This is due to the fact that the price of pipe, fitting, and flange is fluctuated as per steel price. The price of piping materials also varies due to the availability of goods at difference period of time. The 4 main-criteria and 18 sub-criteria are summarized in Table 2.

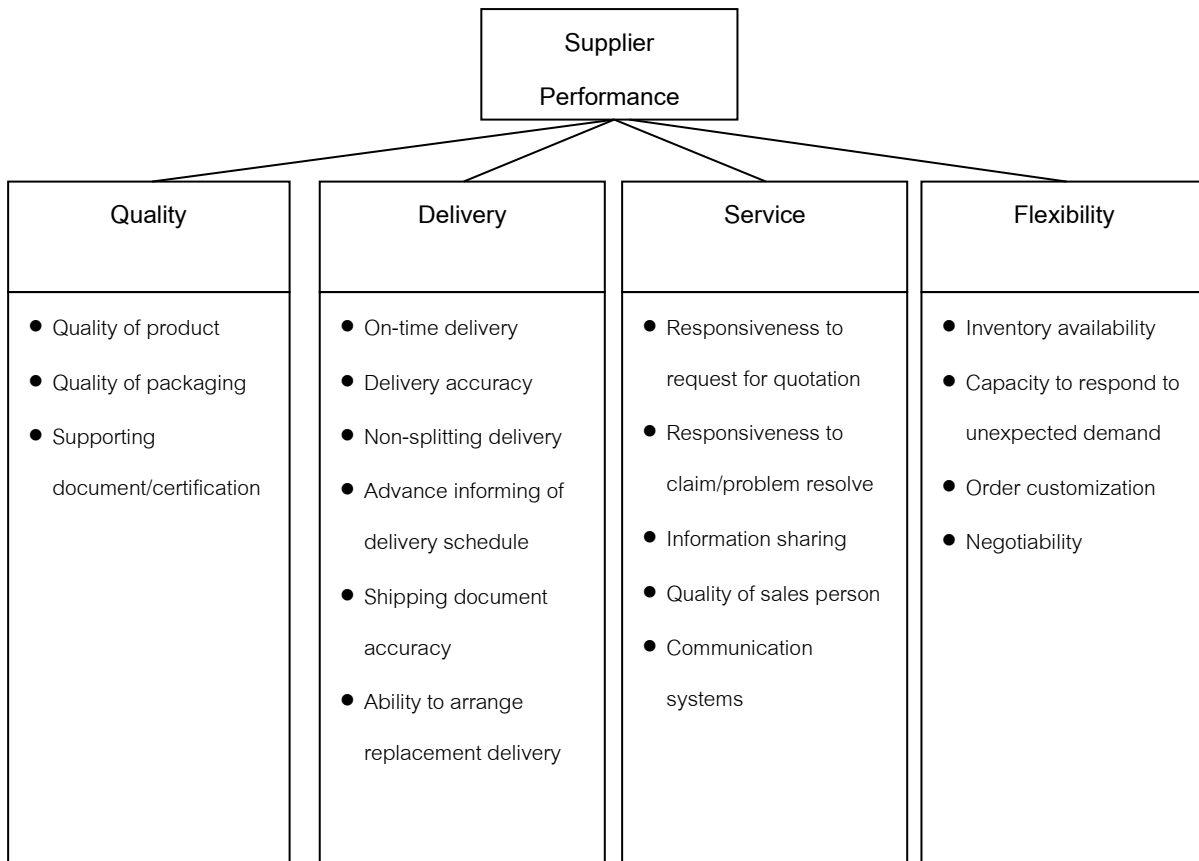**Table 2: Four Main-criteria with eighteen Sub-criteria for performance evaluation**

