EVALUATING SUPPLIER PERFORMANCE USING DATA ENVELOPMENT ANALYSIS (DEA)

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I hereby declare that I have checked this project report and in my opinion this report is satisfactory in term of scope and quality for the award of Degree of Bachelor of Industrial Technology Management with Honors.

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DEDICATION

This thesis is dedicated to my supervisor Dr Cheng Jackkie, my late lecturer Allahyarham Prof Razman Bin Mat Tahar, my parents, friends for their continuous encouragement and supports me all the way during this research.

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I would like to express my sincere gratitude to my supervisor Dr Cheng Jackkie for brilliant ideas, valuable information, continuous encouragement and support in making this research possible and complete and her commitment spending time to guide also spending time proof reading and correcting mistakes.

I also appreciated the contribution of my late supervisor, Prof Razman Bin Mat Tahar. He was the most humble person with great knowledge I had ever met. My deep condolence goes to his family.

I acknowledge my sincere indebtness and gratitude to my parents for their love, dream and prayer throughout my life.

Not to forget, big thanks to my DEA group study to give high cooperation and act as my inspiration, commenter and contribute to successful completion of this study.

ABSTRACT

Data Envelopment Analysis (DEA) has been widely applied to address various decision analysis problems due to its usefulness in evaluating multi-criterion systems and providing improvement targets for such systems. A supplier selection is inherently a multi-criterion decision problem, and DEA has been applied to evaluate suppliers. This paper proposes and demonstrates the application of DEA in evaluating the overall performances of suppliers in a firm. A research is then presented to demonstrate supplier performance evaluation using DEA for supplier selection and consideration of performance improvement. In this research, supplier performance was measured in terms of efficiency and performance. Out of 8 suppliers of Usahawan.com Sdn Bhd was analyzed, DEA identified 2 efficient suppliers. The rest 6 suppliers' slack factors that contribute to inefficiency were point out. Some variable have rooms to be improving in order to achieve great performance. The most efficient supplier is used as reference set to which are not efficient. Criteria that was used for supplier performance measurement in this study used for DEA application (distance, late deliveries, supply variety, quality) is consistent with academic research results on most important supplier evaluation criteria (Dickson, 2000) and most often used criteria for supplier evaluation in academic research (Weber, 2004).

ABSTRAK

Data Envelopment Analysis (DEA) telah digunakan secara meluas untuk menangani pelbagai masalah analisis keputusan kerana kegunaannya dalam menilai sistem multi-kriteria dan menyediakan target untuk sistem tersebut. Memilih pembekal adalah pelbagai kriteria penyelesai masalah dan DEA telah digunakan untuk menilai pembekal. Kertas kerja ini mencadangkan dan menunjukkan permohonan DEA dalam menilai prestasi keseluruhan pembekal di firma. Penyelidikan kemudiannya dikemukakan untuk menunjukkan penilaian prestasi pembekal menggunakan DEA untuk pemilihan pembekal dan pertimbangan peningkatan prestasi. Dalam kajian ini, prestasi pembekal diukur dari segi kecekapan dan prestasi. Daripada 8 pembekal Usahawan.com Sdn Bhd telah dianalisis, DEA dikenal pasti 2 pembekal cekap. Selebihnya faktor kekurangan yang menyumbang kepada ketidakcekapan 6 pembekal adalah dikenalpasti. Beberapa pembolehubah mempunyai ruang untuk diperbaiki untuk mencapai prestasi yang hebat. Pembekal yang lebih berkesan digunakan sebagai set merujuk kepada yang tidak cekap. Kriteria yang digunakan untuk mengukur prestasi pembekal dalam kajian ini digunakan bagi permohonan DEA (jarak, penghantaran lewat, pelbagai bekalan, kualiti) adalah selaras dengan hasil penyelidikan akademik mengenai kriteria yang paling penting dalam penilaian pembekal (Dickson, 2000) dan kriteria yang paling sering digunakan untuk pembekal penilaian dalam penyelidikan akademik (Weber, 2004).

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LIST OF ABBREVIATIONS

DEA	Data Envelopment Analysis
DMU	Decision Making Unit
AHP	Analytic Hierarchy Process

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

DEA is a non-parameter method for evaluating the efficiency of non-profit DMU-s. It contains solutions for several mutually connected linear programming mathematical models for each of the DMUs. While each of these models addresses managerial and economic issues and provides useful results, their orientations are different and, more important, they generalize and provide contact with these disciplines and concepts. Thus, the models may focus on increasing, decreasing or constant returns to scale as found in economics, which are here generalized into the form of multiple inputs and outputs.

Nowadays is highly competitive environment, the effective selection of suppliers is very essential to the success of a firm. Existing supplier performance criteria along with a ranking by manufacturers, manufacturing has improved the types and order of supplier selection criteria presented by Anthony and Buffa (2005). The strategic purchasing, which encourages achieving needed strategic goals through purchasing choices, has been more and more recognized. Many companies and firms have given growing attention to the strategic supplier selection in the struggle of decreasing the number of suppliers to support effective practice.

Major reductions in costs, late deliveries, and rejected materials can be achieved with inefficient supplier can become more DEA efficient. When suppliers are compared for their overall performances, an aggregate evaluation relevant to the considerations of a firm needs to be conducted. Such a whole performance evaluation of suppliers should be based on performance evaluation for all part types supplied to the purchasing company. A potential use of an overall performance assessment of suppliers **is to provide benchmarking data** for reducing the number of suppliers, which in turn results in in profits including reduction in the costs of parts and order processing, and better partnership with suppliers.

One more potential use of evaluating the aggregate performances of suppliers is **to provide improvement targets and recommendation performance for current suppliers.** In this paper, data envelopment analysis is proposed to evaluate the over-all performances of suppliers. DEA can be used for supplier evaluation for an individual product and same group commodity of product.

1.2 RESEARCH OBJECTIVES

1. To identify criteria of efficient supplier.
2. To measure the efficiency of supplier performance using DEA.
3. To identify the inefficiency or the slack factor in supplier performance.

1.3 PROBLEM STATEMENT

There are problems that arise in supplier selection faced by the buyer according to Rajeshekar (2011):

1. Supplier selection is a multi-criteria problem and there are not a lot of efficient techniques or algorithms that addresses this problem. The conventional methods that are being used for supplier evaluation like categorical or key-factor rating method, weighted-cost method and cost ratio method are very subjective in nature. They are subjective because the buyer assigns values to various factors that are involved in selection of suppliers and the values vary from one buyer to another for the same supplier. So the need for methods/algorithms that are more objective in nature, that involves assigning common set of values to the selection criteria, is to be used.

2. It is difficult to evaluate an organization's performance when there are multiple inputs and multiple outputs to the system. The difficulties are further enhances when the relationships between the inputs and the outputs are complex and involve unknown tradeoffs. Thus, DEA is used to calculate the relative efficiencies of multiple decision-making units (DMUs), in our case suppliers, based on multiple inputs and outputs. This relative efficiency calculation can provide benchmarking data for reducing the number of suppliers, which in turn would result in effective supply chain management.

1.4 RESEARCH QUESTION

1. What are the best criteria of supplier selection?
2. What are the factors of inefficiency of supplier?
3. How can DEA be used as a tool for measuring supplier efficiency performance?
4. Why this study is important for buyer to determine the factor of supplier efficiency?

1.5 BACKGROUND OF STUDY

Purchasing and suppliers are of major strategic importance to most companies today. This is because a substantial amount of the resources used by a company are made available through its suppliers. Purchases from suppliers account for more than half of total costs for most companies and in some industries, such as electronics, telecommunications, construction, and automotive, this portion is normally substantially higher (Gadde and Hakansson 2003). Suppliers are important to buying firms not only in financial terms. To an increasing extent they provide customers with new technology. Supplier performance thus considerably impacts on the efficiency and effectiveness of the customer firm and is of vital importance.

To make sure that the performance of vendors is adequate a mass of supplier evaluation programs have been developed. Some of these programs deal mainly with efforts of securing that suppliers function in accordance with expectations in the short run, while others focus on the long-term development of suppliers and its connection to performance. Back then, in a survey of 350 Fortune-500 companies Krause and Ellram (2002) found that performance evaluation was deemed a vital part of the supplier development programs.

Even those companies that had no formalized development program regarded supplier evaluation very important. Carr and Pearson (2000) conducted a study of 739 firms in a cross industry analysis and observed that firms with a strategic approach to purchasing were more involved in supplier evaluation than other firms. It was shown also that this strategic approach had a positive impact on buyer seller relationships and, finally, supplier evaluation systems had a positive effect on the buying firm's financial performance.

1.6 SCOPE OF STUDY

This research will be conducted on Usahawan.com Sdn Bhd that is located in Negeri Sembilan, Malaysia. The resource of the sample is from suppliers in the same commodity group which is machinery parts out of over 40 suppliers in the company. About 8 suppliers involve in this framework. This research will be emphasized on the criteria of supplier selection and performance of efficiency each selected supplier. The criteria are described as variable input and output.