Main-criteria	Sub-criteria	Description
Quality	Quality of product	Supplied goods comply with specifications with no defect
	Quality of packaging/packing	Supplied goods are properly packed and packaging is suitable for transportation & storage
	Supporting document/material certificate	Required supporting document and material certificate are completely submitted
Delivery	On-time delivery	Goods are delivered to the required destination as per PO date
	Delivery accuracy	Goods are delivered accurately with no missing or excess items
	Non-splitting delivery	Goods are delivered in large lot and with no partial delivery
	Advance informing of delivery schedule	Supplier informs in advance if the delivery schedule is not as planned
	Shipping document accuracy	Shipping document is issued correctly and accurately
	Ability to arrange replacement delivery	Supplier promptly arranges replacement delivery if defect or discrepancy is found
Service	Responsiveness to request for quotation	Supplier promptly submits quotation after receiving a request for quotation
	Responsiveness to claim/problem resolve	Supplier quickly responses back when claim/problem is reported
	Information sharing	Supplier willingly supports and shares information, e.g. reference price, market situation, and etc.
	Quality of sales person	Salesperson is knowledgeable about the goods and works

Main-criteria	Sub-criteria	Description
		accurately and courteously to support company's procurement
	Communication systems	Supplier has good and reliable communication system, e.g. email system, document tracking system, and etc.
Flexibility	Inventory availability	Supplier always has inventory on-hand to fulfill customer's demand
	Capacity to respond to unexpected demand	Supplier always has inventory on-hand to meet unexpected change order
	Order customization	Supplier has ability to customize order as per company's request, e.g. special coating, marking , color coding, and etc.
	Negotiability	Supplier is willing to negotiate on price and delivery schedule

6. CONCEPTUAL FRAMEWORK

According to the literatures, the supplier evaluation criteria and the evaluation matrix are analyzed and applied to create the conceptual framework for this study. The authors examine and compare the importance level of 4 main-criteria and 18 sub-criteria and develop performance evaluation system for Pipes, Fittings, and Flanges suppliers. The proposed conceptual framework for supplier performance evaluation is shown in Figure 2.

Figure 2: Conceptual framework for supplier performance measurement

Supplier Performance

Quality	Delivery	Service	Flexibility
• Quality of product	• On-time delivery	• Responsiveness to request for quotation	• Inventory availability
• Quality of packaging	• Delivery accuracy	• Responsiveness to claim/problem resolve	• Capacity to respond to unexpected demand
• Supporting document/certification	• Non-splitting delivery	• Information sharing	• Order customization
	• Advance informing of delivery schedule	• Quality of sales person	• Negotiability
	• Shipping document accuracy	• Communication systems	
	• Ability to arrange replacement delivery		

After the conceptual framework is developed, in-depth interviews with key company XYZ staffs whose work related to procurement of pipe, fitting, and flange are carried out to confirm the appropriateness of the performance evaluation criteria. The interviewees include inventory management manager, procurement manager, senior procurement officer, and senior mechanical engineer. The interview is designed to reach the objective of confirming the correctness of the performance evaluation criteria. The supplier performance evaluation criteria as stated in the conceptual framework are presented to the interviewees.

After the evaluation criteria have been confirmed by the interviewees that they are appropriate to be applied in pipe, fitting, and flange supplier performance evaluation, a questionnaire is developed to gather primary data which are pair-wise comparison judgments between each pair of main-criteria and sub-criteria and the performance scores of the suppliers under each criterion. There are 28 evaluators (respondents) who are requested to carry out pair-wise comparison between each main-criterion. Nine-point comparative scale is used as shown in Table 3.

Table 3: The definition and explanation of AHP 9-point scale

Level of Importance	Definition	Explanation
1	Equal importance	Two criteria contribute equally to the performance of the supplier
3	Weak importance of one over another	Experience and judgment slightly favor one criterion over another
5	Essential or strong importance	Experience and judgment strongly favor one criterion over another
7	Demonstrated importance	A criterion is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one criterion over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

Source: Adapted from Saaty (1996)

The data gathered from the questionnaire is analyzed by applying statistical method and AHP model to find out the relative importance level, weighted performance score under each criterion and overall weighted supplier performance score.

6.1 Statistical treatment of data
         The reliability of the questionnaire is analyzed by SPSS program in order to validate the consistency and accurateness of the gathered data. The Cronbach's alpha value should be more than 0.7, thus the survey test is considered as reliable in general research study (Kannan and Tan, 2003).