1.7 THEORETHICAL FRAMEWORK

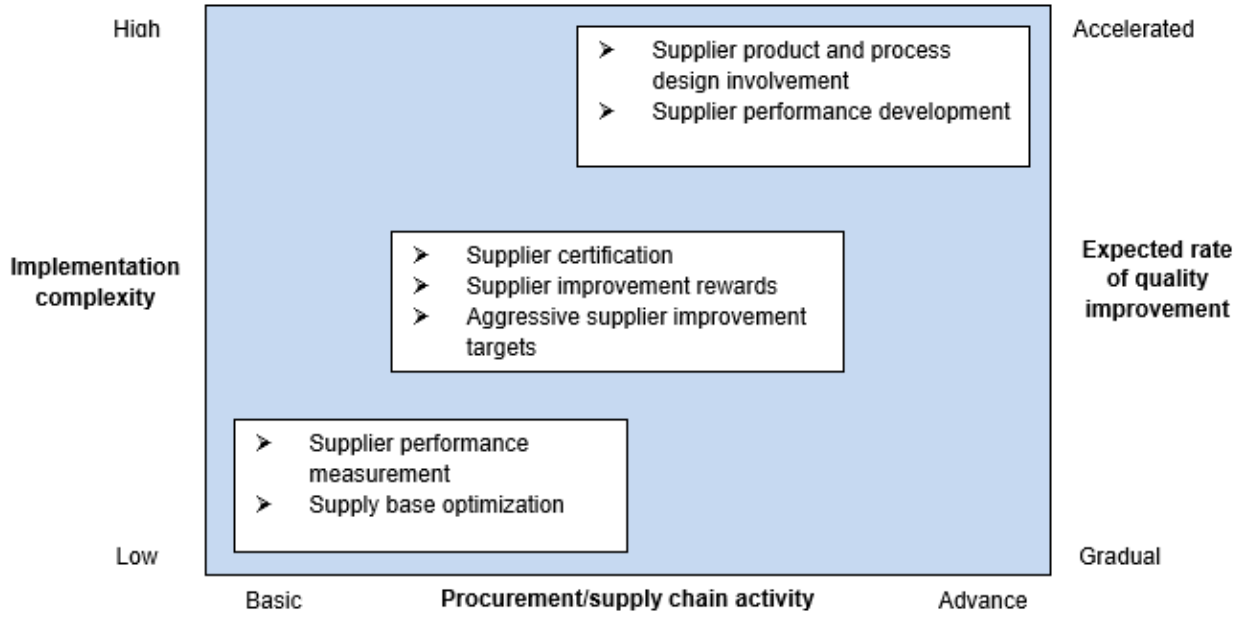


Figure 1.1: Achieving World Class Supplier Quality

Source: Trent and Monczka 2000

Rank	Factor	Mean rating	Evaluation
1	Quality	3.508	Extreme importance
2	Delivery	3.417	
3	Performance history	2.998	
4	Warranties and claim policies	2.849	
5	Production facilities and capacity	2.775	Considerable importance
6	Price	2.758	
7	Technical capability	2.545	
8	Financial position	2.514	
9	Procedural compliance	2.488	
10	Communication system	2.426	
11	Reputation and position in industry	2.412	
12	Desire for business	2.256	
13	Management and organization	2.216	
14	Operating controls	2.211	
15	Repair service	2.187	Average importance
16	Attitude	2.120	
17	Impression	2.054	
18	Packaging ability	2.009	
19	Labor relation record	2.003	
20	Geographical location	1.872	
21	Amount of past business	1.597	
22	Training aids	1.537	
23	Reciprocal arrangement	0.610	Slight importance

Figure 1.2: Supplier Selection Criteria Ranking

Source: Dickson (2000)

1.8 OPERATIONAL DEFINITION

Data envelopment analysis (DEA)

DEA is a linear programming based technique for measuring the relative performance of DMUs where in the presence of multiple inputs and outputs. DEA is nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (or DMUs).

DMU

A short from Decision Making Units is unit involve in evaluation. The number of DMU is should be multiple of the number of inputs a the number of outputs

Supplier or vendor,

A party that supplies goods or services. A supplier may be distinguished from a contractor or subcontractor, who commonly adds specialized input to deliverables. A supplier is an entity that supplies goods and services to another organization. This entity is part of the supply chain of a business, which may provide the bulk of the value contained within its products. Some suppliers may even engage in drop shipping, where they ship goods directly to the customers of the buyer.

Evaluation

It is a systematic determination of a subject's merit, worth and significance, using criteria governed by a set of standards. It can assist an organization, program, project or any other intervention or initiative to assess any aim, realizable concept/proposal, or any alternative, to help in decision-making; or to ascertain the degree of achievement or value in regard to the aim and objectives and results of any such action that has been completed.

Efficiency

Efficiency is the extent to which time, effort, or cost is well-used for the intended task or function. It often comprises specifically the capability of a specific application of effort to produce a specific outcome effectively with a minimum amount or quantity of waste, expense, or unnecessary effort.

Usahawan.com Sdn Bhd

It is a company 100% owned by Bumiputera, (formerly known as the Evora Marketing, established in 2005). It is an entrepreneurial project Malaysians in accordance with the standards and tastes of the local market.

1.9 SIGNIFICANCE OF STUDY

In any organization, for an effective supply chain management to operate, the purchasing function is very essential to perform effectively. It is the responsibility of purchasing managers to choose suppliers to purchase the required products for their company. Thus, it is very common for purchasing managers to conduct supplier evaluation techniques effectively to choose the best supplier amongst suppliers. This research will reveal the criteria in supplier selection in the industry. As this search use DEA, the criteria or factor of efficiency will be identified as output and input.

1.10 EXPECTED RESULT

The outcome of the study suggests that the company is making selection process based on Delivery performance, Distance factor, Quality and Supply variety. The efficiency of the supplier performance using DEA can be calculated and evaluated using DEA Solver Software. Identify the inputs and outputs that are strategically important or critical to the buyer. The inputs and outputs are used as the selection criteria for the suppliers. The inefficient supplier information can be obtained from DEA procedure. Improvement targets based of supplier performance can be provided to the inefficient suppliers. The supplier that shows the most efficient marks can be used as benchmark for other supplier that less efficient.

1.11 SUMMARY

This chapter generally to discover the purpose of this study and research. Partly, it is to determine the usefulness of DEA and apply it in evaluating supplier in a firm. Many advantage of DEA can be found and this will lead to more compromising approach of any organization performance evaluation. Basically, this chapter is to achieve research objective 1 which is to identify criteria of efficient supplier. The previous research of Dickson and Weber prove that the variable that is going to be used in this research (Distance, Late Deliveries, Quality and Supply Variety) is reliable with academic research results on most important supplier evaluation criteria.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Supplier selection is becoming increasingly critical as companies continue to develop more collaborative and long-term relationship with their suppliers. With the purchasing function playing a more strategic role, supplier selection has now become a strategic decision, particularly in relation to strategic purchased items. One of the most important objectives in the purchasing process is that of the selection and maintenance of an effective supply base. When a supplier selection decision needs to be made, the buyer establishes a set of evaluation criteria that can be used to compare the potential sources. These evaluation factors are classified into input and output factors. A study carried out by Dickson surveyed buyers to identify the factors they considered in awarding contracts to suppliers. Although some supplier selection criteria were found to vary in different situations, in addition to price three common criteria emerged as important, regardless of the type of purchased product. These were quality, on-time delivery, and supplier performance history along these criteria. Another study carried out by Lehman and O'Shaughnessy, found that, the key factors generally thought to affect supplier selection decisions were price, quality, delivery, and service.

The criteria that were mentioned on supplier selection have focused on quantifiable measures such as cost, delivery, quality, and other related factors. These are important factors that should be considered in almost any supplier selection decision. However, under partnership sourcing, it becomes not a task of supplier selection but

rather a question of identifying the best partner for a long-term relationship. In this situation, a new set of supplier selection criteria come into consideration, equally as important as some of the criteria mentioned above.

In any organization, for an effective supply chain management to operate, the purchasing function is very essential to perform effectively. It is the responsibility of purchasing managers to choose suppliers to purchase the required products for their company. Thus it is very common for purchasing managers to conduct supplier evaluation techniques effectively to choose the best supplier amongst all suppliers. This project focuses on the Data Envelopment Analysis technique (DEA) to measure relative efficiency of supplier by implementing the DEA and explains the lack of inefficiency of the vendors.

This portion provides the review of scholar work within the supplier efficiency performance evaluation literature. It also covers a discussion on why supplier performance evaluation is a significant process and what challenges firms encounter when conducting the process. This stands as an input into a later discussion on how the supplier performance measurement process of Usahawan.com is conducted.

The importance of supply chain management has increased in a second half of the 20th century. Trent and Monczka (2000) described and foresaw executive managers‘perceptions, and pointed out that throughout the 1990‘s there was a trend of increasing understanding of the supplier importance to the firm and that this trend would continue to hold. It is now considered that supply chain management may lead to a sustained competitive advantage. Purchasing process, being part of the whole supply chain management concept, is about providing the firm with essential components, to make it able to run its own value generating activities. This is where supplier‘s capabilities and willingness to act in accordance with buyer‘s needs and expectations play a crucial role. Dealing with suppliers and achieving the desired results is a constantly challenging task. The following chapter introduces a framework on achieving high quality supplier performance.

RANK	FACTOR
1	QUALITY
2	DELIVERY
3	PERFORMANCE HISTORY
4	WARRANTIES AND CLAIM POLICIES
5	PRODUCTION FACILITIES
6	PRICE

Table 2.1: Criteria Rankings

Source: Dickson 2000

After a few years, in 2004, Weber at al. reviewed Dickson‘s classification by conducting own analysis on supplier (performance) evaluation factors used in scholar literature. They re-ranked the factors used by Dickson. A total of 30 articles were analyzed, and evaluation and performance measurement criteria extracted, systemized and ranked. Table 2 shows the top 6 ranked factors, according to Weber et al. It is important to mention, that Dickson‘s work regarded the criteria as used for supplier selection as so did Weber et al (2004). The reason this thesis presents the work of Dickson and Weber et al, is to reflect the purchasing managers‘ and researchers‘organized perception on the important supplier evaluation criteria. The number of parts; supply variety, that a supplier supplies is considered as an output in order to pursue a strategic orientation of reducing the total number of suppliers (Jian,2000).

RANK(D)	RANK	FACTOR
6	1	NET PRICE
2	2	DELIVERY
1	3	QUALITY
5	4	PRODUCTION FACILITIES
20	5	GEOGRAPHIC LOCATION
9	6	SUPPLY VARIETY

Table 2.2: Criteria Rankings

Source: Weber 2004

2.1.1 Different Settings of DEA Applications

Epstein and Henderson (2002) describes DEA method as a linear programming-based technique that converts multiple input and output measures into a single comprehensive measure of productivity efficiency. Narasimhan (2001) refers to DEA as a nonparametric multi-factor productivity analysis model that evaluates the relative efficiencies of a homogenous set of decision making units in the presence of multiple input and output factors. The information provided by DEA may possess a major advantage over benchmarking and other techniques where only one measure can be evaluated at a time, gaining no insight into overall efficiency (Easton et al, 2002).

On the other hand, Schmidt (2003) argued that DEA model produces biased estimates in presence of measurement error or other statistical noise. Assumption, that DEA selects the weights for variables so that it would result in a maximum efficiency score, means that relatively lower variable value receive lower weight, and that is the source of biases. Banker (2003) showed both that DEA is a maximum likelihood estimator of efficiency and that the estimates are consistent, meaning that biases are tend to decrease when the sample size is increasing. Ruggiero (2004) showed that the biases stem from the fact, that unit under analysis is biased relative to the frontier, and the frontier is biased upward due to measurement error. He also indicated that biases can be evaded if the model is used on averaged data set.

DEA applications are quite widely documented in the academic literature and vary with regard to what the Decision Making Units are. That may be public or private companies, departments within the companies, or even companies across countries. One of the early works in DEA applications was the Charnes, Cooper and Rhodes model developed in 1978 for measuring the efficiency of Decision Making Units within the organizations.

Sherman (2000) used DEA in analyzing the medical-surgical areas of seven hospitals and was able to identify inefficient units that were not previously identified by regression or single ratio analysis, and locate the sources of inefficiency. Ahn et al (2002) applied DEA in efficiency analysis for public institutions of higher learning in Texas, while Charnes (2004) compared DEA, ratios and regression systems for efficiency measurement of electric cooperatives in Texas. Kleinsorge et al. (2000) conducted a longitudinal study of the carrier by using DEA, Clarke and Gourdin (2000) used DEA for comparison of vehicle maintenance activities of maintenance shops.

2.1.2 DEA Applications for Supplier Evaluation

There were DEA studies within supply chain management as well. Weber and Desai (2004) compared 6 suppliers of one of the Fortune 500 companies. They were able to identify inefficient suppliers for the purpose of negotiation leverage. In addition, they presented how parallel coordinates can be used to determine which aspects of the supplier‘s performance need improvement to increase the overall efficiency. Narasimhan (2001) proposed a framework for supplier performance evaluation and rationalization, combining supplier performance and efficiency scores, thus helping the studied firm to revise the supplier base or encouraging introducing supplier improvement programs.

Talluri, Narasimhan and Nair (2006) applied a case study in a division of Fortune 500 pharmaceutical company. They compared the CCDEA (chance-constrained) results to deterministic DEA results and highlighted its usefulness in the decision-making process. Wu and Blackhurst (2009) introduced an augmented DEA model. Their proposed methodology incorporated standards that enhanced the ability for companies to evaluate and rank suppliers. By doing that, augmented DEA had enhanced discriminatory power over basic DEA models to rank suppliers. In addition, weight constraints were introduced to reduce the possibility of inappropriate input and output factor weights.

Kang et al (2010) introduced a supplier performance evaluation model based on combined methodology. Analytical Hierarchy Process (AHP) and DEA were combined together to conduct quantitative and qualitative analysis. During a case study of microchip packaging suppliers, a quantitative analysis was performed through DEA, while qualitative analysis was performed through AHP. The DEA part used defect rate, price and response-tochange-time as input variables. On-time delivery rate, process capability and capacity were the output variables. Then the matrix of measures acquired from both models was generated.

Finally, the suppliers were ranked according to scores received by multiplying relative qualitative performance (obtained from AHP) and relative quantitative performance (obtained from DEA) with relative weight vectors of qualitative and quantitative factors (obtained from experts‘ pair wise comparison and the Delphi method).

Wu (2010) model is a methodological extension to Data Envelopment Analysis and applicable to efficiency analysis for entities from different systems with imbedded uncertainty. Suppliers from different countries were grouped in three groups that represented business situation for each country relative to other countries. Efficiency analysis proceeded as follows: they evaluated the efficiency of vendors in Country A (severe business situation) only in relation to other vendors of Country A. Vendors in Country B (normal business situation) were evaluated in relation to both countries A and B. Vendors in Country C (advantageous business situation) were assessed in relation to all three countries. Thus, the vendors were evaluated under operating handicaps by taking into account their particular environments. Overall evaluation criteria categories were quality, price, performance and facilities/capabilities.

In Zeydan et al (2011) study, a methodology was introduced and proposed for increasing the supplier selection and evaluation quality. The approach considered both qualitative and quantitative variables in evaluating performance of suppliers based on efficiency and effectiveness in one of the biggest car manufacturing factory in Turkey. This methodology was realized in two steps. Firstly, qualitative performance evaluation was performed by using fuzzy AHP (Analytical Hierarchical Process) in finding criteria weights and then fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was utilized for finding the ranking of suppliers. In this way, qualitative variables were transformed into a quantitative variable for using in DEA methodology as an output, named quality management system audit.

Secondly, DEA was performed with four output variables - quality management system audit, warranty cost ratio, defect ratio, quality management. The only input variable was selected to be a dummy variable, and all suppliers were assigned an equal value of 1 of input, thus ignoring the supplier differences from the input point of view.

Azadi and Saen (2012) proposed a chance-constrained DEA model in the presence of uncontrollable outputs. They then demonstrated the model application in supplier evaluation, by conducting the case study at the health informatics company. Company under investigation had 20 specialized application developers, whose performance was addressed. The number of personnel and average time for serving the customers were used as the input variables, while profit margin and supplier variety were considered as the output variables. Supplier variety was considered to be non-discretionary output (non-controllable) as this factor could not be increased at least in short term.

Some new DEA derivations occurred during past several years, such as chance constrained or augmented DEA. However, this thesis builds on the classic DEA model developed by Cooper, Charnes and Rhodes (1978) because the model is very well established and regarded as guidance in many other scholar works. It also successfully deals with multiple criteria (with no need of identifying weights) considerations providing a comprehensive evaluation of supplier, and is aimed for evaluation of homogenous group of DMU‘s. Vendors supplying same type of products are just that – a comparable, homogenous set of units. To deal with possible statistical noise problem, data normalization is conducted prior to DEA model is run. A deeper presentation of methodology is found in chapters 3.2 and 3.3. The following chapterart 3.1 presents the case study company

There are a few conditions of DEA which are:

- Positive property.

DEA formulation may include requires that the inputs and outputs to be positive.

- Isotinicity property

It is required that the functions relating inputs to outputs have mathematical property called isotinicity which meanst that an increase in any inputs results some output increase and not a decrease in output.

- Number of Decision Making Units (DMUs)

A general rule of using three DMUs for input and output variables used in the model in order to insure sufficient degrees of freedoms for a meaningful analysis. Boussofiane et.al (1991) stipulate that to get good discriminatory power out of the CCR or BBC models the lower bound on the number of DMUs should be the multiple of the number of inputs and number of outputs. In this study , a 3 input shoud be multiply with 1 output which brings out of 3 Decision Making Unit (DMUs) or 3 banks. Golany and Roll (1989) establish a rule of thumb that the number of units should be at least twice the number of inputs and outputs considered. Bowlin (1998) mentions that need to have three times the number of DMUs as there are inputs and output variables. Dyson et.al (2001) recommend a total of two times the product of the number of input and output variables. In this study, 3 inputs with 2 outputs model Gollany and Roll recommend using 8 DMUs, while Bowlin recommends 15 DMUs and Dyson et.al recommend 12.

- Homogeneity of DMUs

DEA requires a relatively homogeneous set of entities. That is all the entities involved in evaluation set should be have the same inputs and outputs of the positive number.

- Window Analysis

In order to evaluate the variations over time of efficiency, Charnes proposed a techniques called Window Analysis in DEA. Window Analysis assesses the performance of DMUs over time by treating it as a different entity in each time period. This method allows for tracking the performances of a unit or processes. If there are n units of data on the inputs and outputs measure in k periods, a total of no need to be assessed simultaneously to capture the efficiency variations over time.

2.1.3 ADVANTAGES OF DEA

DEA can handle multiple input and multiple output models. Thus, DEA is used to calculate the relative efficiencies of multiple decision-making units (DMUs), in our case suppliers, based on multiple inputs and outputs. This relative efficiency calculation can provide benchmarking data for reducing the number of suppliers, which in turn would result in effective supply chain management. In any organization, for an effective supply chain management to operate, the purchasing function is very essential to perform effectively. DEA identifies possible peers as role models who have an efficiency of 1 and sets improvement targets for them. By providing improvement targets, DEA acts as important tool for benchmarking. Possible sources of inefficiency can be determined using DEA. According to Savitri Narayanan 2009, DEA has numerous focal points why it has been a well-known strategy for assessing efficiencies, they have been classified below:

1. It has the capability of handling multiple inputs and outputs
2. Inputs and outputs can have different units of measure.
3. It is a non-parametric method which does not need a functional form for computing efficiency
4. It can calculate the sources and the extent of inefficiency in inputs and outputs
5. It can use benchmarking techniques to use the efficient units as a benchmark to evaluate inefficient units
6. It can be used in the measurement of productivity in addition to efficiency analysis.
7. It can be used as an "what-if" analysis tool to include certain inputs and exclude outputs for a DMU

2.2 SUMMARY

This chapter is generally about finding the nearest previous research and study that related to this title. Dozens of literature review from previous year basically implying and state the DEA as a tool of efficiency performance evaluation on suppler as suitable method. DEA is being used as other different setting such as AHP to achieve competitiveness of an organization. Many advantages of DEA is technically proven before such as it has the capability of handling multiple inputs and outputs or named as variable.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The DEA (data envelopment analysis) requires step in the methodology. Firstly is formulating research problem and objectives. Second is identification of output and input. Then, from the identification of input and output, numerous literatures were reviewed. Next is data collection followed by data processing. Calculation of efficiency by DEA is done using the input and output. From that the inefficiency of supplier is identified and improvement can be done. The DEA model requires both input and output variables, therefore the criteria mentioned above needed to be considered either as input or output. Cost Reduction Performance was set as an input variable and considered to be a result of supplier‘s cost management practices, both internal (example: development of internal manufacturing, management or administrative processes) and external (example: managing own suppliers, distribution channels). Quality, delivery and invoice automatically were selected as output variables. The logic behind this distribution is such that DEA model analyzes how the results of suppliers cost management practices (input variable) impact the overall service level (output variables) that suppliers are able to provide. In other words, the model analyses how an increase or decrease of the price over the period of time is supported by corresponding shifts in overall service level.