6.2 Analytical Hierarchy Process (AHP) model
         The Analytical Hierarchy Process (AHP) model is applied in this research to determine the relative importance level of each main-criterion and sub-criterion which will be interpreted to be the weight or the multiplier for the performance score.
         First, the authors formulate a proper hierarchy of the AHP model consisting of the goal, main-criteria, sub-criteria, and the alternatives or the suppliers to be evaluated. In this study, the goal is to evaluate the performance of pipe, fitting, and flange suppliers. The goal, supplier performance, is positioned on the first level of the hierarchy. Consequently, four main-criteria, namely: quality, delivery, service, and flexibility, form the second level of the hierarchy. The third level consists of eighteen sub-criteria which are grouped with regard to the four main-criteria occupying the second level. The lowest hierarchy, the fourth level, contains the alternatives which are pipe, fitting, and flange suppliers to be

evaluated. The AHP model of pipe, fitting, and flange supplier performance evaluation is shown in Figure 3.

As per traditional AHP method, the alternative listed on the lowest level hierarchy will be directly pair-wise compared with another alternative under each sub-criterion. The best alternative of supplier will be selected based on the comparison result. However, there are quite a number of sub-criteria formulated in this study so it is a time consuming process to do so. It also becomes infeasible for computation as well. However, the use of rating scale is capable of overcoming these difficulties as each evaluator can simply assign a rating score to each supplier without making direct comparison (Tam and Tummala, 2001) Therefore, in this study, evaluators are asked to use the five-point Likert rating scale to determine the performance rating of each supplier under each sub-criterion. Consequently, the assigned performance score will be used to formulate the overall supplier performance score and the suppliers will be ranked base on their overall performance score.

Figure 3: AHP model for pipe, fitting, and flange supplier performance evaluation
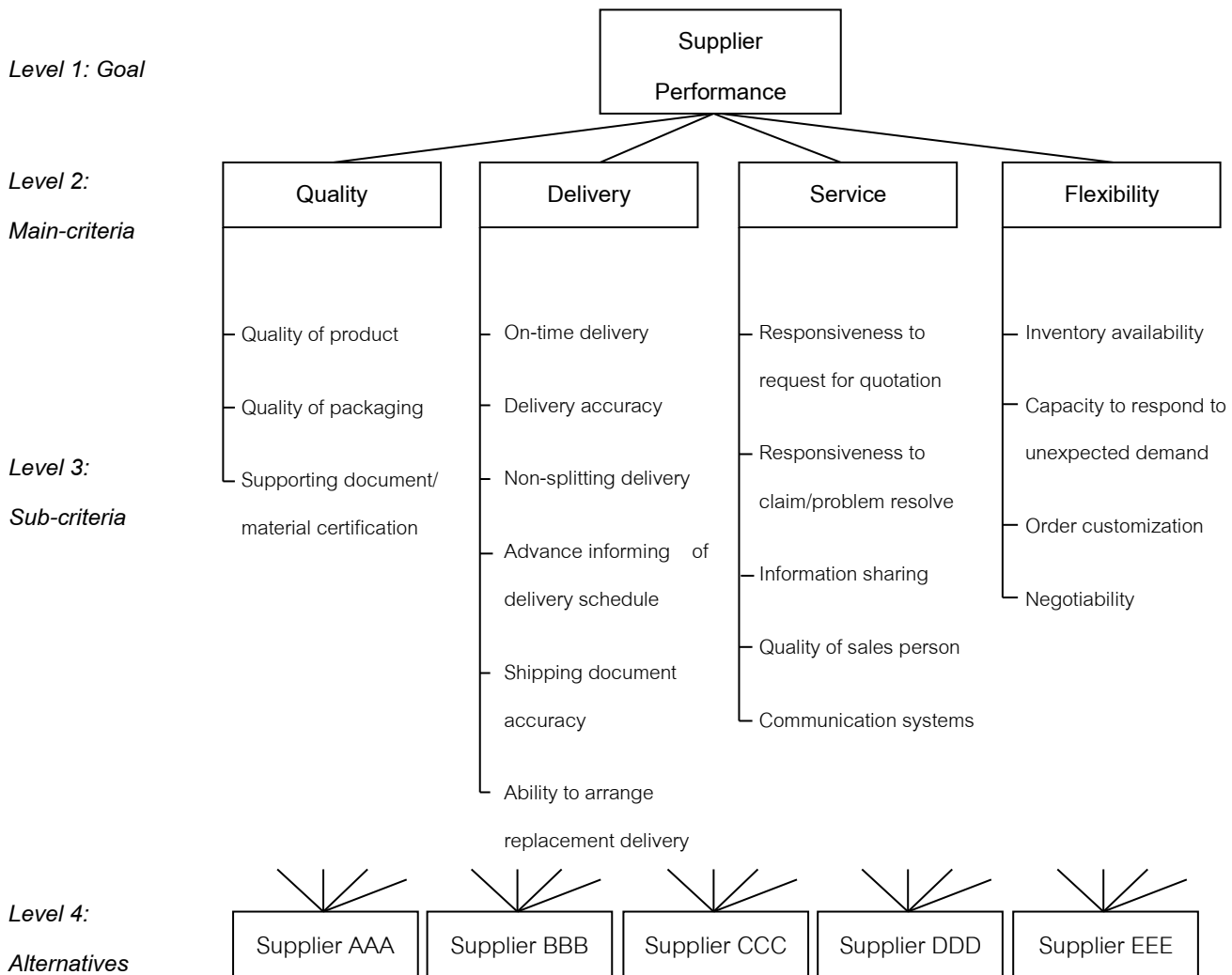
7. DISSCUSSION OF RESULTS
7.1 Key Evaluators Profile

Twenty eight questionnaires were distributed to key evaluators as planned. The evaluators consist of 5 project engineers, 5 mechanical engineers, 6 material/stock controllers, 3 procurement managers, 6

procurement officers, and 3 expeditors. All twenty eight questionnaires were returned meaning that the overall return rate equals to 100 percent. Most key evaluators (65%) hold a Master Degree while the rest (35%) hold a Bachelor Degree. The evaluators have working experience at company XYZ for different period of time ranging from less than 5 years up to 15 years as shown in Table 4.3.

7.2 Reliability analysis

The results of the data gathering by questionnaires are analyzed using SPSS program and Microsoft Excel. SPSS program is used for analyzing the evaluators' profile and reliability of data while Microsoft Excel is used for calculating local and global priority weight of main and sub-criteria and average score of each supplier in each performance evaluation criterion. The reliability analysis of the questionnaires is conducted by using SPSS Program. The survey scales instruments are considered to be indicative and reliable if the value of α exceeds or equal to 0.7 (Kannan and Tan, 2003). According to the result of data survey which measures both the importance level of each main-criterion and sub-criterion, the value of the Cronbach's Alpha are 0.720 and 0.769 consecutively. Therefore, it can be concluded that all questions are consistent and reliable in being applied as the research instrument in this study.

7.3 Important Level of Performance Evaluation Criteria

Starting from the third hierarchy (sub-criteria level), the authors formulate the eigenvectors of sub-criteria by creating matrix of importance ratios and applying AHP model based on the pair-wise comparisons assigned by the evaluators. The eigenvectors calculated are referred as local priority weights. Subsequently, the local priority weights of each questionnaire are averaged to form the average local priority weights of sub-criteria under each main-criterion.

Quality of product is the most important sub-criterion under main-criterion "Quality" with local priority weight equals to 0.5828. For sub-criteria under main-criterion "Delivery", On-time delivery is the most important criteria with local priority weight of 0.3332. With 5 sub-criteria under Service, Responsiveness to claim/problem resolve is the most important, its local priority weight equals to 0.4738. For the last main-criterion "Flexibility", Inventory availability comes in the first rank, its local priority weight equals to 0.4578.

Subsequently, the authors compute the eigenvectors of four main-criteria on the second hierarchy by creating matrix of importance ratios and applying AHP model with the similar approach done with sub-criteria. It was found that Quality is the most important and positions on the first rank with local priority weight of 0.4223 following by Delivery which its local priority weight of 0.3900. The third rank is Service which has local priority weight of 0.1086. Flexibility is the least important main-criteria with local priority weight of 0.0792.

The next step is to determine the average global priority weights for all 18 sub-criteria by multiplying together the average local priority weight of main-criteria with sub-criteria with respect to all successive hierarchical levels. The average local priority weights and global priority weight of each sub-criterion are summarized on Table 5.

From the result, it can be concluded that the performance of supplier to deliver high quality product is the most important. The ability to completely provide required supporting document and material certificate is on the second rank, follows the second position by the performance of suppliers to deliver their goods to the required destination as per PO date. Table 6 summarizes the ranking of important level of performance evaluation sub-criteria.