The general rule within this model is that supplier is more efficient when it delivers higher output by utilization of same or lower input. Therefore, the input variable is being calculated in a way, that a lower value is preferred to higher, while output variables are calculated in an opposite way - higher value is preferred to lower value. What is very important to underline, is that even though Data Envelopment Analysis in its essence is used for measuring efficiency of any DMU, the input utilization to produce outputs that is described in this thesis is not necessarily the exact measure of actual supplier efficiency.

Research Methodology:

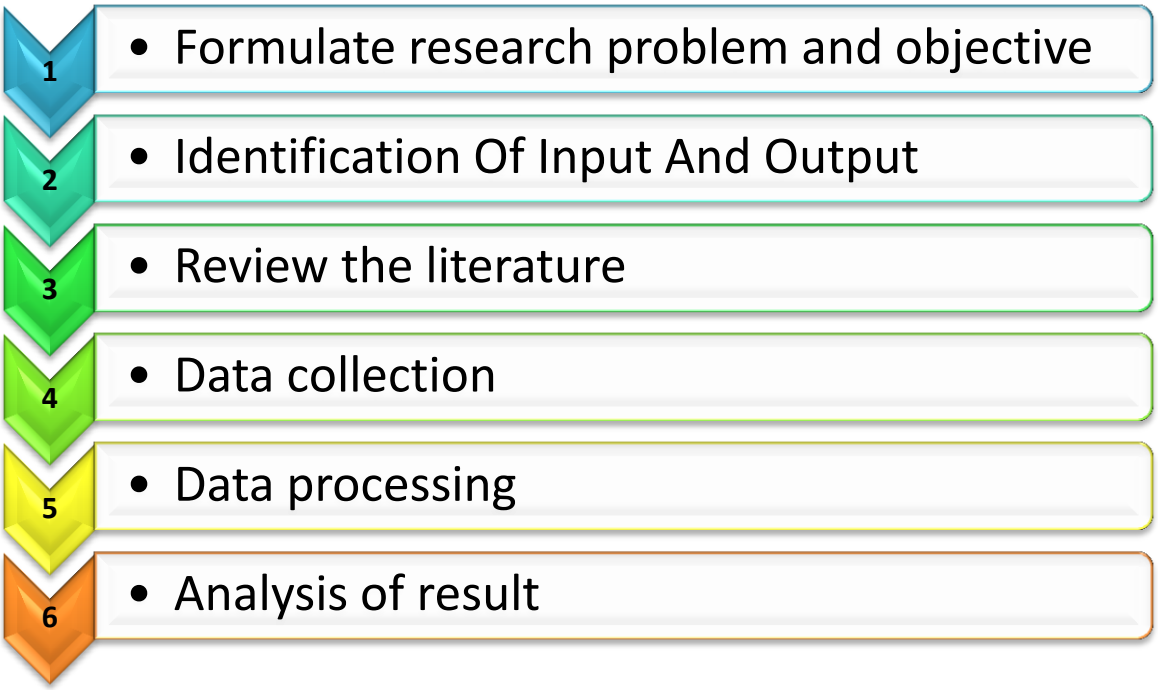


Figure 3.1: Research Methodology

3.2 FORMULATE RESEARCH PROBLEM AND OBJECTIVE

Formulate the research problem and objective is the first step of the research on evaluating supplier is defining on what is the problem that company faced in evaluating supplier because selecting the proper vendors may reduce the purchasing expenditures and increases competitiveness corporation situation. It is difficult to evaluate an organization's performance when there are several inputs and numerous outputs to the system. The difficulties are further enhances once the relations between the inputs and the outputs are complex and involve unknown tradeoffs. Research objective is a purpose of doing the research and to solve the organization problem. From the problem, research objective can be achieved in the research design.

3.3 IDENTIFICATION OF INPUT AND OUTPUT

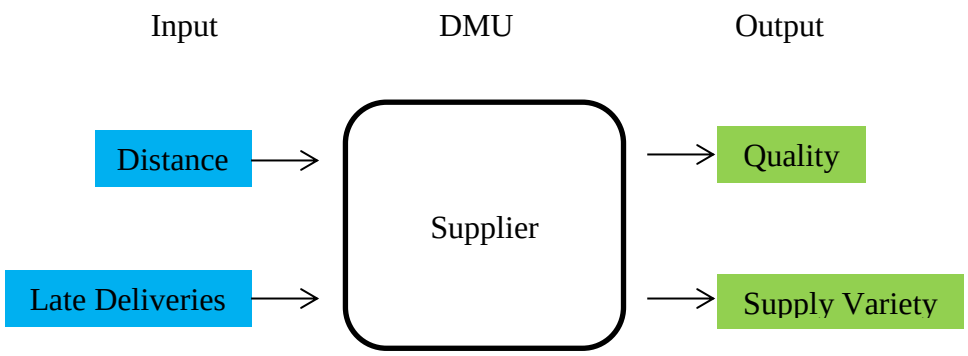


Figure 3.2: The Overall idea of Input Factor, DMU and Output Factor.

RANK	FACTOR
1	QUALITY
2	DELIVERY
3	PERFORMANCE HISTORY
4	WARRANTIES AND CLAIM POLICIES
5	PRODUCTION FACILITIES
6	PRICE

Table 3.1: Criteria Rankings

Source: Dickson 2000

RANK(D)	RANK	FACTOR
6	1	NET PRICE
2	2	DELIVERY
1	3	QUALITY
5	4	PRODUCTION FACILITIES
20	5	GEOGRAPHIC LOCATION
9	6	SUPPLY VARIETY

Table 3.2: Criteria Rankings

Source: Weber 2004

According to Dickson (2000) Quality was ranked first, Delivery was ranked second and performance history was third in supplier criteria. While Weber (2004) reviewed Dickson‘s classification by conducting own analysis on supplier performance evaluation factors used in scholarly literature and ranked net price, quality and delivery as a top criteria factor. It is desirable to have a higher number of parts supplied by each supplier to maximize efficiency toward the goal. Thus number of parts; supply variety, that a supplier supplies is considered as an output in order to pursue a strategic orientation of reducing the total number of suppliers Jian LiuFong (2000). Furthermore, since the Quality of parts is usually the most important management objective for a purchasing company it is also considered as an output in this simplified model. (Dickson 2000).

The inputs proposed in this model include the Distance and late Deliveries. Delivery performance is associated with costs of excess inventory, shortages or time delay and speed up deliveries. The distance factor contributes to part acquisition costs due to aspects including freight charges Weber (2004). Distance also (geographic location) was ranked 5 by Weber while Supply Variety was ranked 6. These outputs and input factors are among the most important considerations for a purchasing company in evaluating its supplier. In order to compare the overall performances of suppliers, the data value of each of the above input and output variables needs to be obtained for each supplier.

DISTANCE (KM): The physical distant of Usahawan.com and supplier using transportation

LATE DELIVERY (%): (No. of late delivery / total purchase orders PO) × 100

QUALITY (%): (Total PO’s - no. of non-conformance item) / total PO’s

SUPPLY VARIETY: Variety of item supplied by the supplier

3.4 REVIEW THE LITERATURE

Then, the researches continue with the review the literature. It is process of study the previous research which is related with the research objective. The literature material can be journal, newspaper, articles, book and any other material that will give information about the research. Besides, the literature must be referring to the latest literature because old literature (1990's and below) cannot support the current situation since the technology nowadays changes are very fast. As referred in the literature analysis, there is seen a frequent usage of price, delivery and quality as criteria for measuring supplier performance, e.g. Weber and Current (2004), Naraasimhan et al (2001), Prahinski and Benton (2004). In addition, level of service is used by some authors as well (Chang et al., 2007). Naraasimhan et al (2001) and Talluri et al (2005) use delivery precision, quality level and price criteria for supplier performance measurement by using DEA. In addition to that, Naraasimhan (2001) uses a Cost Reduction Performance as one of criteria. For this research, suppliers' performance will be measured with regard to their ability to deliver on-schedule; ability to deliver components of the required quality which would contribute to cost reduction for Usahawan.com

3.5 DATA COLLECTION

The data of suppliers is collected at Usahawan.com which has a total about 40 suppliers that supply more than 240 products. They have about 29 commodity groups, for instance; food machinery, premix flour, accessories and equipment. The application of DEA will be conducted on suppliers of each commodity group. Within commodity group, the suppliers can generally be viewed as similar suppliers. To collect data in each commodity group, the company first listed all parts supplied by each supplier to obtain the supply variety. Food Machinery group is selected because it has the most number of supplier which denote that the DMU in DEA is considered to include as many as possible.

It is because there is higher probability to capture high performance units in larger population that would determine the efficient frontier and improve discriminatory power (Joseph 2002)

The method of data collection in this research survey is questionnaire. A standard set of question will be asked at the company selected is chosen to evaluate the overall efficiency and performance of 8 suppliers. The numerical data will be easily being processed. The data for all the inputs and outputs for all decision making units is fed into the system of DEA Solver Software.

3.6 DATA PROCESSING

DEA is a direct programming based system for measuring the relative execution of DMUs where in the vicinity of various inputs and yields. DEA is nonparametric technique in operations research and financial matters for the estimation of generation outskirts. It is utilized to exactly measure gainful proficiency of choice making units (or DMUs). The numerical information for every one of the inputs and yields for all choice making units is encouraged into the arrangement of DEA Solver Software.

This research manages a standout amongst the most fundamental DEA models, the CCR model, which was at first proposed by Charnes, Cooper and Rhodes in 1978. Instruments and thoughts regularly utilized as a part of DEA are likewise presented and the ideas created in Chapter 1 are extended. There, for each DMU, we formed the virtual input and output by (yet unknown) weights.

This includes computing the weighted entirety of information and partitioning the weighted total of yield and data. The information and yield information is being standardized as for the most extreme estimation of the components entered by the client. The efficiency of a DMU is figured in respect to the bunch's watched best practice.

Efficiency = Output/ Input

When there are multiple inputs and multiple outputs, a common measure for relative efficiency is,

Efficiency = Weighted Sum of Outputs / Weighted Sum of inputs

Each DMU picks weights such that it maximizes its own efficiency, subject to constraints that ensure:

- No unit can have an efficiency score greater than 1
- Every weight must be strictly >0.

3.6.1 CCR MODEL

CCR Model was named after its developer Chames, Cooper and Rhodes. This is the first and fundamental DEA model, built on the notion of efficiency. The CCR ratio model calculates an overall efficiency for the unit and the obtained efficiency is never absolute as it is always measured relative to the field. The Chames et al (1978) article marked the birth of DEA, and despite the numerous modified models that have appeared, the CCR model is still the most widely known and used of DEA models.

This study is using basic CCR model. Boussofiane et.al (1991) stipulate that to get discriminatory power out of the CCR and BBC models the lower bound on the number of DMUs should be the multiple of the number of inputs and number of outputs. Hence, since this study consist of three inputs and an output, the minimum total number of DMUs should be three for some discriminatory power to exist in the model. Since the adopted model is CCR model, the supplier are more efficient when it is able to use less input to produce same level of output as compared with other supplier. The highest efficiency degree that can be achieved 1.

3.7 ANALYSIS OF RESULT.

After the relative efficiencies of suppliers are computed by DEA, the subsequent decision is to address supplier selection and supplier performance improvement. Since low efficiency score indicates a poor performance relative to other suppliers in order to reduce the total number of suppliers, the parts supplied by the suppliers of low efficiency scores may be considered to be transferred to supplier of high efficiency scores with excess capacity. The inefficient supplier can be obtained from DEA procedure. Improvement targets based of supplier performance can be provided to the inefficient suppliers. Negotiation with suppliers can be also being made based on the benchmarking results from DEA.

3.8 SUMMARY

This chapter concluded the methodology in this research where about 6 steps were involved. Every step is being explained deeply to achieve the objective and make it crystal clear.

CHAPTER 4

RESULT AND ANALYSIS

4.1 INTRODUCTION

This chapter will present the data acquired and the analysis of the data attained during the research. Information and data collection process during the thesis development period took place at Usahawan.com Sdn Bhd, Negeri Sembilan. A meeting and extensive communication were held with Managing Director of Usahawan.com Sdn Bhd, Mr Ahmad Faizal in order to get a grasp of the purchasing environment within the company. The communication started with their type of products get from supplier and was continued down the commodity group of supplier available in the company. Purchasing managers responsible for sub departments and purchasers were addressed in order to get familiar with everyday purchasing processes. These addressees were also asked to identify attributes of the ideal supplier.

4.1 DATA FINDINGS

Currently Usahawan.com has a total about 40 suppliers that supply more than 240 products. The company can reduce the total number of suppliers while maintaining high quality of parts. With smaller number of suppliers, the company will able to develop better partnerships with suppliers; this in turn can result in reduced order processing process costs, reduced part pieces, and better part quality. The company purchased parts was divided into 29 commodity groups for instance; food machinery, premix flour, accessories and equipment. The application of DEA will be conducted on suppliers of each commodity group. Within commodity group, the suppliers can generally be viewed as similar suppliers. To collect data in each commodity group, the company first listed all parts supplied by each supplier to obtain the supply variety. The commodity group that is used in this data is machinery part. This is because it has the highest number of supplier compared to other commodity group. Also it obeys the rule of thumb that requires at least 4 suppliers in this case depends on this 2 input × 2 outputs.

The inputs proposed in this research include distance and late delivery. The distance contributes to cost due to aspect delivery cost and logistic cost. The late delivery associates with percentage of late deliveries within given window which in this case, past year (June–December) 2014. One acceptable delivery is considered to be a delivery of one purchase order on agreed time.

The number of items supplied by per supplier is supply variety. Towards the goal of reducing the total number of suppliers, it is desirable to have higher number of parts supplied by each supplier. Thus the supply variety is considered as an output in order to pursue a strategic orientation of reducing the total number of suppliers. Quality of supplier is measured in terms of conform, non-defective and agreed content of item per total number of purchase order. The quality of parts is usually the most important management objective for a purchasing company, it is also considered as an output. A set of 8 supplier data was given by the Usahawan.com manager from the questionnaire as shown on table below.

SUPPLIER	(I) DISTANCE (km)	(I) LATE DELIVERY (%)	(O) QUALITY (%)	(O) SUPPLY VARIETY
BAN HING Holding Sdn Bhd	79.7	11	80	5
Berjaya Steel Malaysia	38.8	0	97	5
Esm Machinery (Kl) Sdn Bhd	64.5	10	80	3
Fresh Cocoa Supply	81.5	23	65	4
Giant Machinery Sdn Bhd	47.4	26	61	6
Sen Jin SDN BHD	54.1	13	74	2
Solutionpack (M) Sdn Bhd	48.3	5	93	10
Sumo's (M) Sdn Bhd	67.9	2	96	4

Table 4.1: Overall Supplier Data

All the necessary data on supplier performance that is used in this thesis was acquired from Procurement Department. Primary data was processed by Usahawan.com responsible employees, Mr Ahmad Faizal and the summarized data was used for this study. A questionnaire was filled to answer the necessities and act as summary of the data. The company's privacy of this research did not allow double-checking of the data further. About 2 weeks needed for the employee to answer the question.

4.2 MODEL DEVELOPMENT

This research data is run using DEA Solver Software. The DEA-Solver-Pro runs using Microsoft Excel. The CCR model was used in creating model development of DEA. The CCR models (dual and primal) with input orientation are still the most widely known and used DEA models despite the numerous modified models that have appeared. CCR Model was named after its developer Charnes, Cooper and Rhodes. This is the first and fundamental DEA model, built on the notion of efficiency. The CCR models assume constant returns to scale. DMU operates under constant returns to scale if an increase in the inputs results in a proportionate increase in the output levels. This model calculates an overall efficiency in which both its technical efficiency and its scale efficiency are aggregated into a single value.

DEA-Solver-Pro details are:

- Software title: DEA-Solver, Version 3.0
- System requirements: Microsoft Windows, Microsoft Excel

Figure 4.1: Starting running DEA software

To run the data, first the excel data as Table 4.1 must be completed with correct position of DMU, input and output. Then open the DEA solver software to run data.

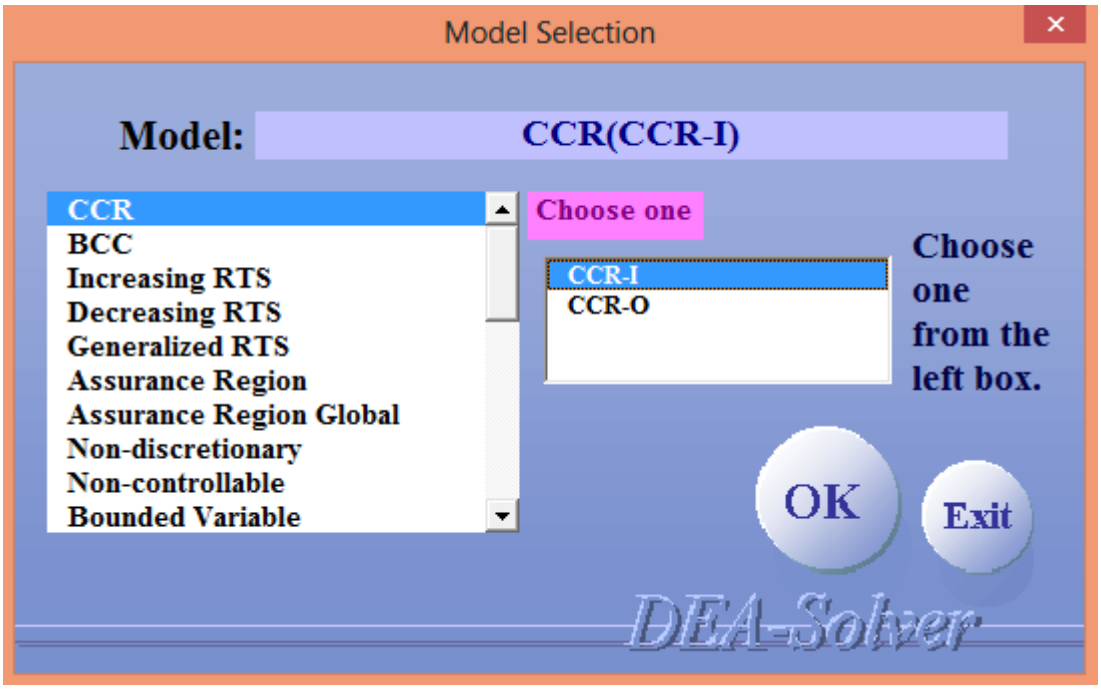


Figure 4.2: Selecting CCR input orientedSelection of CCR Input Oriented is the crucial step because the selection of model is based on the objective of research.

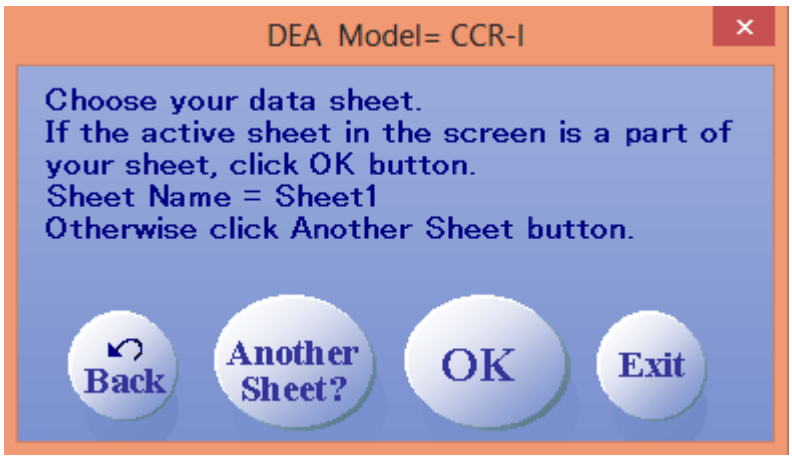


Figure 4.3: Selecting Data Sheet

Select the file from Table 4.1 as data sheet to run in the software.