Table 5: The Average Global Priority Weights of each Sub-criterion

Main-criteria (Level 2 Hierarchy)	Local priority weights	Sub-criteria (Level 3 Hierarchy)	Local priority weights	Global priority weights
Quality	0.4223	Quality of product	0.5828	0.2461
		Quality of packaging/packing	0.1034	0.0437
		Supporting document/material certificate	0.3138	0.1325

Main-criteria (Level 2 Hierarchy)	Local priority weights	Sub-criteria (Level 3 Hierarchy)	Local priority weights	Global priority weights
Delivery	0.3900	On-time delivery	0.3332	0.1299
		Delivery accuracy	0.2896	0.1130
		Non-splitting delivery	0.0859	0.0335
		Advance informing of delivery schedule	0.0866	0.0338
		Shipping document accuracy	0.0645	0.0252
		Ability to arrange replacement delivery	0.1402	0.0547
Service	0.1086	Responsiveness to request for quotation	0.2187	0.0237
		Responsiveness to claim/problem resolve	0.4738	0.0514
		Information sharing	0.0962	0.0104
		Quality of sales person	0.1174	0.0128
		Communication systems	0.0939	0.0102
Flexibility	0.0792	Inventory availability	0.4578	0.0363
		Capacity to respond to unexpected demand	0.3161	0.0250
		Order customization	0.1392	0.0110
		Negotiability	0.0868	0.0069
Total				**1.0000**

Table 6: Ranking of important level of each Sub-criteria

Sub-criteria	Global priority weights	Rank
Quality of product	0.2461	1
Supporting document/material certificate	0.1325	2
On-time delivery	0.1299	3
Delivery accuracy	0.1130	4
Ability to arrange replacement delivery	0.0547	5
Responsiveness to claim/problem resolve	0.0514	6
Quality of packaging/packing	0.0437	7
Inventory availability	0.0363	8
Advance informing of delivery schedule	0.0338	9
Non-splitting delivery	0.0335	10
Shipping document accuracy	0.0252	11
Capacity to respond to unexpected demand	0.0250	12
Responsiveness to request for quotation	0.0237	13
Quality of sales person	0.0128	14
Order customization	0.0110	15
Information sharing	0.0104	16
Communication systems	0.0102	17
Negotiability	0.0069	18
Total	**1.0000**	

7.4 Supplier Performance Scores

In this section, the weighted supplier performance score in all criteria are combined together. The overall supplier performance score was calculated by summing up all weighted performance scores under 4 main-criteria, Quality, Delivery, Service, and Flexibility. The equation for calculation of overall supplier performance score is as below.

Overall supplier performance score = weighted quality score + weighted delivery score +
weighted service score + weighted flexibility score

Table 7 summarizes the overall supplier performance score of all 5 piping materials suppliers. The result shows that supplier DDD is the best supplier who is in the first rank as per supplier

performance evaluation in this study. This supplier performs the best with the score of 4.20 points. The ranking of the other suppliers is as follow:

The first rank: Supplier DDD with overall performance score of 4.20
The second rank: Supplier BBB with overall performance score of 4.07
The third rank: Supplier AAA with overall performance score of 3.23
The fourth rank: Supplier CCC with overall performance score of 3.09
The fifth rank: Supplier EEE with overall performance score of 3.03