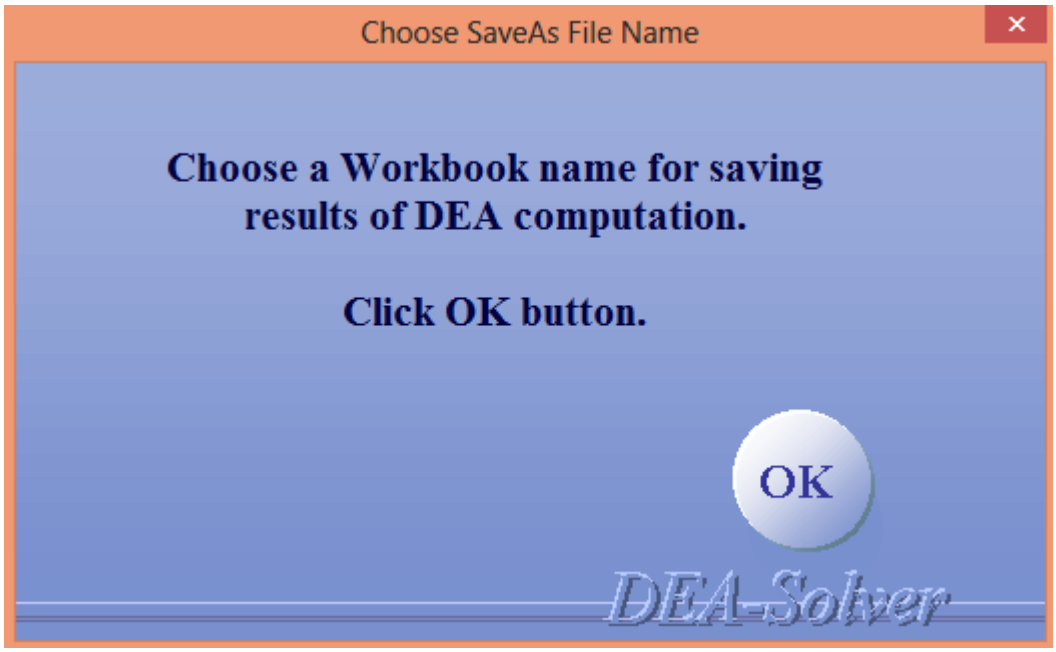


Figure 4.4: Choose Workbook Name

Figure 4.5: Run the Data

4.3 ANALYSIS OF DEA RESULTS

No.	DMU	Score	Excess DISTANCE (km) S-(1)	Excess LATE DELIVERY (%) S-(2)	Shortage QUALITY (%) S+(1)	Shortage SUPPLY VARIETY S+(2)
1	BAN HING Holding Sdn Bhd	0.424948	0	3.832838491	0	0
2	Berjaya Steel Malaysia	1	0	0	0	0
3	Esm Machinery (Kl) Sdn Bhd	0.496124	0	4.96124031	0	1.12371134
4	Fresh Cocoa Supply	0.336009	0	7.104449979	0	0
5	Giant Machinery Sdn Bhd	0.643218	0	13.98108368	0	0
6	Sen Jin SDN BHD	0.547135	0	7.112754159	0	1.81443299
7	Solutionpack (M) Sdn Bhd	1	0	0	0	0
8	Sumo's (M) Sdn Bhd	0.565538	0	1.13107511	0	0.948453608

Table 4.2: Slack of Data

This is the first data result run on the software. Score indicating the efficiency result of each DMU (supplier). The excess and shortage indicate the score of each variable.

The most efficient score is 1 by supplier Berjaya Steel Malaysia and Solutionpack (M) Sdn Bhd. Ban Hing Holding Sdn Bhd efficiency score is 0.4249. The excess in late delivery percentage score is 3.8328.

Esm Machinery (Kl) Sdn Bhd score is 0.4961. The excess in late delivery percentage score is 4.961. The shortage of supply variety percentage is score 1.1237. Other variable score is zero.

Fresh Cocoa Supply efficiency score is 0.3360. The excess in late delivery percentage score is 7.1044. Other variable score is zero.

Giant Machinery Sdn Bhd efficiency score is 0.6432. The excess in late delivery percentage score is 13.9810. Other variable score is zero.

Sen Jin Sdn Bhd efficiency score is 0.5471. The excess in late delivery percentage score is 7.1127. The shortage of supply variety percentage score is 1.8144. Other variable score is zero.

Sumo's (M) Sdn Bhd efficiency score is 0.5655. The excess in late delivery percentage score is 1.1310. The shortage of supply variety percentage score is 0.9484. Other variable score is zero.

4.3.1 Projection of Data/Recommended Improvement

No.	DMU I/O	Score Data	Projection	Difference	%
1	Ban Hing Holding Sdn Bhd	0.424948			
	DISTANCE (km)	79.7	33.868317	-45.83168	-57.51%
	LATE DELIVERY (%)	11	0.8415842	-10.15842	-92.35%
	QUALITY (%)	80	80	0	0.00%
	SUPPLY VARIETY	5	5	0	0.00%
2	Berjaya Steel Malaysia	1			
	DISTANCE (km)	38.8	38.8	0	0.00%
	LATE DELIVERY (%)	0	0	0	0.00%
	QUALITY (%)	97	97	0	0.00%
	SUPPLY VARIETY	5	5	0	0.00%
3	Esm Machinery (Kl) Sdn Bhd	0.496124			
	DISTANCE (km)	64.5	32	-32.5	-50.39%
	LATE DELIVERY (%)	10	-1.11E-15	-10	-100.00%
	QUALITY (%)	80	80	0	0.00%
	SUPPLY VARIETY	3	4.1237113	1.123711	37.46%
4	Fresh Cocoa Supply	0.336009			
	DISTANCE (km)	81.5	27.384752	-54.11525	-66.40%
	LATE DELIVERY (%)	23	0.6237624	-22.37624	-97.29%
	QUALITY (%)	65	65	0	0.00%
	SUPPLY VARIETY	4	4	0	0.00%
5	Giant Machinery Sdn Bhd	0.643218			
	DISTANCE (km)	47.4	30.488515	-16.91149	-35.68%
	LATE DELIVERY (%)	26	2.7425743	-23.25743	-89.45%
	QUALITY (%)	61	61	0	0.00%
	SUPPLY VARIETY	6	6	0	0.00%
6	Sen Jin SDN BHD	0.547135			
	DISTANCE (km)	54.1	29.6	-24.5	-45.29%
	LATE DELIVERY (%)	13	-3.33E-16	-13	-100.00%
	QUALITY (%)	74	74	0	0.00%
	SUPPLY VARIETY	2	3.814433	1.814433	90.72%
7	Solutionpack (M) Sdn Bhd	1			
	DISTANCE (km)	48.3	48.3	0	0.00%
	LATE DELIVERY (%)	5	5	0	0.00%
	QUALITY (%)	93	93	0	0.00%
	SUPPLY VARIETY	10	10	0	0.00%
8	Sumo's (M) Sdn Bhd	0.565538			
	DISTANCE (km)	67.9	38.4	-29.5	-43.45%
	LATE DELIVERY (%)	2	0	-2	-100.00%
	QUALITY (%)	96	96	0	0.00%
	SUPPLY VARIETY	4	4.9484536	0.948454	23.71%

Table 4.3: Projection of Data

The score data indicate the actual input/output data and the efficiency score of each supplier. Projection is the value that the supplier ought to achieve based on the score data. This means projection is the recommended value of each input and output room of improvement. The difference means the difference of actual output/input data and projection (score - projection = difference). The % (percentage) means the (difference/score data) × 100. Below is the explanation each of supplier projection.

No.	DMU I/O	Score Data	Projection	Difference	%
1	Ban Hing Holding Sdn Bhd	0.424948			
	DISTANCE (km)	79.7	33.86832	-45.8317	-57.51%
	LATE DELIVERY (%)	11	0.841584	-10.1584	-92.35%
	QUALITY (%)	80	80	0	0.00%
	SUPPLY VARIETY	5	5	0	0.00%

Table 4.4: Projection of Ban Hing Holding Sdn Bhd

For Ban Hing Holding Sdn Bhd the Distance should in range 33.9 kilometer. The difference is about 57.51% from actual data. The Late of Delivery should be 0.84%. The difference is about 92.35%. The percentage of Quality and Supply Variety show no deviations. No changes mean no improvement is required.

No.	DMU I/O	Score Data	Projection	Difference	%
2	Berjaya Steel Malaysia	1			
	DISTANCE (km)	38.8	38.8	0	0.00%
	LATE DELIVERY (%)	0	0	0	0.00%
	QUALITY (%)	97	97	0	0.00%
	SUPPLY VARIETY	5	5	0	0.00%

Table 4.5: Projection of Berjaya Steel Malaysia

The Distance, Late Delivery, Quality and Supply Variety show no difference in projection of Berjaya Steel Malaysia. Thus the supplier already achieves efficiency.

No.	DMU I/O	Score Data	Projection	Difference	%
3	Esm Machinery (Kl) Sdn Bhd	0.496124			
	DISTANCE (km)	64.5	32	-32.5	-50.39%
	LATE DELIVERY (%)	10	-1.11E-15	-10	-100.00%
	QUALITY (%)	80	80	0	0.00%
	SUPPLY VARIETY	3	4.123711	1.123711	37.46%

Table 4.6: Projection of Esm Machinery (Kl) Sdn Bhd

For ESM Machinery (KL) Sdn Bhd the Distance should in range 32 kilometer. The difference is about 50.39% from actual data. The Late of Delivery should be nearly zero which means the delivery should be 100% conform the purchase order. The supply variety shows some changes in projection. The ideal number is 4. The difference is 1.

No.	DMU I/O	Score Data	Projection	Difference	%
4	Fresh Cocoa Supply	0.336009			
	DISTANCE (km)	81.5	27.38475	-54.1152	-66.40%
	LATE DELIVERY (%)	23	0.623762	-22.3762	-97.29%
	QUALITY (%)	65	65	0	0.00%
	SUPPLY VARIETY	4	4	0	0.00%

Table 4.7: Projection of Fresh Cocoa Supply

For Fresh Cocoa Supply the Distance should in range 27.3 kilometer. The difference is about 54.1 from actual data. The difference is about 66.4%. The Late of Delivery percentage should be nearly zero. The difference is about 97.2%. The percentage of Quality and Supply Variety show no deviations. No changes mean no improvement is required.

No.	DMU I/O	Score Data	Projection	Difference	%
5	Giant Machinery Sdn Bhd	0.643218			
	DISTANCE (km)	47.4	30.48851	-16.9115	-35.68%
	LATE DELIVERY (%)	26	2.742574	-23.2574	-89.45%
	QUALITY (%)	61	61	0	0.00%
	SUPPLY VARIETY	6	6	0	0.00%

Table 4.8: Projection of Giant Machinery Sdn Bhd

For Giant Machinery Sdn Bhd the Distance should in range 30.4 kilometer. The difference is about 16.9 from actual data. The Late of Delivery should be nearly 3. The difference is about 89.45%. The percentage of Quality and Supply Variety show no difference. No changes mean no improvement is required.

No.	DMU I/O	Score Data	Projection	Difference	%
6	Sen Jin SDN BHD	0.547135			
	DISTANCE (km)	54.1	29.6	-24.5	-45.29%
	LATE DELIVERY (%)	13	-3.33E-16	-13	-100.00%
	QUALITY (%)	74	74	0	0.00%
	SUPPLY VARIETY	2	3.814433	1.814433	90.72%

Table 4.9: Projection of Sen Jin Sdn Bhd

For Sen Jin Sdn Bhd the Distance should in range 29.6 kilometer. The difference is about 16.9 from actual data. The Late of Delivery should be nearly 0. The percentage of Quality shows no deviations. No changes mean no improvement is required. However the Supply Variety illustrates to project to nearly 4 for ideal number of supplied item.

No.	DMU I/O	Score Data	Projection	Difference	%
7	Solutionpack (M) Sdn Bhd	1			
	DISTANCE (km)	48.3	48.3	0	0.00%
	LATE DELIVERY (%)	5	5	0	0.00%
	QUALITY (%)	93	93	0	0.00%
	SUPPLY VARIETY	10	10	0	0.00%

Table 4.10: Projection of Solutionpack (M) Sdn Bhd

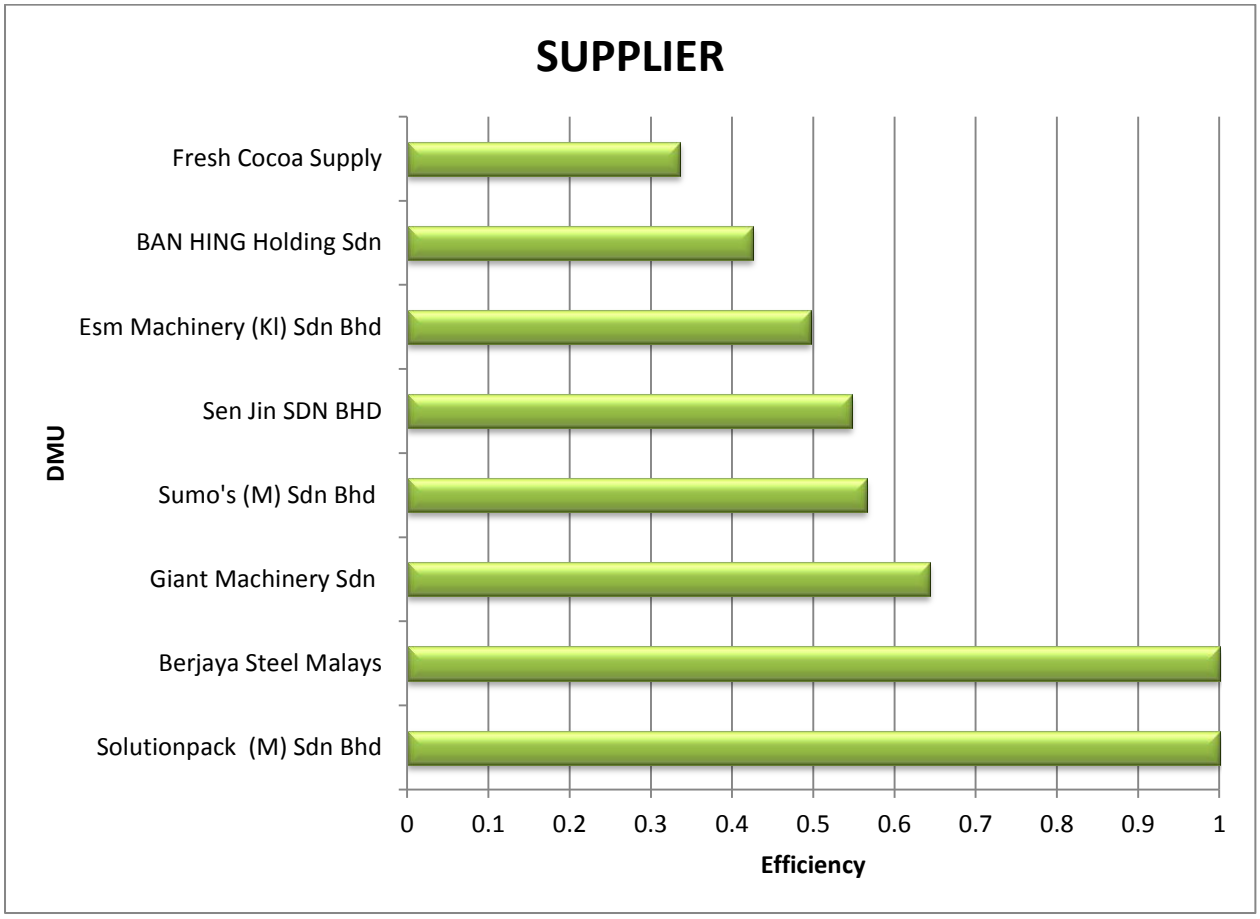
The Distance, Late Delivery, Quality and Supply Variety show no variation in projection of Solutionpack (M) Sdn Bhd. Thus the supplier already achieves efficiency among other supplier.

No.	DMU I/O	Score Data	Projection	Difference	%
8	Sumo's (M) Sdn Bhd	0.565538			
	DISTANCE (km)	67.9	38.4	-29.5	-43.45%
	LATE DELIVERY (%)	2	0	-2	-100.00%
	QUALITY (%)	96	96	0	0.00%
	SUPPLY VARIETY	4	4.948454	0.948454	23.71%

Table 4.11: Projection of Sumo's (M) Sdn Bhd

Lastly, Sumo's (M) Sdn Bhd Distance should in range 38.4 kilometer. The difference is about 43.45% from actual data. The Late of Delivery should be exact 0. The percentage of Quality shows no deviations. No changes mean no improvement is required. However the Supply Variety illustrates to project to nearly 5 for ideal number of supplied item. The difference is about 23.71% from actual data.

4.3.2 Ranking of supplier efficiency



Graph 4.1: Supplier Ranking

Above graph illustrate the ranking of suppliers based on their efficiency from least efficient to the most efficient. The least efficient supplier is Fresh Cocoa Supply which in the least range which in 0.3-0.4. Ban Hing Holding and ESM Machinery (KL) Sdn Bhd is in range 0.4-0.5). Sen Jin Sdn Bhd and Sumo's (M) Sdn Bhd efficiency is in range 0.5-0.6. Giant Machinery Sdn Bhd follows up at range 0.6-0.7. However, Berjaya Steel Malaysia and Solutionpack (M) Sdn Bhd illustrate significant difference in graph fluctuation. Both of the suppliers achieve perfect score of 1

4.3.3 Reference Set

No.	DMU	Score	Rank	Reference set (lambda)			
1	BAN HING Holding Sdn Bhd	0.424948	7	Berjaya Steel Malaysia	0.663366	Solutionpack (M) Sdn	0.168317
2	Berjaya Steel Malaysia	1	1	Berjaya Steel Malaysia	1		
3	Esm Machinery (Kl) Sdn Bhd	0.496124	6	Berjaya Steel Malaysia	0.824742		
4	Fresh Cocoa Supply	0.336009	8	Berjaya Steel Malaysia	0.550495	Solutionpack (M) Sdn	0.124752
5	Giant Machinery Sdn Bhd	0.643218	3	Berjaya Steel Malaysia	0.10297	Solutionpack (M) Sdn	0.548515
6	Sen Jin SDN BHD	0.547135	5	Berjaya Steel Malaysia	0.762887		
7	Solutionpack (M) Sdn Bhd	1	1	Solutionpack (M) Sdn I	1		
8	Sumo's (M) Sdn Bhd	0.565538	4	Berjaya Steel Malaysia	0.989691		

Table 4.12: Reference Set of Supplier

Lambda is remark as Reference Set of DMU. Most of suppliers that are not achieving perfect score of efficiency is indicate Berjaya Steel Malaysia as benchmarking or reference set except Solutionpack (M) Sdn Bhd which already accomplishes perfect score. Solutionpack (M) Sdn Bhd is second reference set for Ban Hing Holding Sdn Bhd, Fresh Cocoa Supply and Giant Machinery Sdn Bhd.

Statistics on Input/Output Data				
	DISTANCE (km)	LATE DELIVERY (%)	QUALITY (%)	SUPPLY VARIETY
Max	81.5	26	97	10
Min	38.8	0	61	2
Average	60.275	11.25	80.75	4.875
SD	14.62999915	8.742854225	12.90106585	2.260392665

Table 4.13: Statistics on Input/Output Data

Table above shows the maximum, minimum, average and standard deviation of the supplier's input and output. The average of supplier Distance is in range 60.3 km. the late delivery percentage average of supplier indicate 11.25%. the Quality is 80.75% average score. The supply variety average for the suppliers is nearly 5.