Table 7: Summary of Supplier Performance Scores

Criterion	Supplier AAA	Supplier BBB	Supplier CCC	Supplier DDD	Supplier EEE	Average Score
Quality						
Quality of product	0.80	1.02	0.78	1.21	0.56	*0.87*
Quality of packaging/packing	0.13	0.18	0.14	0.20	0.16	*0.16*
Supporting document/material certificate	0.39	0.41	0.52	0.58	0.30	*0.44*
Sub-Total	*1.32*	*1.61*	*1.44*	***1.99*** *	*1.03*	*1.48*
Delivery						
On-time delivery	0.53	0.55	0.32	0.54	0.39	*0.46*
Delivery accuracy	0.35	0.48	0.36	0.37	0.35	*0.38*
Non-splitting delivery	0.10	0.08	0.07	0.11	0.10	*0.09*
Advance informing of delivery schedule	0.10	0.16	0.07	0.14	0.11	*0.12*
Shipping document accuracy	0.11	0.11	0.10	0.10	0.06	*0.10*
Ability to arrange replacement delivery	0.13	0.24	0.16	0.17	0.21	*0.18*
Sub-total	*1.32*	***1.61*** *	*1.08*	*1.43*	*1.21*	*1.33*
Service						
Responsiveness to request for quotation	0.07	0.11	0.05	0.11	0.11	*0.09*
Responsiveness to claim/problem resolve	0.15	0.22	0.11	0.22	0.20	*0.18*
Information sharing	0.03	0.05	0.03	0.03	0.04	*0.04*
Quality of sales person	0.03	0.06	0.04	0.05	0.05	*0.05*
Communication systems	0.04	0.04	0.04	0.04	0.04	*0.04*
Sub-total	*0.33*	***0.48*** *	*0.28*	*0.46*	*0.45*	*0.40*
Flexibility						
Inventory availability	0.11	0.18	0.15	0.15	0.17	*0.15*
Capacity to respond to unexpected demand	0.08	0.12	0.08	0.12	0.10	*0.10*
Order customization	0.03	0.04	0.03	0.04	0.04	*0.04*
Negotiability	0.03	0.03	0.02	0.03	0.03	*0.03*
Sub-total	*0.25*	***0.37*** *	*0.28*	*0.33*	*0.35*	*0.32*
Overall supplier performance score**	***3.23***	***4.07***	***3.09***	***4.20*** *	***3.03***	***3.52***

Remark: * Highest score in each criterion
              ** The full score equals to 5.00

Despite the fact that supplier DDD is the top performer, their weighted performance scores on main-criteria apart from Quality are not on the top rank. This implies that Quality is the strongest point of supplier DDD. It is noticeable that supplier BBB, who is on the second rank, have better performance on Delivery, Service, and Flexibility meaning that if supplier BBB can improve their Quality, they can develop to be a potential best supplier.

The scores of supplier AAA, CCC, and EEE are below the average in almost every evaluation criteria except that supplier EEE's performance scores on Service and Flexibility are quite high comparing to the rests. It can be interpreted that Service and Flexibility are their strengths but they need to work to improve their Quality and Delivery in order to progress to the higher rank. For supplier AAA and CCC, they are weak in all main-criteria; their performance scores are lower than average scores in every main-criteria.

8. CONCLUSION

The main objective of this study is to develop a supplier performance evaluation system for company XYZ. To initiate the performance evaluation system, selection of the methodology which fits with the company is very important. After review of related literatures, the AHP model approach was selected with a strong credence that this approach can respond and fulfill the objective of this study. This is due to the fact that each evaluation criterion has difference relative level of importance when compares with homogenous criteria. AHP is designed to break down a complicate, multiple criteria problem into levels of hierarchy. With its flexibility and systemization, it can signify the elements of a complicate problem. Performance evaluation criteria are also selected to form the conceptual framework of this study, the performance of pipe, fitting, and flange suppliers will be measured by referring to four main-criteria, namely: Quality, Delivery, Service, and Flexibility, and eighteen sub-criteria under those four main-criteria. However, when it comes to developing a performance evaluation system, it is very crucial that the chosen framework be aligned with what the company necessitates to assess. Therefore, in-depth interviews with staffs and managements, who have expertise and are currently involving in the supply chain of the company, were held to confirm the appropriateness of the evaluation model. Nevertheless, all interviewees agreed that main-criteria and sub-criteria as listed on the conceptual framework are well-cover the performance evaluation of the supplier.

According to the results calculated based on the data gathered from the questionnaires, it can be concluded that all four main-criteria and eighteen sub-criteria are important in evaluating supplier performance but with different important levels. Therefore, the performance evaluation system should be designed by referring to weighted performance score under those main and sub-criteria. The result of AHP model approach showed that the most important criteria of piping materials supplier performance evaluation is Quality followed by Delivery, Service and Flexibility respectively. According to the summary of overall supplier performance scores, it was found that supplier who had obtained the highest overall performance score did not get highest performance score on every main-criterion. They performed well on Quality which is the most important criterion. Hence, it is confirmed that the weighted performance score has great impact to the supplier performance.

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