4.3.4 Correlations between Variables

Correlation				
	DISTANCE (km)	LATE DELIVERY (%)	QUALITY (%)	SUPPLY VARIETY
DISTANCE (km)	1	0.277983112	-0.28838882	-0.345956552
LATE DELIVERY (%)	0.277983112	1	-0.98355703	-0.137572664
QUALITY (%)	-0.288388817	-0.983557027	1	0.27326293
SUPPLIER VARIETY	-0.345956552	-0.137572664	0.27326293	1

Table 4.14: Correlation between Variables

The correlation means the relationship between variables which are the inputs and outputs. Below shows the indication of each score.

±0.70 or higher : Very Strong relationship

±0.40 to 0.69 : Strong relationship

±0.30 to 0.39 : Moderate relationship

±0.20 to 0.29 : Weak relationship

±0.01 to 0.19 : No or negligible relationship

VARIABLE	SCORE	CORRELATION
Distance and Late Delivery	0.2779	weak positive
Distance and Quality	-0.2883	weak negative
Distance and Supplier Variety	-0.3459	moderate negative
Late Delivery and Quality	-0.9835	very strong negative
Late Delivery and Supplier Variety	-0.1375	negligible
Quality and Supplier Variety	0.2732	weak positive

Table 4.15: Correlation Summary

Between Distance and Late Delivery is weak positive relationship (0.2779). Between Distance and Quality is weak negative relationship (-0.2883). Between Distance and Supplier Variety is moderate negative relationship (-0.3459). Between Late Delivery and Quality is very strong negative relationship (-0.9835). Between Late Delivery and Supplier Variety is negligible relationship (-0.1375). Between Quality and Supplier Variety is weak positive relationship (0.2732).

4.4 DATA VALIDATION AND VERIFICATION

The exact a portion of this study bases on the information of data given by Usahawan.com Managing Director, which cannot be investigate further if error of data exist, since that would have required an immeasurable measure of time and would have surpassed the extension and point of the expert proposal. After some research on previous journal, the study indicate the outputs and inputs are consistent with academic research results on most important supplier evaluation criteria (Dickson, 2000) and most often used criteria for supplier evaluation in academic research (Weber , 2004). A meeting and extensive communication were held with Managing Director of Usahawan.com Sdn Bhd, Mr Ahmad Faizal in order to get the grasp of what criteria that their company seek in supplier evaluation. Distance, Late Deliveries, Supply Variety, Quality and Price are some of the value that Usahawan.com Sdn Bhd would consider in considering to further the contract with current supplier.

The extent, to which the findings and results of this thesis may be treated as valid, largely depends on the quality of the data provided by Usahawan.com Sdn Bhd. This regards the initial process of data attainment. The degree, to which the outcomes and results of this research may be is valid, mainly be influenced by on the quality of the data provided by Usahawan.com. This regards the initial process of data attainment.

The number of Decision Making Unit (DMU) Boussofiane et.al (1991) specify that to get good discriminatory power out of the CCR models the lower bound on the number of DMUs should be the multiple of the number of inputs and number of outputs which is tally with this study. The recommended models for each organization were then subjected to validation. The results were validated through reviews with the decision makers from the respective organizations Usahawan.com Sdn Bhd. Historical data for periods which in this study is from June to December 2014 with major drops in efficiency were considered to ensure that the company management team would identify those periods as poor performers independent of the DEA results.

4.5 CONCLUSION

No.	DMU	Score
1	BAN HING Holding Sdn Bhd	0.424948
2	Berjaya Steel Malaysia	1
3	Esm Machinery (Kl) Sdn Bhd	0.496124
4	Fresh Cocoa Supply	0.336009
5	Giant Machinery Sdn Bhd	0.643218
6	Sen Jin SDN BHD	0.547135
7	Solutionpack (M) Sdn Bhd	1
8	Sumo's (M) Sdn Bhd	0.565538

Table 4.16: Summary

The lowest score of efficiency is Fresh Cocoa Supply. While Berjaya Steel Malaysia and Solutionpack (M) Sdn Bhd is the most efficient. Most of the suppliers need to set Berjaya Steel Malaysia as reference in order to achieve great performance. This chapter is achieving the objective 2 and 3 which is to measure the efficiency of supplier performance using DEA and to identify the inefficiency or the slack factor in supplier performance.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This paper evaluated the use of DEA for performance efficiency measurement and improvement target setting of 8 suppliers. For each of the suppliers, inputs and outputs of interest to the respective decision makers and comprehensible with the DEA assumptions were certain.

5.2 RESEARCH SUMMARY

A supplier evaluation is characteristically a multi-criterion decision problem, and DEA has been applied to evaluate suppliers. This paper proposes and demonstrates the application of DEA in evaluating the overall performances of suppliers in a firm. A research is then presented to demonstrate supplier performance evaluation using DEA for supplier selection and consideration of performance improvement. In this research, supplier performance was measured in terms of efficiency and performance.

Out of 8 suppliers of Usahawan.com Sdn Bhd was analyzed, DEA identified 2 efficient suppliers which is Berjaya Steel Malaysia and Solutionpack (M) Sdn Bhd. The rest 6 suppliers' slack factors that contribute to inefficiency were point out. Some

variable have rooms to be improving in order to achieve great performance. The most efficient supplier is used as reference set to which are not efficient. Criteria that was used for supplier performance measurement in this study used for DEA application (distance, late deliveries, supply variety, quality) is consistent with academic research results on most important supplier evaluation criteria (Dickson, 2000) and most often used criteria for supplier evaluation in academic research (Weber, 2004). Objective 1 which is (to identify criteria of efficient supplier) was achieved in Chapter 2 from literature review.

From the result and analysis in chapter 4, the organization can identify the efficiency of supplier performance, ranking, slack factor and room for improvement for existing current supplier. The lowest score of efficiency is Fresh Cocoa Supply. While Berjaya Steel Malaysia and Solutionpack (M) Sdn Bhd is the most efficient. Most of the suppliers need to set Berjaya Steel Malaysia as reference in order to achieve great performance. This reasearch is showing that the objective 1, 2 and 3 were achieved, which is to measure the efficiency of supplier performance using DEA and to identify the inefficiency or the slack factor in supplier performance. The research result and analysis in previous chapter which is (to measure the efficiency of supplier performance using DEA and to identify the inefficiency or the slack factor in supplier performance) were achieved.

5.3 RECOMMENDATION

This study suggests a few continuation directions by combine the DEA method with other benchmarking technique. For example is combining DEA with AHP (Analytical Hierarchal Process). The organization may be able to maximize the evaluation and make the result more reliable.Second is implementing DEA as procedure to evaluate the supplier performance in every firm because DEA is not limit to any amount of variables and factor. The criteria can be set as an objective to DEA whether to minimize it or maximize it.

Other example is combining the DEA method which is quantitative method with other qualitative method. For such is House of Quality.

DEA can be set as an overall objective in a firm. The objective is multi criterion problem that has room of improvement. Thus DEA is suitable to implement in every firm.

Thirdly after the implementation of DEA, the firm can buy parts from the more efficient supplier rather than least efficient supplier in order to reduce the number of supplier. This can contribute to the reduction of cost, increasing profit, better relationship or partnership with supplier, less rejected part and more on time deliveries

5.4 LIMITATION

The disadvantages of Data Envelopment Analysis includes the results are potentially sensitive to the selection of inputs and outputs, so their relative importance needs to be analyzed prior to the calculation. These limitations include DEA does not account for random error and such error may lead to an inaccurate result, DEA is unable to accurately model small sample sizes, DEA only provides a relative efficiency score, not a theoretical frontier and if is backward-looking and future projections are not available.

5.5 CONCLUSION

The research objectives were completed. An application of Data Envelopment Analysis was demonstrated to measure the supplier performance in terms of efficiency in utilizing inputs to produce outputs. Criteria selected for supplier performance measurement were regarded in academic literature as amongst the most important criteria for such cases. Two applications of DEA followed, one for measuring performance of existing suppliers, and other for measuring performance of existing suppliers in relation to Ideal Supplier. Ideal Supplier represented performance level Usahawan.com expects from its food machinery supplier commodity group.

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APPENDIX A1

SAMPLE OF QUESTIONNAIRE

USAHAWAN.COM

SUPPLIERS IN FOOD MACHINERY IN 2014

SUPPLIER	DISTANCE (km)	LATE DELIVERY (%)	QUALITY (%)	SUPPLY VARIETY

DESCRIPTION:

SUPPLIER: The supplier company's name

DISTANCE (KM): The physical distant of Usahawan.com and supplier using transportation

LATE DELIVERY (%): (Total purchase orders (PO) - No. of late delivery) / total PO

QUALITY (%): (Total PO's - no. of non-conformance item)/ total PO's

SUPPLY VARIETY: Variety of item supplied by the supplier

APPENDIX A2

(GANTT CHART)

A WORK PROGRESS OF UNDERGRADUATED RESEARCH PROJECT 1

PROGRESS/ RESEARCH ACTIVITY	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Identify Research Issues														
Deciding The Topic and Research Objectives														
Preparation of Research Proposal														
CHAPTER 1 : Introduction														
Problem Statement														
Research Question														
Method of Analysis														
Significance of The Study														
Scope of Study														
Expected Result														
CHAPTER 2 : Literature Review														
CHAPTER 3 : Research Methodology														
Submit Draft Proposal														
Presentation														
Submit Report FYP 1														

A WORK PROGRESS OF UNDERGRADUATED RESEARCH PROJECT 2

PROGRESS/ RESEARCH ACTIVITY	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Data Collected During July & August 2015														
CHAPTER 4 : Finding and Analysis														
Data Finding														
Model Development														
Analysis of Data														
Data Verification & Validation														
CHAPTER 5 : Conclusion and Recommendation														
Submit Draft Thesis														
Mock Presentation														
Turn it in & submit														
Submit Poster (in pdf)														
Presentation (Poster)														
Submit the Corrected Report														